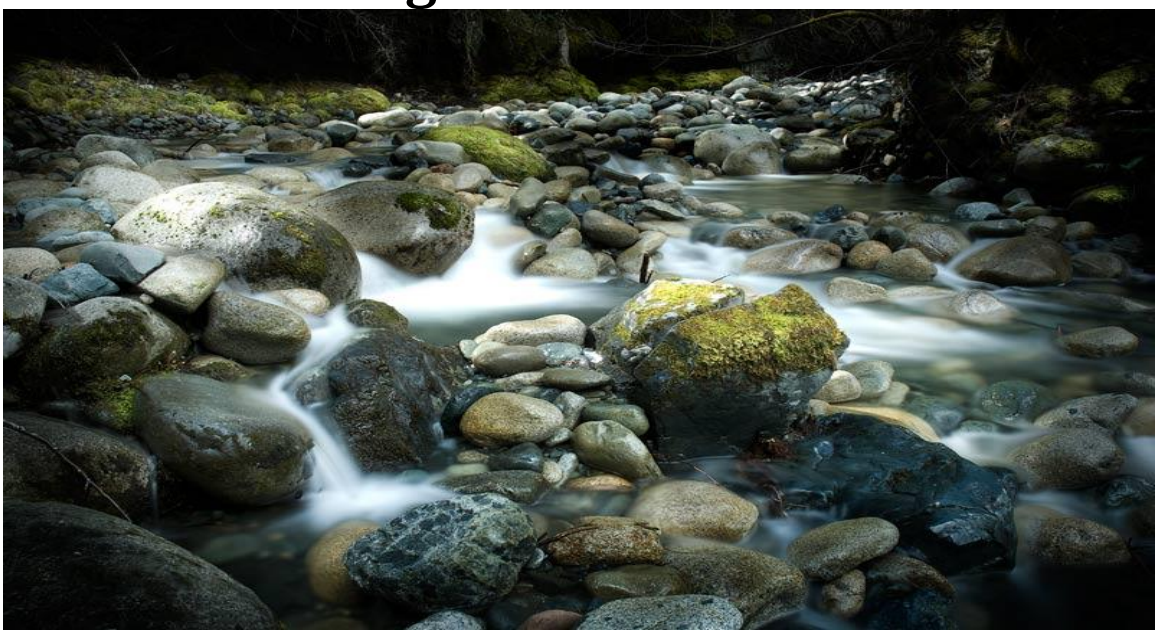
# Water Quality and Stream Invertebrate Assessment for the C.W. Young Spawning Channel, Englishman River



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## Executive Summary

This report was conducted to provide an overview of the overall water quality, microbiology and stream invertebrate communities residing in the C.W. Young Spawning Channel. The C.W. Young Spawning Channel is located in Parksville, British Columbia, Canada on the Northern bank of the Englishman River.

Vancouver Island University (VIU) field and lab work was preformed both on and off campus. All water quality analysis was conducted in the VIU laboratory; with the exception of the ALS samples which were shipped and analyzed at the ALS laboratory in North Vancouver. All VIU analysis, technical proposal and report writing was performed by the four RMOT 306 students assigned to the C.W. Young Spawning Channel, Englishman River (Shawn L., Brydon P., Sam S., and Brad W.) during the 2012 fall semester. Through the extent of the study Dr. John Morgan (RMOT 306 Professor) oversaw and directed our investigation of the status of the C.W. Young Spawning Channel.

A series of five sites were sampled at two separate occasions. First sample event was during a period of low flow on October 28, 2012. The second sample event was on the later date of November 20, 2012, historically known for relatively high flow. These five sites have been previously used by the Englishman River study groups and remained constant during the 2012 study for continuity and to further build a data set that could be compared and contrasted with past years data. During the first sampling event water quality parameters and flow assessments were conducted at all sites. ALS samples were taken at sites 1, 3 and 5. Microbiology and invertebrate sampling was conducted at sites 3, 4 and 5. During the second event water quality parameters and flow assessments were

again conducted at all sites however; no microbiology analysis or invertebrate sampling was conducted. Quality assurance and quality control measures which are described in the ambient fresh water and effluent sampling guidelines (RISC, 1998) were used during all analysis of samples to ensure the most accurate results possible.

All water quality analysis was determined to be within B.C. Ministry of Environment water quality guidelines and no alarming or unusual data presented itself. Invertebrate analysis indicates that the overall health rating of the C.W. Young Channel is rated as acceptable to good with an overall assessment rating average of 3.5. The C.W. Young is a relatively new area of spawning habitat and long term study is essential to establish a stable baseline measure of productivity and health of the channel. The Englishman River is a river on the rebound and it is a hope that the C.W. Young Channel can continue to provide the quality habitat needed for salmon spawning.

## Acknowledgements

The authors would like to extend the following thanks to Dr. John Morgan, Professor and Advisor for Bachelor of Natural Resource Protection and Faculty for Science and Technology, for organizing ALS samples, lab time, and personal time for consultation. Sarah Greenway, Technician at Vancouver Island University of the Bachelor of Natural Resource Protection Degree, for her aid in acquiring laboratory time and analysis equipment setup and takedown. ALS Laboratory provided analytical services for this project and previous projects completed for the Environmental Monitoring course. Parks and Trails, Recreation and Parks Department, and the Regional District of Nanaimo for allowing us vehicle access to the sites. The Vancouver Island University Biology Department and Sturgeon Centre, for the use of the laboratory supplies, equipment and time spent within the laboratory. Finally, an extra acknowledgement to the faculty of Vancouver Island University who accommodated our sampling times and use of equipment while Vancouver Island University staff experienced strike action over a period of the semester.

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# 1.0 Introduction

The C.W. Young Spawning Channel is located in Parksville British Columbia and is situated on the Northern bank of the Englishman River. The channel's creation was engineered towards the spawning and rearing habitat for salmon, specifically Pink (*Oncorhynchus gorbuscha*), Chum (*Oncorhynchus keta*) and Coho (*Onchorhynchus kisutch*), as well as habitat to accommodate other various salmonid species such as Rainbow Trout (*Onchorhynchus mykiss*) and Cutthroat Trout (*Onchorhynchus clakrii*). Since the channel is a man-made it has a good proportion of pools, glides, and riffles, making it ideal spawning and rearing habitat for salmonids. The side channel is approximately 4100 meters long and is situated 7km upstream from the Englishman River estuary. It is located in a park setting which provides public hiking access to portions of the channel (Hawkes et al., 2008). The main water of the Englishman River provides a steady flow of water to the C.W. Young Side Channel. Water is diverted through submerged pipes from the main river, through a set of manual control valves and into the channel. Without the constant flow of water from the main river, the side channel would dry out and be no longer functional. Given the diversion of water, the headwaters of the Englishman River have direct influence on the spawning channel. Englishman River headwaters begin near Arrowsmith Mountain at an elevation of 1819 meters. The river runs to the Strait of Georgia just North of Craig Bay. The watershed has a total drainage area of 324 $km^2$ (Hawkes et al., 2008).

## 1.1 Historical Review

The C. W. Young Spawning Channel was originally constructed in 1992 at which time Timber West logging company was owner of the land (Boss et al., 2011). In 2003 the land was acquired by the Regional District of Nanaimo (RDN) from Timber West and was renamed the Englishman River Regional Park and Conservation Area (ERRPCA). The park was created in order to protect the channel from local urban development and logging (Hawkes et al., 2008). On the Northern side of the park road, in the Western portion of the park there was once an active gravel pit however; the pit operation was suspended in 2005 and has not been active since then (Rueggeberg et al., 2008). In 2007 the C.W. Young Spawning Channel was extended in length giving better access to suitable spawning and rearing habitat for trout and salmon (Boss et al., 2011).

## 1.2 Project Overview

Water quality and stream invertebrate assessment were conducted during two separate sample periods; the first was on October 28, 2012 and the second on November 20, 2012. The reason for the lapse of 24 days was to compare the results of sampling parameters at a time of low flow and high flow.

This project was accomplished by third year Bachelor of Natural Resource Protection students Brad Wilde, Sam Sigal, Brydon Peace, and Shawn Lukas; under the supervision of Dr. John Morgan, professor of the RMOT 306 Environmental Monitoring course.

The goal of the project is to gauge the overall health of the side channel achieved by conducting and analyzing water quality testing, stream invertebrate sampling, and

microbiology analysis on the water within the side channel. The samples were taken from five predetermined sites located along the C.W. Young Spawning Channel. These sample sites have been used each year of this study since 2008 for the establishment of a solid baseline of measurement on the health of the channel.

## 1.3 Potential Environmental Concerns

As previously stated in the introduction, any environmental issues for the C.W. Young Spawning Channel will be directly linked to the main body of the Englishman River. There is the potential for non-point source pollution or contamination to come from new developments and industry situated up river of the channel which could potentially impact the river and side channel. These potential non-point source contaminants could come from housing development, agriculture, forestry activities such as logging, and increased recreational use (Boss et al., 2011). Vehicle access within the park is restricted to those conducting work within the park. Therefore, the potential for vehicle fluid leakage or seepage into the side channel or surrounding area is unlikely however; off-road vehicles such as quads and dirt bikes easily gain access and pose a risk to the riparian areas surrounding the stream. Also the area receives a great number of walker's and hiker's through the trails which always gives the potential for burned in trails to develop if people stray from the main path which can lead to soil erosion and vegetation removal (Boss et al., 2011). The rules of the park state that it is a dog on leash area however, during our study time numerous dogs were observed running through the waters of the channel where salmon were currently spawning. These events witnessed undoubtedly create negative effects on the migrating salmon, fry and the developing

eggs. There are three walkways in place to allow the public to cross the channel and observe without disturbing the salmon or having to enter the stream. RDN Parks staff regularly deconstructs any beaver damn which may pose as an impassable barrier to the migrating salmon and allow for proper flow.

# 2.0 Project Objectives

The objective of this study was to determine the overall health of the C.W. Young Spawning Channel, to locate and address potential areas of environmental concern, and possible changes that might need to be implemented to help improve the condition of the channel. Specific objectives for this project were to obtain water quality samples and field measurements for each of the five sites during two sampling events, collection of stream invertebrates and microbiology samples during the first event and to finally analyze all the data collected and come up with an overall health rating.

