COTTLE CREEK, NANAIMO, BC
ENVIRONMENTAL MONITORING PROJECT

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EXECUTIVE SUMMARY

An environmental monitoring project of the Cottle Creek system took place during the fall of 2012. The objectives of this project were to establish a starting point of data on environmental conditions, as well as assessing the overall health of the water system. Four stations were chosen to be monitored, adhering to the Departure Bay Streamkeepers monitoring project. At these four stations, data was collected in the form of water quality measurements, hydrology, microbiology and aquatic invertebrates. Sampling took place twice over the course of the project, once at a low flow rate, October 31, 2012, and again at a high flow rate, November 21, 2012. During the low flow rate, water quality, hydrology, micro-biology and stream invertebrates were all sampled. On the high flow rate, only water quality and hydrology was tested.

From hydrological data collected during both sampling events, it was found that the second sampling event had a lesser discharge rate compared to the first. This was due to a high rainfall event occurring the day before sampling event one, October 31, 2012.

The data collected was tested by RMOT students on the VIU campus, as well as a professional company ALS Laboratories. Water quality, micro-biology and invertebrate analysis was done at the VIU laboratory. General parameters, nutrients and metal content was analyzed by ALS to be compared with VIU data. All samples tested followed quality assurance and quality control measures outlined in the Ambient Freshwater and Effluent Sampling Guidelines (Ministry of Environment, Lands and Parks 1997).

Overall, most site conditions on Cottle Creek met the aquatic life guidelines from the Guidelines for Interpreting Water Quality Data (Ministry of Environment, Lands and Parks 1998). Some parameters were noted above guidelines, including aluminum, copper and iron. Aluminum was

noted above the guidelines of <0.1mg/L at all stations on both sampling events (Ranged from 0.21-0.80mg/L), copper was noted above guidelines of <0.006mg/L at all stations during the second sampling event (0.013 – 0.018mg), and iron was noted above guidelines of <1.0mg/L at two stations during the first sampling event (1.90mg/L and 1.91mg/L). Extremely high fecal coliform counts were found at the sample site of Upper Cottle in comparison to the other sample sites.

Aquatic invertebrate data varied between sites, representing variable habitat quality along the Cottle system. It was found that Lower Cottle 2 had the highest EPT to Total Ratio Index of 0.4 while Lower Cottle 1 had the lowest of 0.07. The overall Site Assessment Rating for the three invertebrate sample sites ranged from 2.75 – 3.25.

This report is the first year that studies have been done on Cottle Creek by RMOT students. It is recommended that consecutive studies are done to collect a larger database of information to monitor the short and long term changes to the system.

ACKNOWLEDGEMENTS

The following are acknowledgements to those that have assisted us in the production of this environmental monitoring project. First we would like to thank Dr. John Morgan for his assistance throughout the course of the project. This support included providing materials for sampling in the field, equipment for laboratory analysis, and recommendations when compiling the final report. Secondly, we would like to thank Sarah Greenway for her assistance in the lab set-up and lab analysis. We would also like to thank the Departure Streamkeepers for inspiring the project and providing the locations of sample stations.

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1.0 INTRODUCTION

1.1. Project Overview

This is an interpretive report for the environmental monitoring project on Cottle Creek, Nanaimo, BC, in reference to basic hydrology, water quality and aquatic invertebrate communities. The Cottle Creek system flows from west to east through the Linley Valley and discharges into the northwest corner of Departure Bay near the Pacific Biological Station (Appendix 1, Map 1) (City of Nanaimo 2005). Cottle Creek is a relatively small creek with varying gradients and minimal flow rates. The total Cottle Creek watershed area covers about 4.5 km^2 and encompasses three tributaries: 1) Upper Cottle Creek from the headwaters off Rutherford Road to Cottle Lake; 2) North Cottle Creek from Lost Lake to Cottle Lake; 3) Lower Cottle Creek from Cottle Lake to Departure Bay. For the purposes of this project, one sample station is located on North Cottle Creek in Linley Valley Park, one on Upper Cottle Creek, and two are located along Lower Cottle Creek (City of Nanaimo and NALT 1999). This project will be developed and undertaken by two students enrolled in the RMOT 306 - Environmental Monitoring course at Vancouver Island University taught by Dr. John Morgan. In continuance, students from this class will routinely monitor and assess the basic hydrology, water quality, and invertebrate populations in Cottle Creek to assess short and long term impacts. Data from this report will be used by local stewardship groups such as Nanaimo Area Land Trust (NALT) and the Departure Streamkeepers.