# 3.0 Methods

## 3.1 Sampling Stations and Habitat Characteristics

Five sample sites were analyzed along the C.W. Young Spawning Channel. The sites were specifically chosen in 2008 to provide a good representation of the different habitat types in the channel and to eventually be able to provide data to assess the overall health of the stream. These five sites which span the distance of the channel, allow each study group to accurately measure the same parameters in the same locations yearly which allows for tracking of changes in water quality, invertebrate community or microbiology composition over time. The five sites can be seen within Figure 1 and are

easily accessible by either car or by foot. Located in Appendix 1 are photos depicting each sites condition during the first sampling event on October 28, 2012.

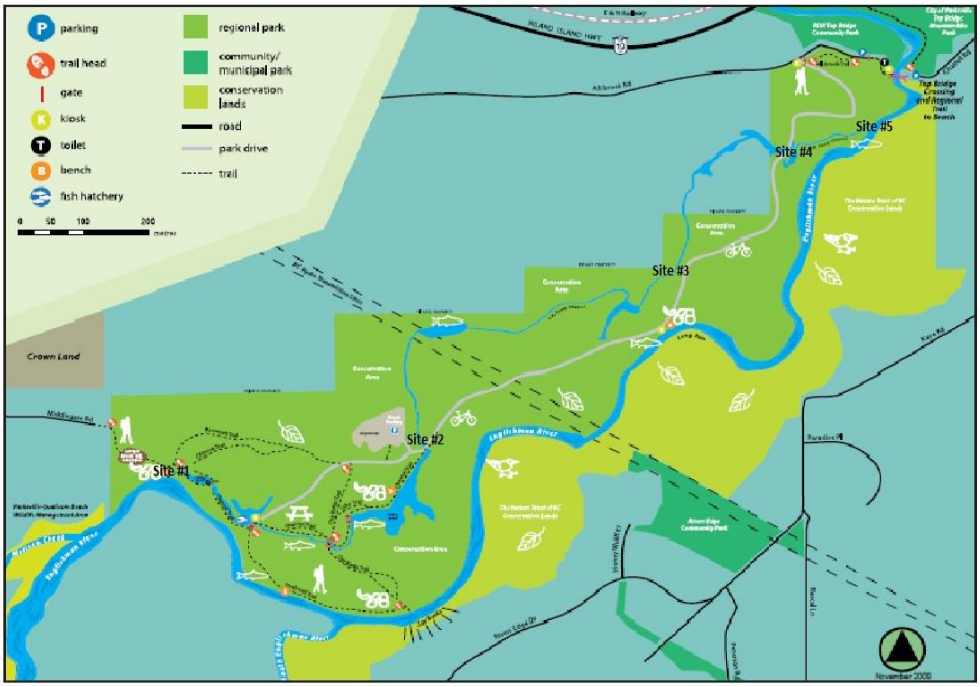



Figure 1: The Approximate location of the sampling sites that were used both on October 29, 2012 and November 20, 2012. The site locations are depicted by the (Site #) on the map. The Englishman River runs with the channel through the park (Regional District of Nanaimo)

### 3.1.1. Site 1

Site1 is located at the headwaters of the channel, approximately 3 meters downstream from where the main waters of the Englishman River feeds water to the channel through the manually controlled flow valve. This valve regulates water flow, ensuring that the water level is consistent at all times of the year. The substrate of site 1 was mostly fines with relatively deep water (approximately 1 meter). Grassy undercut banks were located at this site, making good in stream cover for salmon such as Coho. Photo 1 depicts this site well and can be found in Appendix 1. Access to this site was available down a steep grassy slope, caution was required.

### 3.1.2 Site 2

Site 2 is located approximately 1250 meters downstream from site 1(Boss et al., 2011). This site can be accessed from a culvert that goes under the road, and is roughly 25 yards down the stream. The easily accessible site has large woody debris, medium depth water (approximately 2 feet), with substrate represented by mostly cobble. The water velocity was relatively slow moving water. A photo of this site can be seen in Appendix 1.

### 3.1.3 Site 3

Site 3 is located approximately 2925 meters downstream from site 1, and access to this location is only available by parking along the road a short distance away and walking to the site. Stumps and woody debris has been piled up along the road to deter any vehicle access, a narrow walking path give access to the site approximately 75 meters. The water depth located at site 3 (approximately 2 feet) flowed over a good mixture of gravel and cobble substrate (Appendix 2). Deep pools are situated above and below this site, and ample shade and canopy cover is provided by large coniferous and deciduous trees along the stream. Invertebrate sampling was conducted at this site because of substrate composition, depth of water, and overall site condition.

### 3.1.4 Site 4

Site 4 is located approximately 3800 meters downstream from site 1, next to a pedestrian bridge crossing the channel. Due to the close proximity to this walking trail and bridge this site is at higher risk of becoming eroded due to high pedestrian use. Water feeding into this site first passes through a large pond with fine sediment (Appendix 2). Canopy cover was the best at this site when compared to all the others. In stream cover was fairly minimal due to location and proximity to the road and trail junction. The water velocity was slightly higher at this site compared to other sites because of the steel footbridge right next to it, and the substrate in the area was cobble.

### 3.1.5 Site 5

Site 5 is located at the confluence of the side channel and Englishman River. It is approximately 4100 meters downstream from site 1 (Boss et al., 2011). All water samples and invertebrate samples were taken within an area of direct influence of the main waters of the Englishman River to gain comparison results between the river and the side channel. The substrate characteristics were a boulder cobble blend with fast flowing water. Due to the high velocity basic hydrology measurements were conducted in the outflow of the side channel (Photo 5), and not done within the Englishman River. This site is susceptible to erosion based on the fast moving water and the flashiness of the river. Table 1 gives a complete and concise view of each sites safety, habitat, and coordinates.

Table 1: A summary of all C.W. Young Channel site locations and characteristics

| Site # | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Location (UTM/ NAD 83)** | 10U 0405266mE 5459853mN | 10U 0406108mE 5459975mN | 10U 0407079mE 5460647mN | 10U 0407489mE 5491053mN | 10U 0407836mE 5461183mN |
| **Distance up stream (m)** | 0 | 1250 | 2925 | 3800 | N/A |
| **Access** | Good | Good | Good | Good | Ok |
| **Flow** | low | low | low | Mid | low |
| | | | | | |
| **Depth** | mid | low | low | low | low |
| **Substrate** | Fine/pebble | Cobble/pebble | Cobble/pebble | Cobble/pebble | Cobble |
| **Safe at low flow** | Safe | Safe | Safe | Safe | Safe |
| **Safe at high flow** | Safe | Safe | Safe | Safe | Rain Dependent |
| **Invert. Sample** | No | No | Yes | Yes | Yes |

### 3.1.6 Sampling Frequency

Fieldwork was done on two different dates the first being October 28, 2012 and the second November 20, 2012. Water quality samples were taken from all 5 sites during both sampling events. Samples were also taken at sites 1, 3, and 5 for ALS laboratories to analysis. During the first sampling event invertebrate and microbiology samples were taken; these were taken from sites 3, 4, and 5. Table 2 gives a clear summary of what was taken at each location on each date.

Table 2. A summary of water sampling activities conducted at each station on the C.W. Young Channel during the October 28, 2012 event and November 19, 2012 event. The symbol "A" indicates sampling on October 28, 2012. The symbol "B" indicates sampling on November 20, 2011. The symbol "1" indicates a duplicate sample.

| Station | Field Measurements | VIU Analyses | ALS Lab Analyses | Microbiology | Stream Invertebrates |
|---|---|---|---|---|---|
| **1** | A,B | A[1],B | A,B | —— | —— |
| **2** | A,B | A,B | —— | —— | —— |
| **3** | A,B | A,B | A,B | A | A |
| **4** | A,B | A,B | —— | A | A |
| **5** | A,B | A,B[1] | A,B | A | A |

### 3.2 Basic Hydrology

Two submerged pipes with above ground manually controlled valves, one 24" diameter and the other 12" diameter, located at the headwaters of the C.W. Young Spawning Channel regulates water discharge entering the channel. During both sampling events both pipes were fully open, allowing maximum discharge into the stream (Boss et al., 2011). Basic hydrology measurements were taken during both sampling events from all sites. For Velocity we used the Float Method (with ping-pong ball). This method includes a stopwatch, measuring tape, and a Ping-Pong ball. We measured out 5 meters with the measuring tape in the middle of the channel with one person at either end. The person at the upstream end would drop the ball while at the same time someone else would start the stopwatch, the person at the downstream end would say, "stop" when the ball crossed the five-meter mark. This was repeated three times at each site so that we could calculate an average velocity.

Wetted width and depth were acquired by use of a measuring tape and measuring stick. Wetted width was measured by running a measuring tape from the stream bank across to stream bank where the water meets the shoreline. Depth was acquired by using a meter stick and reading the depths along the tape at set increments. Increments were set by dividing the wetted width by 3. In total, 3 depth measurements taken at each site (to the nearest 0.1m). In order to calculate the discharge ($m^3$/sec), average velocity (m/sec) was required. The velocity of the water was calculated by dividing the length by the time travelled. We then calculated the cross sectional area ($m^2$) by multiplying the wetted width by the average depth. The next step was to multiply the velocity by the area, making sure to add in a correction factor of 0.85 to represent the resistance given by the substrate, giving a total discharge in $m^3$/sec.

## 3.3 Water Quality

### 3.3.1 Field Measurements

The water quality measurements conducted in the field included; conductivity, dissolved oxygen, pH, and temperature. These measurements were obtained using a YSI multi-purpose meter that was pre-calibrated. The simplicity of the instrument's use while in the field minimized any user error in these parameters. For correct use and readings, the probe must be submerged in the water column without any contact with substrate or debris and left for a period of 2-3 minutes while readings are balanced and steady on the display.

### 3.3.2 Water Collection

Water was collected for VIU analysis in 500ml reusable plastic bottles. When filling the bottles assurance was made to not touch the bottle rims, the plunge approach was used to fill being sure not to contaminate any surface inside the bottle. All bottles were rinsed 3 times with water at the site prior to the collection of the sample and capping.

We did not need to rinse the ALS bottles before use because they came sterile. All ALS bottles were noted for date, time, location, and preservative addition prior to filling with sample water. When filling, assurance was made to remove the caps while the bottles were submerged to minimize any event of contamination from the environment. Samples that required preservatives were inverted 5 times to ensure complete mixing of the fluids. ALS required three samples to be taken. First sample was a 1L plastic bottle with no preservatives added to be used for general parameter testing. Second sample was a 250ml white plastic bottle, this had nitric acid preservative added and was used to measure the total level of metals in the water. The third sample was a 250ml amber glass that required sulphuric acid added in order to measure nutrient levels.

Accompanying every water collection was a trip blank, this was a sample container filled with distilled water. This blank was to ensure that there was no contamination of the samples during our time in the field. It is also important to note that when taking all water samples we approached the area of sample from downstream, making sure to get clean, clear water. All water samples collected went into a cooler in order to keep them at stream temperature, approximately 5 degrees, until they could be put into a fridge on the VIU campus.

### 3.3.3 VIU Laboratory Water Analysis

The water samples that were taken for the lab at VIU were analyzed within 48 hours of taking the sample. They were tested for total alkalinity, conductivity, hardness, nitrate, pH, phosphorous and turbidity. Total Suspended Solids were calculated with the 2100P Turbidimeter made by Hach, alkalinity was found using the phenolphthalein & total alkalinity (10244), and hardness was calculated using the Master Chemical Corp. (TRIM) drop titration. Nitrate was found with the DR 2800; Cadmium Reduction Method (8171). R. phosphorus (Orthophosphate) was establish by using the DR 2800; Amino Acid Method (8178).

### 3.3.4 ALS Laboratory Water Analysis

ALS Samples were collected as described in 3.3.2 of this report. The water samples were kept in a cool environment and sent from VIU the ALS lab. The ALS lab tested for general water quality parameters, nutrient analysis and a total metal scan (31 metals). The samples for nutrients and metals were preserved using sulphuric acid and nitric acid; this ensured that the water did not lose any of its qualities.

### 3.3.5 Quality Assurance/Quality Control

A trip blank was taken along on both sampling dates to be able to see if the water had picked up any contaminants during travel time. Duplicated samples were taken at one site each trip to make sure that the measurements in the VIU lab were consistent. Gloves were worn when possible and the samples were kept in a cool temperature to ensure the quality. All the VIU lab sample bottles were rinsed 3 times before use; the ALS lab bottles were not rinsed, as they were sterile. Each member of the crew had the same job during both sampling dates, in order to maintain consistency and minimize human error.

All sampling sites were approached from downstream in order to avoid unnecessary contamination.

### 3.3.6 Data Analysis and Comparison to Guidelines:

The water quality results were compared to the B.C. water guidelines (RISC. 1998). The B.C. water guidelines outline the maximum concentration that is sustainable for aquatic life. The guidelines were used to help determine stream health; by comparing our results with the guidelines it gave us a good indication of the overall health of the stream. The results from the water quality sampling were compared to the Water Guidelines to help determine stream health.

### 3.4.7 Microbiology

Coliforms were tested at sites 3, 4, and 5 on October 28, 2012. Samples were taken with the use of sealed and sterile 120-ml whirl packs. The whirl pack bags were filled with sample water sealed using the ties provided with the bags, and stored in a cool environment until laboratory analysis.

The samples were analyzed for fecal coliforms, non-fecal coliforms and non-coliform bacteria. A 25ml amount of water from each sample was filtered through a membrane filter using a vacuum pump. The membrane was removed using sterile forceps and placed on an absorbent pad within a sterile petri dish. The pad was then saturated with m-coliBlue24 broth for incubation. Once completed, the petri dish was transferred to incubator where it was kept at a temperature of 35°C a minimum of 24 hours. This would allow for colonies to form and become visible for counting with the aid of a dissection microscope.

Three types of colonies were observed on the filter pads: fecal, non-fecal, and non-coliform bacterial. All three colonies were present at each site sampled. The non-fecal coliforms, show up as red, are not generally harmful and live in warm-blooded animal's intestines. The fecal coliforms (commonly known as E. coli), show up as blue and may be harmful to humans as they derive from the feces of animals. The clear colonies are non-coliform bacteria and have no harmful or helpful attributes.

## 3.4 Sampling Invertebrate Communities

Invertebrate sampling was done during the first sampling event in the C.W. Young Spawning Channel, where only three of the 5 sites were sampled. The three sites sampled for invertebrates were sites 3, 4, and 5. Sites 3 and 4 have been sampled in past years; however; site 5 had not been sampled before. Sample location for site 5 was chosen to represent the correlation between the invertebrate communities and the density main waters of the Englishman River and the waters of the C.W. Young Spawning Channel.

### 3.4.1 Invertebrate Sample Collection

The type of sampler that we used was a Hess sampler; the Hess sampler has a circular sample area of .09$m^2$. Three replicates were taken at each site that was sampled, making the sample size 0.27$m^2$. To use the Hess sampler effectively it has to be pushed firmly into the substrate making sure that the open screen is facing upstream and the catch bag downstream. Once the Hess sampler is in place, you must turn over rocks and rub the underside of them with your hands, making sure to thoroughly knock off all the invertebrates. The Hess sampler was then removed from the water and care was taken to

sweep everything down to the cylinder screen catch. Whatever was in the cylinder would then be transfer to a 150 ml bottle and would be mixed with 70% ethanol; this would kill the invertebrates, preserving them for later analysis. All samples were collected according to methods outlined in lecture (John Morgan 2012).

### 3.4.2 VIU Laboratory Analyses

In the lab at VIU we analyzed the nine samples which were taken from three sites; three replicate samples from each of the three sites. We counted each site as a group, each member with one of the site samples to keep continuity of taxa counts (VIU, 2012), the individuals were enumerated a separated into petri dishes for easy of counting and identification. Dissecting microscopes were used for precise counts and identification; the counted samples were then removed and kept in species based dishes to avoid potential recounts.

### 3.4.3 Quality Assurance/Quality Control

For each of the invertebrate samples taken, the Hess sampler was rinsed out in the river to make sure that there was nothing left in the invertebrate catcher. The bottles used to collect samples were filled with 70% ethanol to preserve any invertebrates for later analysis. The bottles were then labeled with the appropriate site number and sample number. All samples were stored at the VIU lab and were not opened until the day of analyzing.

When counting the invertebrates we used clean jars, petri dishes, and dissecting microscopes. Notes were taken on different taxonomic features in order to avoid double counting of any taxa. The data was recorded right after counting so that it would not be

forgotten. The enumerators took regular breaks in order to avoid eyestrain and false results.

### 3.4.4 Data Analyses

The numbers of the counted invertebrates were then written on the Invertebrate Survey Field Data Sheets (Appendix 2). These data sheets are used to calculate totals and sub totals of the number of taxa and of the number of invertebrates counted. It also calculates the invertebrate density per total area sampled, predominant taxon, pollution tolerance index, (EPT) index, EPT to total ratio index, and an overall stream rating.

# 4.0 Results and Discussion

## 4.1 General Field Conditions

During the first sampling period on October 28, 2012 the ambient air temperature ranged from 10°C - 12°C (ECD 2012) over the four hour sampling period and overhead conditions were cloudy and remained overcast for the entire sampling period. The second sampling event took place on November 20, 2012; ambient air temperatures ranged from 6°C - 8.4°C (ECD 2012) over the three hour sampling period. Again overhead conditions remained cloudy and overcast with the occasional light rain fall. According to the City of Parksvilles' rainfall records the month of September was the driest recorded month of 2012 receiving only 2.6mm of rain over the entire month. The month of October which corresponds with the first sampling event received 142mm of rainfall indicating that the month of October was the period of fall flush for 2012. The month November received 150mm of rain over the month which continued to increase the flow in the main body of the river. These rapid increases in precipitation over the months of October and November dramatically affect the flow rate of the main body of the river however; the side channel where our sampling was conducted the flow is controlled by a check valve and regulated so that this dramatic increase in flow during the fall flush does not blow out the spawning side channel.

## 4.2 Water Quality

### 4.2.1 Field Measurements

During the first sampling event which took place on October 28, 2012 the average water temperature was 7.7°C. The second sampling event which took place on November 20, 2012 had an average water temperature of 6.0°C. The slight drop in water temperature was expected as the ambient air temperature drops so does the water temperature.

Dissolved Oxygen (DO) readings were taken during both sampling periods. The fist sampling period indicated DO levels between 10.49 - 11.5mg/L. During the second event DO ranged between 9.5 - 11.01 mg/L. Both sampling periods are well within the guidelines for aquatic life.

Conductivity during the first sampling event ranged from 59-85 µS/cm and during the second sampling event ranged from 39-56 µS/cm. Both are within the water quality guidelines for aquatic life and seem to follow a similar trend of the 2011 study group as our readings were higher during the first sampling event than they were in the second. Conductivity is based on ion content in the water, perhaps the reason for the second reading being smaller is due to flushing of ions during the fall flush period.

The pH for the first event ranged from 7.64-8.09 and the second event ranged from 5.79-7.46. According to Ministry of Environments water quality guidelines it is not uncommon for BC coastal streams to have a pH range from 5.5-6.5 which brings our pH reading within the water quality guidelines for aquatic life however; the lower pH can lead way to problems with ammonia and ionization of heavy metals. This is an important water quality parameter to measure and monitor and should be assessed continually.

### 4.2.2 VIU Laboratory Analysis

Alkalinity during the first sampling event ranged from 17.6-20.8 mg/L and during the second sampling event ranged from 12.8-20.6 mg/L. The lowest readings both came from sample site 5 which is located in the tail out of the spawning channel where the spawning channel meets the main body of the river however; it is important to note that for the second sampling event site 5 was the location for all duplicate samples; the duplicate sample reading for alkalinity at site 5 read 17.2 mg/L, a much closer measure to the first sampling event for site 5. It is likely that the initial measure of 12.8 mg/L was an error conducted in the lab. In both cases alkalinity readings show to be in the range of 10-20 mg/L indication moderate sensitivity to acidic inputs within the water course (RISC, 1998).

Hardness during the first sample event ranged from 21.1-29.2 mg/L with the lowest hardness reading from station 1 and the highest from site 4. During the second sampling event the water hardness ranged from 15-20 mg/L with the lowest reading at site 5 and the highest from site 4. Coastal BC lakes and streams have reading typically below 60 mg/L and most water courses are considered as soft water, our hardness readings are considered normal for this part of BC (RISC, 1998).

Turbidity during the first sample event ranged from 0.5-0.8 NTU indicating very clear water. The second sampling event ranged from 1.36-2.42 NTU, marking a slight decrease in the waters clarity however; this increase in turbidity is small and is most likely due to increased precipitation during the month of November resulting in greater sediment loading into the channel.

Nitrate's for the first sampling event ranged between 0.02-0.04 mg/L and for the second sampling event ranged between 0.02-0.06 mg/L. According to the (RISC, 1998) most surface waters without anthropogenic inputs have less than 0.3 mg/L nitrates making our readings within the water quality guidelines.