1.2. Historical Review

The Cottle Creek tributaries are within the moist maritime coastal Douglas-fir Biogeoclimatic Zone. Due to logging in the early to mid-1900s, second growth forests are the current dominant forest type in Linley Valley. Portions of the Cottle Creek system consist of rocky outcrops high in diversity that are associated with Arbutus and Garry Oak ecosystems on the east coast of Vancouver Island and include rare and endangered species (City of Nanaimo 2005). Although urbanization is occurring around the Cottle Creek system, a large portion of the water shed is protected by the Linley Valley (Cottle Lake) Park. Managed by the City of Nanaimo, the park encompasses Cottle Lake and a portion of the three Cottle Creek tributaries. Environmental management outside the park boundaries includes a city bylaw that protects a 15-metre wide riparian buffer zone on both sides of Cottle Creek. Interestingly, unlike nearby coastal streams, Cottle Creek does not support any sea-going salmonid species. Due to the steep drop into Departure Bay, Pacific salmon cannot migrate up the water system. Cottle Creek however, supports a natural cutthroat trout population. The Cottle Creek cutthroat trout thrive in this system due to the lack of competition for the deep lakes, pools, gravel beds and food (City of Nanaimo and NALT 1999).

1.3. Potential Environmental Concerns

The Cottle Creek water system consists of many different types of environmentally sensitive ecosystems such as riparian, wetland and mossy bluff (City of Nanaimo 2005). The most pressing environmental concern on Cottle Creek is urban development. Urban development around Cottle Creek increases every year and surrounds a large portion of Lower Cottle Creek. Surrounding slopes are being logged and cleared causing mass siltation in the water systems. Another developmental concern is the construction of culverts which disturb the natural migration patterns of fish in the system (City of Nanaimo and NALT 1999).

2.0 PROJECT OBJECTIVES

The objectives for this project were to collect sample data from four stations on the Cottle Creek water system to assess and monitor the general health of the stream. Our team collected data on basic hydrology, water quality, and invertebrate biodiversity and populations. The research done on Cottle Creek will be used by students in the RMOT 306 class in consecutive years to monitor long and short term environmental impacts and changes. This ongoing research will be of interest to local groups such as Nanaimo Area Land Trust (NALT) and the Departure Streamkeepers.

3.0 METHODS

3.1. Sampling Stations

Four sites were chosen on Cottle Creek based on ease of access for future monitoring and area representation. The four stations were also selected to be consistent with the Departure Streamkeepers, who also tested parameters on the system (Table 1). Stations were named from upstream to downstream, starting with North Cottle followed by Upper Cottle, Lower Cottle 1 and Lower Cottle 2 (Figure 1).

Table 1. Station names and locations according to the Departure Streamkeepers.

Station	Street	UTM (WGS 88, Zone 10U)
North Cottle	Burma Rd.	0428587mE, 5452624mN
Upper Cottle	Landalt Rd.	0427941mE, 5452180mN
Lower Cottle 1	Nottingham Drive	0430192mE, 5452022mN
Lower Cottle 2	Stevenson Point Rd.	0430579mE, 5451399mN