Phosphates or orthophosphorus levels during the first sampling event ranged from 20-40 µg/L and during the second sampling event ranged from 40-110 µg/L. According to the BC Ministry of Environment W.Q.G. for phosphorus most lakes and streams that have not been affected by anthropogenic sources generally have phosphorus levels below 10µg/L indicating that there is some non natural input of phosphorus into the C.W. Young side channel. Potential inputs of phosphorus could come from sewage treatment plant effluent, agriculture, urban development (particularly from detergents) and industrial effluents. This data is puzzling as the ALS data does not match the VIU analysis for phosphates however the 2011 study VIU analysis mirrors the 2012 VIU data quite closely. It is recommended that more effort be put into determining the input of phosphorus into the side channel or to figure out if the VIU analysis is accurate for phosphorus.(A list of general water parameters is available in table 3 and table 4).

Table 3.Field Measurements and laboratory analysis results for water quality parameters sampled on October 28, 2012 at five sites along the C.W. Young Channel of the Englishman River.

| Parameter | Units | Station 1 | Duplicate 1 | Station 2 | Station 3 | Station 4 | Station 5 | Blank |
|---|---|---|---|---|---|---|---|---|
| Conductivity | µs/cm | 59 | 59 | 67 | 73 | 85 | 62 | 0 |
| Temperature | °C | 7.3 | 7.3 | 7.75 | 8.09 | 8.31 | 7.77 | -- |
| D.O. | mg/L | 11.5 | 11.5 | 10.62 | 10.49 | 10.6 | 10.59 | -- |
| pH | NoUnits | 7.76 | 7.76 | 8 | 7.9 | 8.09 | 7.64 | 6.2 |
| Turbidity | NTU | 0.8 | 0.8 | 0.5 | 0.5 | 0.7 | 0.7 | 0.2 |
| Alkalinity | mg/L$CaCO_3$ | 18.4 | 18.4 | 18 | 18.8 | 20.8 | 17.6 | 1.2 |
| Hardness | mg/L$CaCO_3$ | 21.1 | 23.1 | 25.1 | 28.2 | 29.2 | 26.2 | BDL> 1mg/L |
| Nitrates | mg/L $NO_3$ | 0.03 | 0.04 | 0.03 | 0.03 | 0.04 | 0.02 | 0.01 |
| Phosphates | mg/L$PO_4^{3-}$ | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.02 | 0.01 |

Table 4.Field Measurements and laboratory analysis results for water quality parameters sampled on November 20, 2012 at five sites along the C.W. Young Channel of the Englishman River.

| Parameter | Units | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 5 Duplicate | Blank |
|---|---|---|---|---|---|---|---|---|
| **Conductivity** | µs/cm | 39 | 40 | 41 | 56 | 36 | 36 | 0 |
| **Temperature** | °C | 6 | 5.8 | 5.69 | 6 | 6.2 | 6.2 | —— |
| **Dissolved O2** | | 11.01 | 9.91 | 9.88 | 9.5 | 10.8 | 10.8 | —— |
| **pH** | No Units | 5.79 | 6.63 | 6.77 | 7.46 | 7.09 | 7.09 | 6.1 |
| **Turbidity** | NTU | 1.46 | 1.68 | 1.75 | 2.42 | 1.36 | 1.47 | 0.18 |
| **Alkalinity** | mg/L as$CaCO_3$ | 20 | 14.8 | 14 | 20.6 | 12.8 | 17.2 | 5.2 |
| **Hardness** | mg/L $CaCO_3$ | 16 | 18 | 17 | 20 | 15 | 14 | BDL >1mg/L |
| **Nitrates** | mg/L $NO_3$ | 0.04 | 0.06 | 0.02 | 0.02 | 0.05 | 0.05 | 0.05 |
| **Phosphates** | mg/L$PO_4^{3-}$ | 0.08 | 0.11 | 0.06 | 0.05 | 0.04 | 0.07 | 0.04 |

### 4.2.3 ALS Laboratory Analysis

Water samples were collected for ALS analysis during both sampling periods and were analyzed for physical tests, anions & nutrients and total metals. The results were compared to the BC Water Quality Guidelines; using the recommended aquatic life guidelines. A complete summary of ALS results is included in appendix 2**.**

Conductivity measures are fairly consistent with the ALS samples, for the first sampling event the VIU samples conducted with the YSI meter are consistently 2µs/cm higher than the ALS samples. For the second sampling event the samples follow a similar trend however; in this case the VIU samples are only 1µs/cm higher than the ALS samples.

Hardness measured roughly 2µs/cm higher from the VIU analysis when compared to what was analyzed through ALS for the first sampling event. During the second sampling event the VIU analysis mirrored the ALS data almost exactly. Regardless, both data sets indicate that the water in the C.W. Young Spawning Channel is soft water making it susceptible to acidification should metals contaminate the watercourse somehow.

The pH analysis from VIU was slightly different then what was described from ALS. For the first sampling event the VIU analysis for sites one, three and five read 7.76, 7.9 and 7.64 respectively; the ALS data read 7.52, 7.54 and 7.54. The second event followed a similar trend however; the two data sets were further apart with VIU's readings for sites one, three and five reading 5.79, 6.77 and 7.09 respectively; the ALS data read as 7.41, 7.39 and 7.09. Possible reasoning for the discrepancies in the two sets of data is the time between analysis and the method used to attain the pH levels. ALS

samples were collected roughly one week before analysis; perhaps this waiting period altered the pH in some way. The second possible factor is that VIU analysis was conducted in the field using the YSI meter, perhaps the ALS lab technicians used a different method of obtaining the pH measure and this provided a more accurate or less accurate measure.

Nutrients levels were below the recommended guidelines for aquatic life when analyzed by ALS and according to the B.C. aquatic life guidelines considered the water in the side channel to be oligotrophic however; when the same data was analyzed from VIU the phosphate levels were considerably higher and rated the system as eutrophic. The 2011 VIU data collected indicates a similar trend (Table 5.). According to the water quality guidelines lakes and streams have an acceptable phosphorus level 5-15µg/L.

Table 5.Summary of phosphorus analysis data for 2011 &2012 from VIU data and ALS data.

| Sample year | Site 1 | Site 3 | Site 5 | Highest reading |
|---|---|---|---|---|
| **2011 sample 1 VIU** | 150 µg/L | 40 µg/L | 70 µg/L | 150 µg/L |
| **2011 sample 2 VIU** | 60 µg/L | 30 µg/L | 70 µg/L | 70 µg/L |
| **2012 sample 1 VIU** | 30 µg/L | 30 µg/L | 20 µg/L | 40 µg/L |
| **2012 sample 2 VIU** | 80 µg/L | 60 µg/L | 40 µg/L | 110 µg/L |
| **ALS. 11 sample 1** | 2.1 µg/L | 12.2 µg/L | 18.1 µg/L | --- |
| **ALS. 11 sample 2** | 2.3 µg/L | 19.2 µg/L | 19.7 µg/L | --- |
| **ALS. 12 sample 1** | 3.2 µg/L | 5.7 µg/L | 4.8 µg/L | --- |
| **ALS. 12 sample 2** | 8.4 µg/L | 15 µg/L | 7.5 µg/L | --- |

From this data we can conclude that the phosphate levels in the stream are more representative of the ALS samples. As phosphorus is the limiting nutrient in fresh water it would be important to note for the 2013 study to pay extra attention to the phosphorus analysis in the VIU lab.

Metal analysis from ALS indicates that all metal parameters except aluminum are below the recommended guidelines for aquatic life. The readings from the second sample event for aluminum were higher than the first sample event, the reason for this is unknown however; it would be a point of interest for the 2013 study to assess if this trend of increased aluminum levels continues through the fall flush.

### 4.2.4 Quality Assurance/Quality Control

The ALS analysis lab is professionally run lab that has built its reputation on quality assurance and quality control practices. Some of the measures that the ALS lab has adapted are sample duplicates, laboratory control spikes, matrix spikes and proficiency testing as well as the use of proper sterilization of equipment and sterile lab practices. Client supplied field blanks and client managed blind inter laboratory duplicate samples (ALS, 2012).

## 4.3 Microbiology

All samples collected from the C.W. Young Spawning Channel contained all 3 of the microbiology parameters tested (Table 6 and Figure 2). Results from site 3 indicate a higher percentage of fecal coliforms. Site 5 had lower percentage of the fecal coliform but higher counts of non-fecal coliform than that of sites 3 and 4. The higher percentage of fecal coliform in site 3 could be due to the close proximity to an active beaver pond and lodge located downstream of the sample site. The total range of the coliforms is only between 12 and 15 CFU/100mL.

Results of total microbiological counts for coliform bacteria is significantly lower than that of similar studies conducted on the C.W. Young Spawning Channel during the fall of 2010 and 2011 where 240-280 CFU/mL were counted (Johnson et al,2010) and 176-2370 CFU/100mL (Boss et al, 2011). During the previous studies, the methods of field collection, lab analysis and incubation time followed the same procedures. Previous studies conducted microbiology tests at all 5 sites on the C.W. Young Spawning Channel which would add to the increased numbers and total results comparatively (Johnson et al, 2010) (Boss et al, 2011).

Table 6. Total coliform, fecal coliform, % fecal coliform and non-fecal coliforms for site's three, four and five.

| Site Sample | Total Coliform (per 100mL) | Fecal Coliform | % Fecal Coliform | Non-Fecal Coliform |
|---|---|---|---|---|
| **Site 3** | 12 | 7 | 58.3 | 16 |
| **Site 4** | 11 | 4 | 36.4 | 24 |
| **Site 5** | 15 | 7 | 46.7 | 30 |

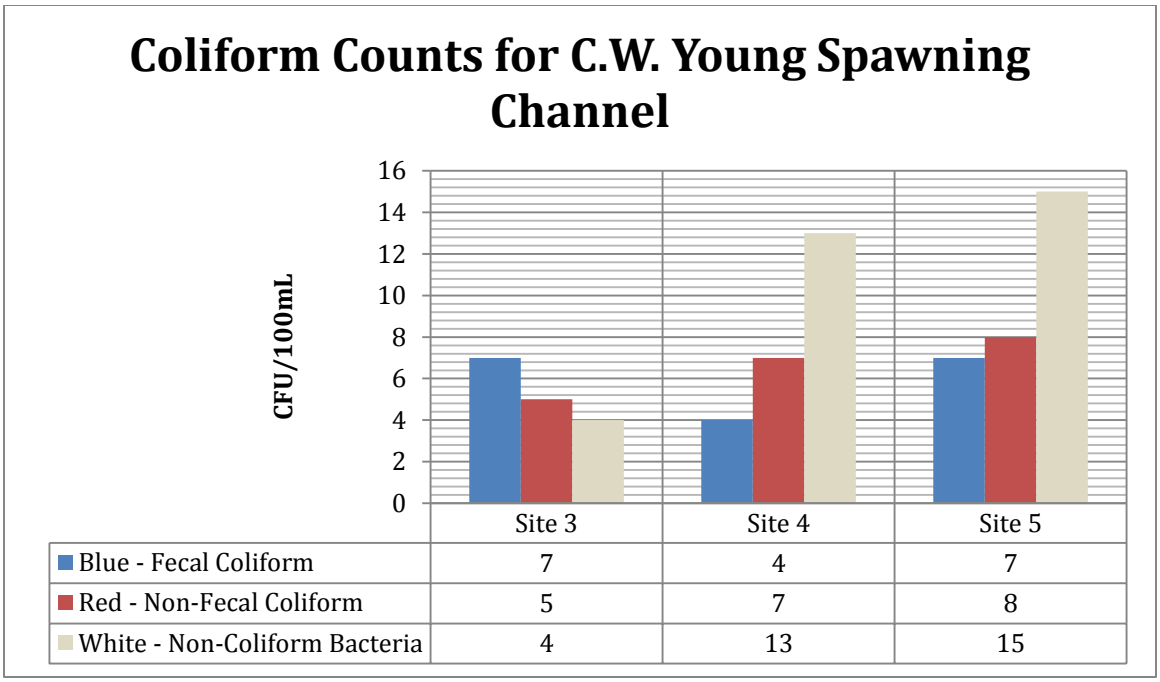



Figure 2.Fecal coliform, non-fecal coliform and non-coliform bacteria colony forming units / 100 mL.

### 4.3.1Quality Assurance / Quality Control

To maintain quality assurance, only clean and specific containers were used when collecting the samples in the field. Hands were kept clean and gloves were used when needed when handling samples. To preserve the samples, a fresh undiluted solution was added to the samples to create an approximate 70% ethanol solution. The samples were placed within a cooler for transportation and stored in the refrigerators of VIU. To maintain quality control, samples were counted numerous times to ensure accuracy. Coliform counts were small enough that whole plate counts were conducted.

## 4.4 Stream Invertebrate Communities

The invertebrate sampling event on October 28th 2012 at the C. W. Young Spawning Channel yielded a total of 1372 invertebrates counted with 48 taxa totaled for sites 3, 4 and 5 (Table 7 and Figures 3-6). Although the samples show different numbers, the results are generally analogous with the Mayflies Nymphs and Stonefly Nymphs being the dominant species.

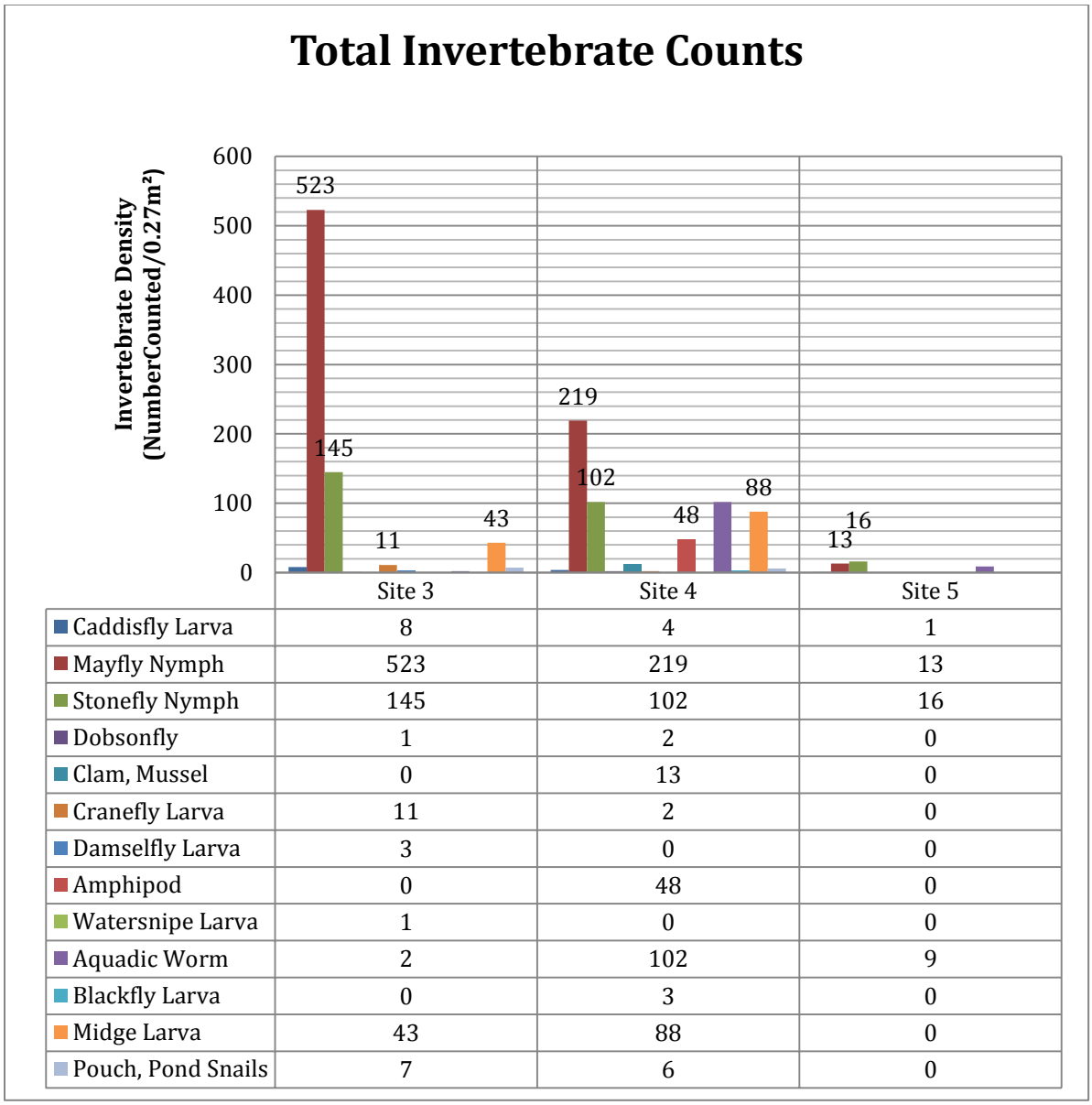
The Site Assessment Rating gives and overall site assessment rating for the sites sampled. The C. W. Young Spawning Channel samples sites found abundance and density to be from 3.25 to 3.75 with an average of 3.5. The site assessment rating assigned is based on 4 being good, 3 acceptable, 2 marginal and 1 being poor (Appendix 3). Table shows the Mayfly Nymphs as the dominant species found at sites 3 and 4 and Stonefly Nymphs at site 5 indicating a strong EPT Index as all species require clean water (RISC, 1998). Table 7 also shows the correlation of the insects found in the C.W. Young Spawning Channel to their tolerance of pollution and the density those insects were found at each site.

Table 7. Breakdown of invertebrate taxa into their appropriate pollution tolerance category for sample sites three, four and five on October 28, 2012.

| Pollution Tolerance | Invertebrate Taxa | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|
| **Category 1 Pollution Intolerant** | Caddisfly Larva (EPT) | 8 | 4 | 1 |
| | Mayfly Nymph (EPT) | 523 | 219 | 13 |
| | Stonefly Nymph (EPT) | 145 | 102 | 16 |
| | Dobsonfly (hellgrammite) | 1 | 2 | 0 |
| **Category 2 Somewhat Pollution Tolerant** | Clam, Mussel | 0 | 13 | 0 |
| | Cranefly Larva | 11 | 2 | 0 |
| | Damselfly Larva | 3 | 0 | 0 |
| | Amphipod (freshwater shrimp) | 0 | 48 | 0 |
| | Watersnipe Larva | 1 | 0 | 0 |
| **Category 3 Pollution Tolerant** | Aquatic Worm (oligochaete) | 2 | 102 | 9 |
| | Blackfly Larva | 0 | 3 | 0 |
| | Midge Larva (chironomid) | 43 | 88 | 0 |
| | Pouch and Pond Snails | 7 | 6 | 0 |
| **Totals** | Total Abundance | 744 | 589 | 39 |
| | Density (Number / $m^2$) | 2565.52 | 2031.03 | 134.48 |
| | Site Assessment Rating | 3.5 | 3.75 | 3.25 |

### 4.4.1 Total Density

Highest counts were found at site 3, where 744 organisms were collected that suggest a density of 2565.52/m² (Figure 4). Site 4 had similar numbers but lower at 589 insects that suggested a density of 2031.03/m² (Figure 5). Results from site 5 showed the lowest numbers of invertebrates collected with only 39 that suggested a density of only 134.48/m² (Figure 6).




| | Site 3 | Site 4 | Site 5 |
|---|---|---|---|
| Caddisfly Larva | 8 | 4 | 1 |
| Mayfly Nymph | 523 | 219 | 13 |
| Stonefly Nymph | 145 | 102 | 16 |
| Dobsonfly | 1 | 2 | 0 |
| Clam, Mussel | 0 | 13 | 0 |
| Cranefly Larva | 11 | 2 | 0 |
| Damselfly Larva | 3 | 0 | 0 |
| Amphipod | 0 | 48 | 0 |
| Watersnipe Larva | 1 | 0 | 0 |
| Aquadic Worm | 2 | 102 | 9 |
| Blackfly Larva | 0 | 3 | 0 |
| Midge Larva | 43 | 88 | 0 |
| Pouch, Pond Snails | 7 | 6 | 0 |

Figure 3. Total invertebrate counts for sites three, four and five during the first sampling event; October 28, 2012.