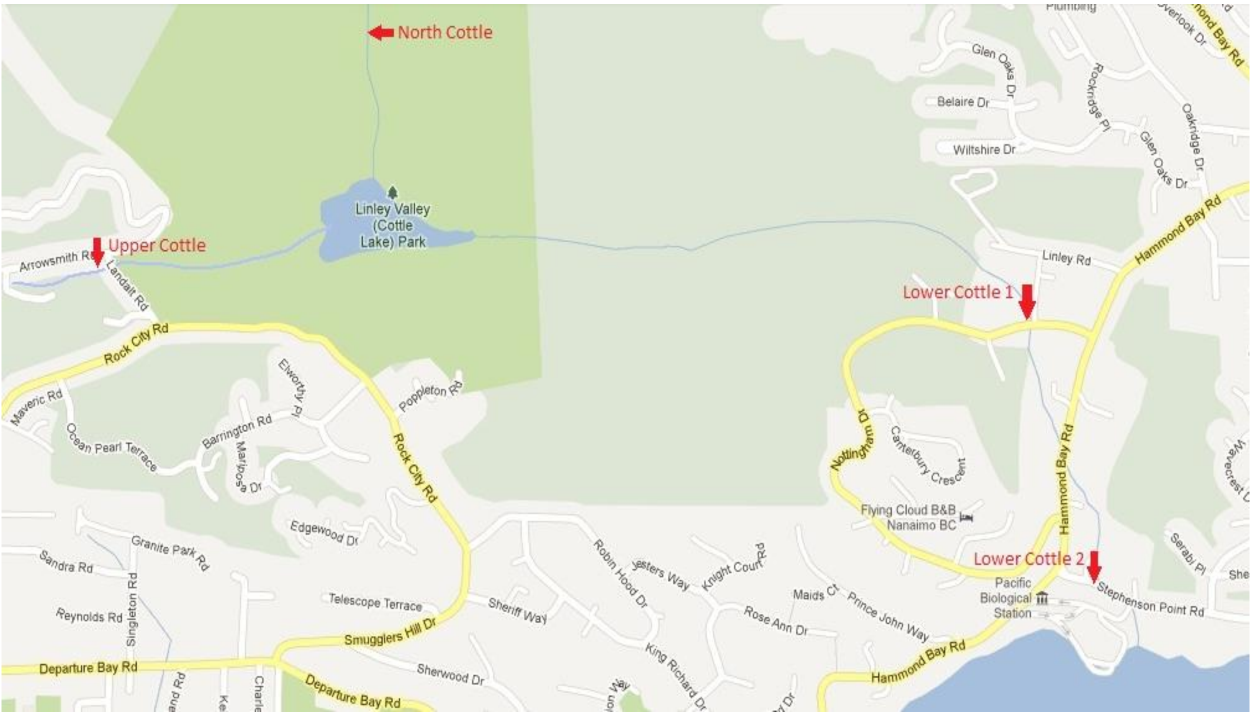

Figure 1. Cottle Creek system showing the stations at the 3 main tributaries. The green area surrounding Cottle Lake represents Linley Valley Park. Red arrows mark sample sites at the road crossings (Google Maps 2012).

3.1.1. North Cottle

North Cottle is located off of Burma Road, in Linley Valley (Cottle Lake) Park (Appendix 2, Figure 2). Linley Valley Park is a high use area for recreational activities such as jogging and dog walking. Access to the stream is directly off a main trail, and is easily accessible to all users, including dogs. The substrate is made up mainly of cobble and silt, and canopy is thick and mainly conifer. At the time of the site visit, no flow was present.

3.1.2. Upper Cottle

Upper Cottle is located on Landalt Road off of Rock City Road (Appendix 2, Figure 4). Access to the stream is easy although there is a slope from the road to the channel. Riparian area is thick with many middle-young maple, cedar and alder trees present. Ferns and other underbrush are also numerous in the site, with fewer invasive species present. Upper Cottle is located in a less developed residential area with less potential for human and/or dog activity. This area of the stream has a low velocity and the channel is wide and shallow. Substrate is mainly gravel and silt and bog plants such as skunk cabbage are present.

3.1.3. Lower Cottle 1

Lower Cottle 1 is located off of Nottingham Drive; approximately 150m from Hammond Bay Road, in the new housing development (Appendix 2, Figure 1). Accessibility to site one is very easy and safe. Due to the developing neighbourhood, there is a potential for recreational and other activities to take place in this area. The riparian zone is dominated by young even-aged alder trees (Appendix 1, Map 2). Some young- medium aged conifers are present in this area, with cedar saplings recently planted. The dominant substrate of station one is silt and flow is minimal.

3.1.4. Lower Cottle 2

Lower Cottle 2 is located off of Stevenson Point Road; approximately 150m from Hammond Bay Road, beside Lifestyles fitness facility, above the Pacific Biological Station (Appendix 2, Figure 3). Substrate is made up mainly of shale bedrock, cobble and silt. Canopy cover is good with middle aged cedar, maple and fir trees. Invasive plant species are also present such as English ivy and Daphne. Stream velocity is highest here due to steep gradient.

3.1.5. Sampling Frequency

Sample frequency occurred twice over the course of the project. The first sample was taken at a low flow rate on October 31, 2012, and the second sample was taken three weeks later at a high flow rate, November 21, 2012, for quality assurance. During the first sampling event, water quality, hydrology, micro-biology and stream invertebrate data was collected. On the second sampling event, water quality and hydrology measurements were taken. Table 2 shows the breakdown of sampling dates and activities (see Appendix 6 for copies of field notes).

Table 2. Dates and details of sight visits for each station.

Station	**Oct 27, 2012**	**Oct 31, 2012**	**Nov 5, 2012**	**Nov 21, 2012**
North Cottle	Preliminary site visit; Photos taken; Site description.	General hydrology; Water quality (VIU).	n/a	General Hydrology; Water Quality (VIU).
Upper Cottle	Preliminary site visit; Photos taken; Site description.	General hydrology; Water quality (VIU); Water quality (ALS).	Triplicate invertebrate sampling (Hess sampler).	General hydrology; Water quality (VIU); Water quality (ALS).
Lower Cottle 1	Preliminary site visit; Photos taken; Site description.	General hydrology; Water quality (VIU); Water quality (ALS).	Triplicate invertebrate sampling (Hess sampler).	General hydrology; Water quality (VIU); Water quality (ALS).
Lower Cottle 2	Preliminary site visit; Photos taken; Site description.	General hydrology; Water quality (VIU); Water quality (ALS).	Triplicate invertebrate sampling (Hess sampler).	General hydrology; Water quality (VIU); Water quality (ALS).