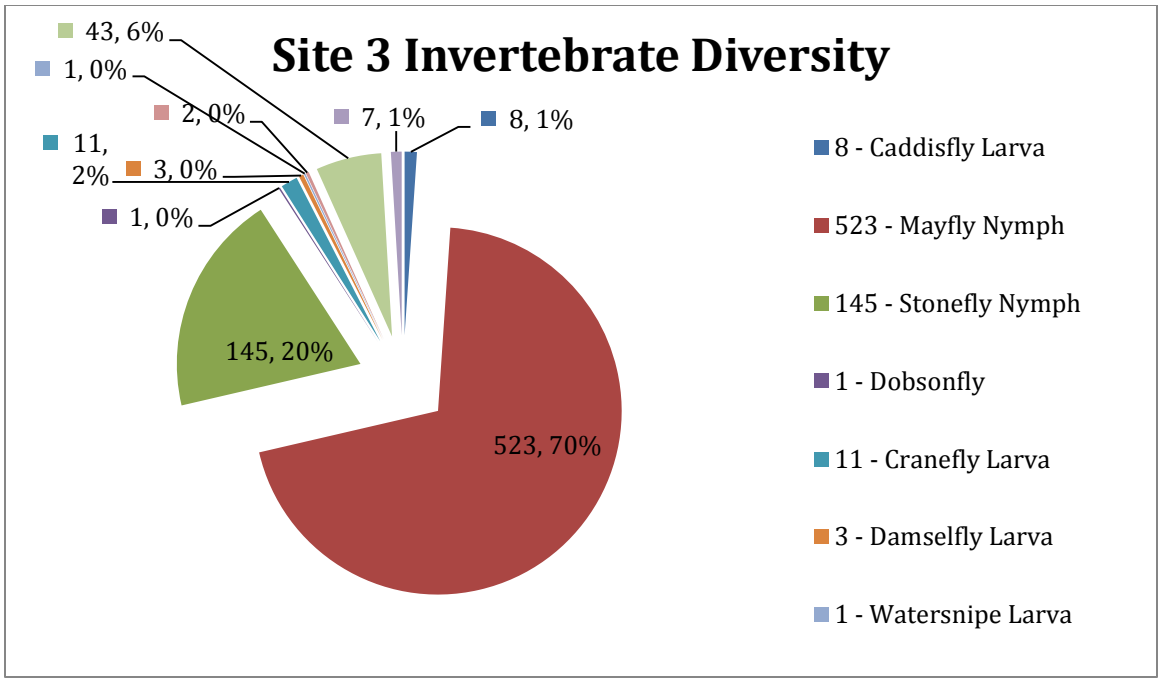



Figure 4. Invertebrate diversity at site three, showing break down of taxa and dominant taxa being mayfly nymph.

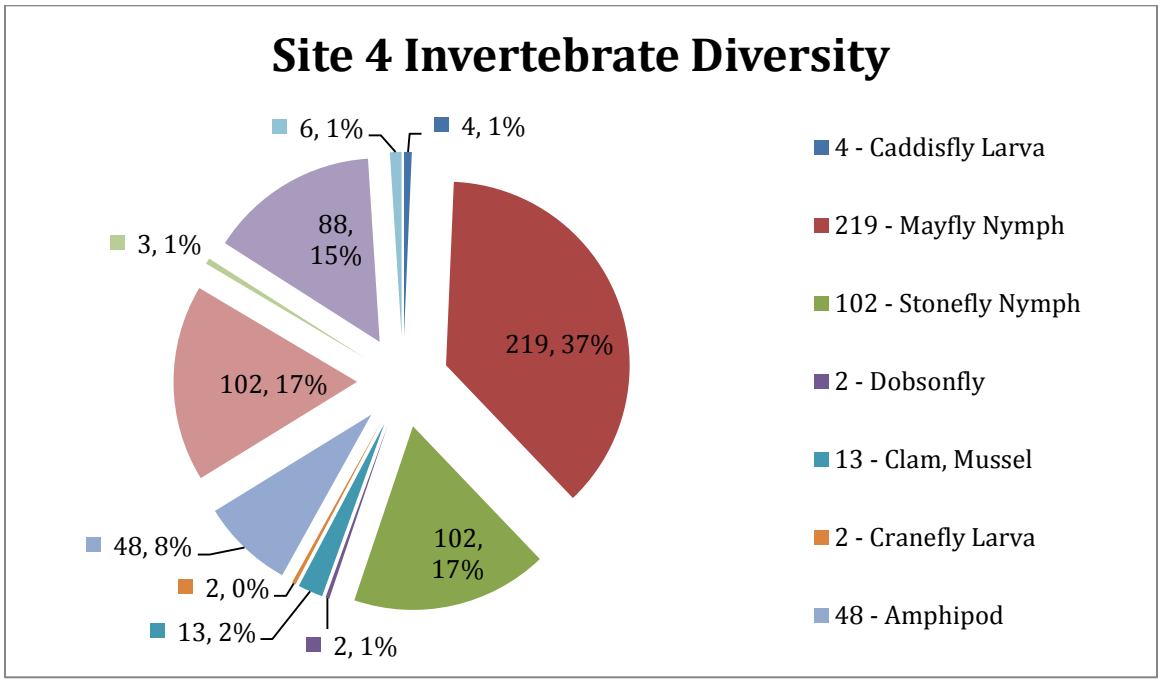



Figure 5. Invertebrate diversity at site four, showing break down of taxa and dominant taxa being mayfly nymph.

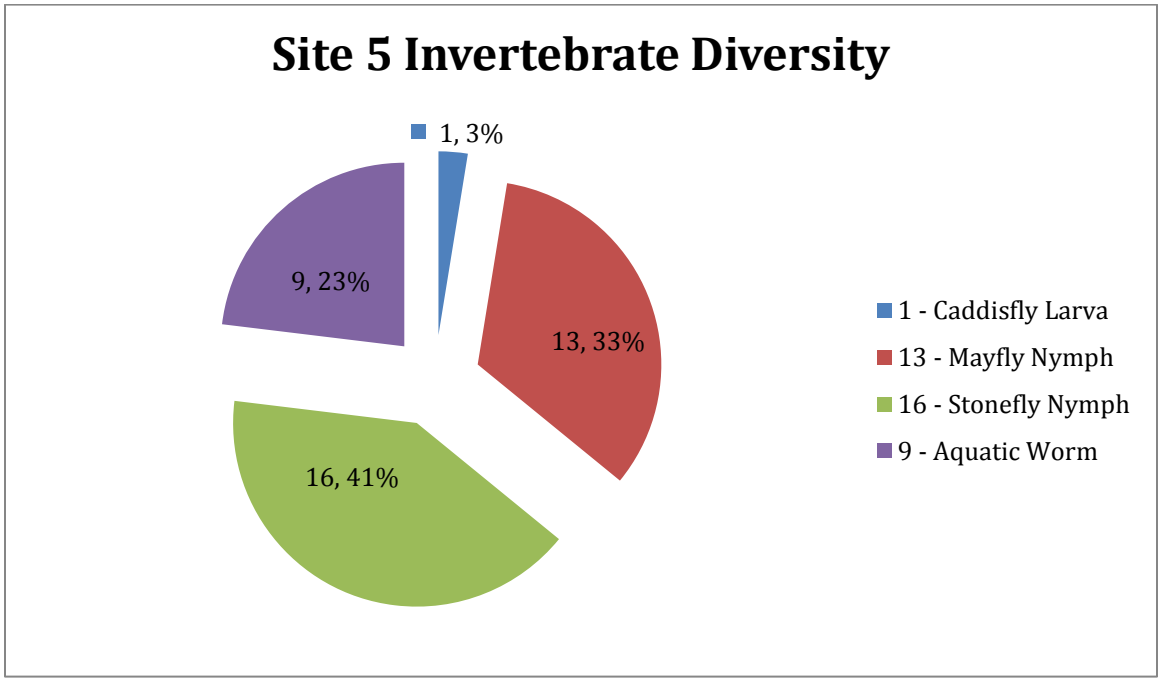



Figure 6. Invertebrate diversity at site five, showing break down of taxa and dominant taxa being stonefly nymph.

### 4.4.2 Taxon Richness and Diversity

Despite finding the highest number of pollution Intolerant insects, site 3 was only assessed as moderate with a predominant taxon ratio index of 0.70. The taxon richness and diversity for site 4 was assessed as good with a predominant taxon ratio of 0.37(Table 7 and Appendix 3). As previously stated, predominant species within sites 3 and 4 was the Mayfly Nymph, a pollution intolerant species (Table 7 and Appendix 3). Site 5 was assessed as acceptable with a predominant taxon ratio of 0.41. Site 5 differed slightly from sites 3 and 4 by the predominant species found being the Stonefly Nymph (Table 7 and Appendix 3). Although a different species, the Stonefly Nymph is also a pollution intolerant species.

### 4.4.3 Quality Assurance / Quality Control

To ensure quality assurance, 3 replicates were chosen at each site. Replicate locations were carefully chosen to ensure sample cyclicity within sites. Samples were collected within the presence of all team members to ensure proper sampling processes were followed. All samples were collected within a rinsed, collection container and filled with ethanol solution. Temperatures were kept via coolers and ice packs during transportation until samples were stored in a refrigerator. Utilization of dissecting microscopes and freshwater macroinvertebrate identification keys ensured correct numbers and species identification.

# 5.0 Conclusions and Recommendations

Having analyzed the parameters to distinguish the overall water quality during the months of October and November 2012, we can conclude that the C.W. Young channel is considered to have a rating between acceptable and good. Results for water samples were within the BC Water Quality Guidelines to sustain freshwater aquatic life and drinking water with the exception of aluminum, which is known to be high in some Vancouver Island waterways (J. Morgan, 2012).Comparative results from previous studies completed on the C.W. Young Spawning Channel proved overall similar attributes (Johnson et al, 2010) (Boss et al, 2011).

Site Hydrology found nothing out of the ordinary. The C.W. Young Spawning Channel was engineered to be fed from the main waters of the Englishman River through a set of manually controlled flow valves situated at the head end of the channel (Site 1) to maintain regular discharge and flow. Results of our tests for flow and discharge found a minor increase in discharge complimented with downstream location. As anticipated, site 5 saw the highest discharge rate as the sample location was directly affected by the higher water levels of the main waters of the Englishman River. For future measurements of discharge, site 5 should be measured in an area that is not affected by the main waters of the Englishman River to maintain a reading that would correspond with the previous sites measured.

Microbiology counts were found to be drastically lower when compared to that of the previous studies performed on the channel. Previous Microbiology counts found the cultured colonies to range from 176-2370 CFU in 2011 (Boss et al, 2011) and 240-280 CFU in 2010 (Johnson et al, 2010) while our counts ranged only from 11-15 CFU. To

have such decreased numbers, sampling error may to be of cause. The other theory taken into account is the time lapse between the culture time and counting. Given the time frame allotted by the members of the group, 72 hours passed, while previous tests allowed only 20 hours passing. It is recommended for future microbiology test to be conducted on the C.W. Young Spawning Channel to follow the timeline strictly and remain uniform with previous tests.

Water Quality results show C.W. Young Spawning Channel was within all parameters with the only exception being the VIU Laboratory analysis of phosphorus. Phosphorus results were found to be higher with all tests completed in the VIU Laboratory from 2012 and 2011. The only trend found is the higher number as results that range from 30-150µg/L in 2011 and 20-150µg/L in 2012. ALS results were significantly lower with a range from 2.1-19.7µg/L (Table 5). The difference in results may possibly be due to the VIU Hach Phosphorus analyzing machine being not as precise as the methods and equipment utilized by ALS Laboratories.

Habitat creation and layout of the C.W. Young Spawning Channel are ideal conditions for the invertebrate community. Results show astounding numbers of pollution intolerant invertebrates thriving within the waters. Compared to the previous invertebrate test on the C.W. Young Spawning Channel, numbers have risen in sites tested. Site 5 saw lower numbers due to the higher water flow where access to the streambed was restricted. The height of the main waters of the Englishman River disallowed a benthic invertebrate test to be committed in the areas of lower summer water level. It was noted the substrate was cleaner looking and devoid of algal growth during

sampling. For future tests on benthic invertebrates, it should be noted the water level within the main river.

Based on the results shown, the C.W. Young Side Channel is a healthy system that is able to support life. The growth occurring within and around the stream is evident of this. Or main recommendation would be the continued monitoring from groups like that of Vancouver Island Universities Natural Resource Protection and Resource Management Officers Technologies, so any potential harmful attributes that may occur will be recognized and identified in the preliminary stages prior to any detrimental effects take place. Other recommendations would include the installation of signs to recognize the sensitive ecosystem around the C.W. Young Side Channel to aid in the deterrence of off-road vehicles such as dirt-bikes and ATV's that seem to regular the park.

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# 7.0 Appendix

**Appendix 1:** Photographs showing site conditions at each sampling station on the C.W. Young Channel

**Photo 1:** Looking up stream at Site one, taken Oct 21, 2012. This site was one site that ALS samples were taken.

**Photo 2:** Looking upstream at Site 2 taken on Oct 21, 2012, this site 20 meters downstream from a culvert and road crossing.

**Appendix 1:** continued

**Photo 3:** Looking downstream at site 3, taken Oct 21, 2012. This site was one of the sites ALS and stream Invertebrates where taken.

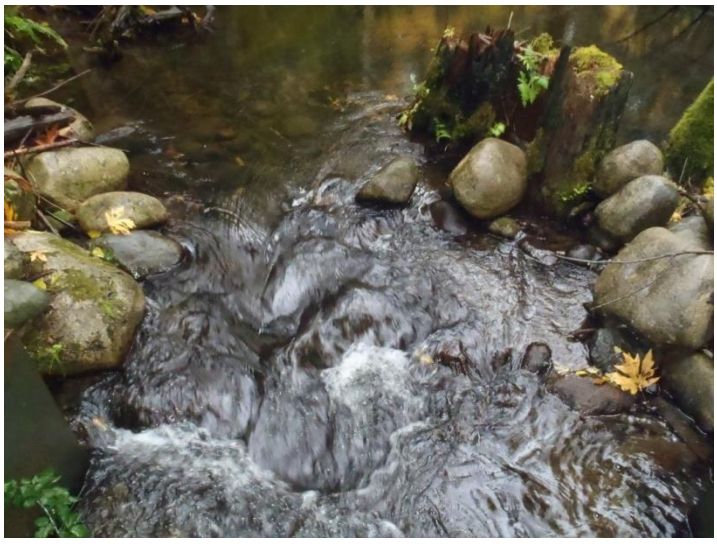

**Photo 4:** Looking at Sample Site 4 from standing on the walkway above. Taken on Oct 21, 2012, this is one of the sites that Invertebrates where taken.

**Appendix 1:** continued

**Photo 5**: Looking down stream at site 5, where the side channel flows back into the Englishman River. ALS and Invertebrate samples were taken at this site. Taken on Oct 21, 2012

**Appendix 2.**

| Sample I.D. | Units | Detection Limit | St. 1. | St.3 | St.5 | St. 1 | St.3 | St.5 | B.C.(W.Q.G) | Within Guideline |
|---|---|---|---|---|---|---|---|---|---|---|
| Date Sampled | | | Oct.28, 12 | Oct.28, 12 | Oct.28, 12 | Nov.20, 12 | Nov.20, 12 | Nov.20, 12 | --- | --- |
| Time Sampled | | | 00:00 | 00:00 | 00:00 | 09:20 | 10:00 | 10:50 | --- | --- |
| ALS Sample I.D | | | L1233439-13 | L1233439-14 | L1233439-15 | L1241956-4 | L1241956-5 | L1241956-6 | --- | --- |
| -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Physical.H2O Tests | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Conductivity | uS/cm | 2.0 | 57.0 | 71.0 | 59.7 | 37.9 | 40.5 | 34.8 | BC Streams= <100uS/cm | OK. |
| Hardness | mg/L | 0.50 | 22.6 | 25.9 | 23.5 | 15.6 | 16.5 | 14.7 | Coastal BC= <6mmg/L | OK. |
| PH | pH | 0.10 | 7.52 | 7.54 | 7.54 | 7.41 | 7.39 | 7.34 | Coastal streams= 5.5-9.0 | OK. |
| Anions + Nutrients | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ammonia | mg/L | 0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | 0.0247 | <0.0050 | 5 mg/L @ $9^0$C | OK. |
| Nitrate | mg/L | 0.0050 | 0.0119 | 0.0092 | 0.0065 | 0.0525 | 0.0485 | 0.0353 | Max=200 mg/L Avg.= 40 mg/L | OK. |
| Nitrite | mg/L | 0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 | Max=0.06 mg/L Avg =0.02 mg/L | OK. |
| Orthophosphate | mg/L | 0.0010 | <0.0010 | <0.0010 | <0.0010 | 0.0018 | 0.0040 | 0.0010 | | |
| Total Phosphorus | mg/L | 0.0020 | 0.0032 | 0.0057 | 0.0048 | 0.0084 | 0.0150 | 0.0075 | 5-15 µg/L <10µg/L=Oligotrphic | OK. |

**Appendix 2.**

| Sample I.D. | Units | Detection Limit | St. 1. | St.3 | St.5 | St. 1 | St.3 | St.5 | B.C.(W.Q.G) mg/L | Within Guideline |
|---|---|---|---|---|---|---|---|---|---|---|
| Date Sampled | | | Oct.28, 12 | Oct.28, 12 | Oct.28, 12 | Nov.20, 12 | Nov.20, 12 | Nov.20, 12 | --- | --- |
| Time Sampled | | | 00:00 | 00:00 | 00:00 | 09:20 | 10:00 | 10:50 | --- | --- |
| ALS Sample I.D | | | L1233439-13 | L1233439-14 | L1233439-15 | L1241956-4 | L1241956-5 | L1241956-6 | --- | --- |
| -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Total Metals | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Aluminum | mg/L | 0.20 | <0.20 | <0.20 | <0.20 | 0.20 | 0.25 | 0.29 | 0.10 | |
| Antimony | mg/L | 0.20 | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 | 0.02 | |
| Arsenic | mg/L | 0.20 | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 | 0.005 | |
| Barium | mg/L | 0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 5 | |
| Beryllium | mg/L | 0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | 0.0053 | |
| Bismuth | mg/L | 0.20 | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 | | |
| Boron | mg/L | 0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | 1.2 | |
| Cadmium | mg/L | 0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 0.00001 | |
| Calcium | mg/L | 0.050 | 7.80 | 8.75 | 7.9 | 5.10 | 5.37 | 4.71 | | |
| Chromium | mg/L | 0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 0.001 | |
| Cobalt | mg/L | 0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 0.11 | |
| Copper | mg/L | 0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 0.004 | |
| Iron | mg/L | 0.030 | 0.045 | 0.144 | 0.126 | 0.171 | 0.284 | 0.269 | 1 | |
| Lead | mg/L | 0.050 | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 | 0.008 | |
| Lithium | mg/L | 0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 0.87 | |

**Appendix 2.**

| Sample I.D. | Units | Detection Limit | St. 1. | St.3 | St.5 | St. 1 | St.3 | St.5 | B.C.(W.Q.G) mg/L | Within Guideline |
|---|---|---|---|---|---|---|---|---|---|---|
| Date Sampled | | | Oct.28, 12 | Oct.28, 12 | Oct.28, 12 | Nov.20, 12 | Nov.20, 12 | Nov.20, 12 | --- | --- |
| Time Sampled | | | 00:00 | 00:00 | 00:00 | 09:20 | 10:00 | 10:50 | --- | --- |
| ALS Sample I.D | | | L1233439-13 | L1233439-14 | L1233439-15 | L1241956-4 | L1241956-5 | L1241956-6 | --- | --- |
| -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Total Metals | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Magnesium | mg/L | 0.10 | 0.76 | 1.00 | 0.90 | 0.70 | 0.75 | 0.72 | | |
| Manganese | mg/L | 0.0050 | <0.0050 | 0.0062 | <0.0050 | <0.0050 | 0.0086 | 0.0056 | 0.73 | |
| Molybdenum | mg/L | 0.030 | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 | 2 | |
| Nickel | mg/L | 0.050 | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 | 0.025 | |
| Phosphorus | mg/L | 0.30 | <0.30 | <0.30 | <0.30 | <0.30 | <0.30 | <0.30 | | |
| Potassium | mg/L | 2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | 373 | |
| Selenium | mg/L | 0.20 | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 | | |
| Silicon | mg/L | 0.050 | 1.98 | 2.27 | 2.26 | 2.59 | 2.59 | 2.70 | | |
| Silver | mg/L | 0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 0.001 | |
| Sodium | mg/L | 2.0 | 3.2 | 4.7 | 3.6 | <2.0 | <2.0 | <2.0 | | |
| Strontium | mg/L | 0.0050 | 0.0328 | 0.0391 | 0.0374 | 0.0193 | 0.0207 | 0.0197 | | |
| Thallium | mg/L | 0.20 | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 | 0.003 | |
| Tin | mg/L | 0.030 | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 | | |
| Titanium | mg/L | 0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 0.011 | 0.015 | 2 | |
| Vanadium | mg/L | 0.030 | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 | 0.006 | |
| Zinc | mg/L | 0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | 0.033 | |

**Appendix 3:** Invertebrate Survey Field Data Sheet completed for triplicate stream invertebrate samples conducted at Sites 3, 4 and 5 on the C.W. Young Spawning Channel during October 28, 2012.

## **INVERTEBRATE SURVEY FIELD DATA SHEET**(Page 1 of 2)

| | | | |
|---|---|---|---|
| Stream Name: | CW Youg Side Channel | Date: | October 28, 2012 |
| Station Name: | Site Number 3 | Flow status: | Normal (regulated) |
| Sampler Used: Hess | Number of replicates 3 | Total area sampled (Hess, Surber = 0.09 $m^2$) x no. replicates | 0.09x3= 0.27$m^2$ |

| Column A Pollution Tolerance | Column B Common Name | Column C Number Counted | Column D Number of Taxa |
|---|---|---|---|
| **Category 1** | Caddisfly Larva (EPT) | EPT1 8 | EPT4 2 |
| | Mayfly Nymph (EPT) | EPT2 523 | EPT5 5 |
| | Stonefly Nymph (EPT) | EPT3 145 | EPT6 4 |
| **Pollution Intolerant** | Dobsonfly (hellgrammite) | 1 | 1 |
| | Gilled Snail | | |
| | Riffle Beetle | | |
| | Water Penny | | |
| **Sub-Total** | | C1 677 | D1 12 |
| **Category 2** | Alderfly Larva | | |
| | Aquatic Beetle | | |
| | Aquatic Sowbug | | |
| | Clam, Mussel | | |
| | Cranefly Larva | 11 | 3 |
| **Somewhat Pollution Tolerant** | Crayfish | | |
| | Damselfly Larva | 3 | 1 |
| | Dragonfly Larva | | |
| | Fishfly Larva | | |
| | Amphipod (freshwater shrimp) | | |
| | Watersnipe Larva | 1 | 1 |
| **Sub-Total** | | C2 15 | D2 5 |
| **Category 3** | Aquatic Worm (oligochaete) | 2 | 1 |
| | Blackfly Larva | | |
| | Leech | | |
| **Pollution Tolerant** | Midge Larva (chironomid) | 43 | 3 |
| | Planarian (flatworm) | | |
| | Pouch and Pond Snails | 7 | 1 |
| | True Bug Adult | | |
| | Water Mite | | |
| **Sub-Total** | | C3 52 | D3 5 |
| **TOTAL** | | CT 744 | DT 22 |

**Appendix 3: continued**

# INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

## SECTION 1 - ABUNDANCE AND DENSITY

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

| S1 |
|---|
| 744 |

**DENSITY:** Invertebrate density per total area sampled:

S1 **744**

÷ 0.27m$^2$ = 2755/ m$^2$

| S2 |
|---|
| 2755/ m$^2$ |

**PREDOMINANT TAXON:**

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

| S3 |
|---|
| Mayfly Nymph<br>523 |

## 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 12 + 2 x 5 + 5 =

| S4 |
|---|
| 51 |

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

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

EPT4 + EPT5 + EPT6

2 + 5 + 4 =

| S5 |
|---|
| 11 |

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

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

(EPT1 + EPT2 + EPT3) / CT

(8 + 523 +145) / 744=

| S6 |
|---|
| 0.91 |

## SECTION 3 - DIVERSITY

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

| S7 |
|---|
| 22 |

**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

523 / 744 =

| S8 |
|---|
| 0.7 |

## 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 |

| Assessment | Rating |
|---|---|
| Pollution Tolerance Index | R1 4 |

| Average Rating |
|---|
| Average of R4, R5, R6, R8 |

| | |
|---|---|
| Acceptable | 3 |
| Marginal | 2 |
| Poor | 1 |

| | |
|---|---|
| EPT Index | R2 4 |
| EPT To Total Ratio | R3 4 |
| Predominant Taxon Ratio | R4 2 |

| |
|---|
| 3.5 |

**Appendix 3: continued**

## **INVERTEBRATE SURVEY FIELD DATA SHEET** (Page 1 of 2)

| | | | |
|---|---|---|---|
| Stream Name: | C.W. Young Channel | Date: | October 28, 2012 |
| Station Name: | Site #4 | Flow status: | Normal |
| Sampler Used: Hess | Number of replicates 3 | Total area sampled (Hess, Surber = 0.09 $m^2$) x no. replicates | 0.27 $m^2$ |

| Column A Pollution Tolerance | Column B Common Name | Column C Number Counted | Column D Number of Taxa |
|---|---|---|---|
| **Category 1** | Caddisfly Larva (EPT) | EPT1 4 | EPT4 2 |
| | Mayfly Nymph (EPT) | EPT2 219 | EPT5 4 |
| | Stonefly Nymph (EPT) | EPT3 102 | EPT6 3 |
| **Pollution Intolerant** | Dobsonfly (hellgrammite) | 2 | 1 |
| | Gilled Snail | | |
| | Riffle Beetle | | |
| | Water Penny | | |
| **Sub-Total** | | C1 327 | D1 10 |
| **Category 2** | Alderfly Larva | | |
| | Aquatic Beetle | | |
| | Aquatic Sowbug | | |
| **Somewhat Pollution Tolerant** | Clam, Mussel | 13 | 1 |
| | Cranefly Larva | 2 | 1 |
| | Crayfish | | |
| | Damselfly Larva | | |
| | Dragonfly Larva | | |
| | Fishfly Larva | | |
| | Amphipod (freshwater shrimp) | 48 | 1 |
| | Watersnipe Larva | | |
| **Sub-Total** | | C2 63 | D2 3 |
| **Category 3** | Aquatic Worm (oligochaete) | 102 | 3 |
| | Blackfly Larva | 3 | 1 |
| **Pollution Tolerant** | Leech | | |
| | Midge Larva (chironomid) | 88 | 1 |
| | Planarian (flatworm) | | |

| | | | |
|---|---|---|---|
| | Pouch and Pond Snails | 6 | 1 |
| | True Bug Adult | | |
| | Water Mite | | |
| **Sub-Total** | | C3 199 | D3 6 |
| **TOTAL** | | CT 589 | DT 19 |

**INVERTEBRATE SURVEY INTERPRETATION SHEET** (Page 2 of 2)

**Appendix 3: continued**

## SECTION 1 - ABUNDANCE AND DENSITY

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

S1: 589

**DENSITY:** Invertebrate density per total area sampled:

S1 589 ÷ 0.27 'm² = S2: 2181.48 / m²

**PREDOMINANT TAXON:**
Invertebrate group with the highest number counted (Col. C)

S3: Mayfly Nymph

## 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 __10___ + 2 x __3___ + ___6__ = S4: 42

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

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

EPT4 + EPT5 + EPT6

__2___ + __4___ + __3___ = S5: 9

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

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

(EPT1 + EPT2 + EPT3) / CT

(__4___ + ___219__ + __102___) / __589___= S6: 0.55

## SECTION 3 - DIVERSITY

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

S7: 19

**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

__219___ / __589___ = S8: 0.37

## 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 4 |
| EPT To Total Ratio | R3 3 |
| Predominant Taxon Ratio | R4 4 |

| Average Rating |
|---|
| Average of R4, R5, R6, R8: 3.75 |

**Appendix 3: continued**

# INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

| | | | |
|---|---|---|---|
| Stream Name: | CW Young Side Channel | Date: | November 7th 2012 |
| Station Name: | Site Number 5 | Flow status: | Mid/Hight |
| Sampler Used: Hess | Number of replicates 3 | Total area sampled (Hess, Surber = 0.09 $m^2$) x no. replicates 0.27 | $m^2$ |

| Column A Pollution Tolerance | Column B Common Name | Column C Number Counted | Column D Number of Taxa |
|---|---|---|---|
| **Category 1** | Caddisfly Larva (EPT) | EPT1 1 | EPT4 1 |
| | Mayfly Nymph (EPT) | EPT2 13 | EPT5 3 |
| | Stonefly Nymph (EPT) | EPT3 16 | EPT6 2 |
| | Dobsonfly (hellgrammite) | | |
| **Pollution Intolerant** | Gilled Snail | | |
| | Riffle Beetle | | |
| | Water Penny | | |
| **Sub-Total** | | C1 30 | D1 6 |
| **Category 2** | Alderfly Larva | | |
| | Aquatic Beetle | | |
| | Aquatic Sowbug | | |
| | Clam, Mussel | | |
| | Cranefly Larva | | |
| | Crayfish | | |
| **Somewhat Pollution Tolerant** | Damselfly Larva | | |
| | Dragonfly Larva | | |
| | Fishfly Larva | | |
| | Amphipod (freshwater shrimp) | | |
| | Watersnipe Larva | | |
| **Sub-Total** | | C2 0 | D2 0 |
| **Category 3** | Aquatic Worm (oligochaete) | 9 | 1 |
| | Blackfly Larva | | |
| | Leech | | |
| | Midge Larva (chironomid) | | |
| | Planarian (flatworm) | | |
| **Pollution Tolerant** | Pouch and Pond Snails | | |
| | True Bug Adult | | |
| | Water Mite | | |
| **Sub-Total** | | C3 9 | D3 1 |
| **TOTAL** | | CT 39 | DT 7 |

**Appendix 3: continued**

# INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

## SECTION 1 - ABUNDANCE AND DENSITY

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

| S1 |
|---|
| 39 |

**DENSITY:** Invertebrate density per total area sampled:

S1 39

÷ 0.27m$^2$ =

| S2 |
|---|
| 144.4/ m$^2$ |

**PREDOMINANT TAXON:**
Invertebrate group with the highest number counted (Col. C)

| S3 |
|---|
| Stonefly Nymph 16 |

## 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 6 + 2 x 0 + 1 =

| S4 |
|---|
| 19 |

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

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

EPT4 + EPT5 + EPT6
1 + 3 + 2 =

| S5 |
|---|
| 6 |

**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
(1 + 3 + 2) / 39=

| S6 |
|---|
| 0.15 |

## SECTION 3 - DIVERSITY

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

| S7 |
|---|
| 7 |

**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
16 / 39 =

| S8 |
|---|
| 0.41 |

## 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 |

| Assessment | Rating |
|---|---|
| Pollution Tolerance Index | R1 3 |
| EPT Index | R2 3 |

| Average Rating |
|---|
| Average of R4, R5, R6, R8 |

| | |
|---|---|
| Marginal | 2 |
| Poor | 1 |

| | |
|---|---|
| EPT To Total Ratio | R3 1 |
| Predominant Taxon Ratio | R4 3 |

| |
|---|
| 2.5 |