3.2. Basic Hydrology

Basic hydrology measurements were taken at all four sites during the low flow rate on October 31 and the high flow rate on November 21. Water velocity (m/s) was measured on a 5m section of the stream. Three measurements were taken along each 5m stretch, one at 25% channel width, one at 50% and one at 75%. The three measurements involved dropping a ping pong ball into the channel and recording the time it took the ball to travel the 5m distance. The times were recorded and used to obtain average stream velocity.

Wetted width was also measured at each station using a measuring tape, accurate to the nearest 0.01m. At the same location, wetted depths were taken using a meter stick, one at 25% channel width, one at 50% and one at 75%. This cross-sectional area data was then used to calculate the stream flow (m^3/sec).

3.3. Water Quality

3.3.1. Field Measurements

Some water quality parameters were measured in the field. Dissolved oxygen and temperature was measured in stream after collecting the samples using an electronic YSI probe. pH was measured with a pH meter and conductivity was measured with a conductivity meter.

3.3.2. VIU Laboratory Analyses

For each sampling station, two water samples were taken using pre-cleaned 500ml Nalgene bottles. The samples were tested on the following parameters: alkalinity, suspended solids (turbidity), hardness, nitrate, phosphate, and total number of coliforms and fecal coliforms (*E. coli*). Alkalinity was tested using the HACH AL-DT digital titration method. A HACH AL-DT DR2000 Spectrophotometer was used to calculate Turbidity. Total hardness was measured using a HACH HA-71A test kit. Finally, nitrate and phosphate were measured using a HACH DR2800 Spectrophotometer.

3.3.3. ALS Laboratory Analyses

Three additional samples were taken on October 31 and November 21, to be sent to a private analytical laboratory (ALS Laboratories). The ALS designated samples were tested on the same parameters as the originally collected samples. Also, the ALS samples were tested for dissolved metals and nutrients.

3.3.4. Quality Assurance / Quality Control

The samples collected at Cottle Creek adhered to the Guidelines for Designing and Implementing Water Quality Monitoring in BC (RISC 1997b) the samples were collected and tested using the Ambient Freshwater and Effluent Sampling Manual (RISC 1997a). The use of both of these BC government documents ensured quality of the sampling project. For example: gloves were worn at all times to ensure no contamination; sample jars were washed three times by the test water where applicable; fingers were kept away from the jars rim and lid; lids were only opened when sampling was occurring; samples were kept in a cool dry place; analysis of samples occurred within 4 days; and ALS samples were no older than 24 hours when sent away. Additionally, one trip blank and one replicate sample (per sampling event) were taken to assure no contamination occurred.

Quality assurance methods were put in place through the use of the professional company ALS. By comparing our test result with a second test result from ALS, we are able to ensure quality results. Additionally, ALS has its own routine quality assurance methods put in place. For example, when testing the samples ALS routinely uses certified reference materials, laboratory duplicates, laboratory control spikes, matrix spikes, secondary and project standards, inter-laboratory (proficiency) testing (ALS 2012).

3.3.5. Data Analyses, Comparison to Guidelines

Each sample was also compared to the Guidelines for Interpreting Water Quality Data (RISC 1998) to assess its health for aquatic life. For example, measurements such as dissolved oxygen, temperature and metal levels were all compared to these guidelines.

3.4. Microbiology

3.4.1. Microbiology Sample Collection

Microbiology collection and analysis also took place during the project. This took place once, during the low flow rate on October 31. Water samples were collected using a sterile 100ml whirlpak bag, and labeled and stored for data collection. Once collected, the whirlpak bags were transported to the lab within 24hrs for data analysis.

3.4.2. VIU Laboratory Analysis

Microbiology was tested in the lab to find the total coliforms and fecal coliforms present. This was done using a vacuum pump filtration system. A petri incubation dish was prepared for the sample, which was filtered through the vacuum pump. These samples were incubated for 24 hours in a temperature controlled climate. After 24 hours, the samples were counted, with non-fecal coliforms being stained red and fecal coliforms being stained blue.

3.4.3. Quality Assurance / Quality Control

Quality assurance methods were taken, including wearing gloves, flaming the forceps to kill any bacteria and washing equipment with deionized water between samples. A filtration blank was also prepared to assure no contamination was present from the pump or other means.

3.5. Stream Invertebrate Communities

3.5.1. Invertebrate Sample Collection

Invertebrates sampling took place once during the project, at the low flow rate, November 5, 2012. At the time of this sampling, three sites were sampled from with three replicates at each site, for a total of nine samples. The sites sampled included Upper Cottle, Lower Cottle 1 and

Lower Cottle 2. Each sample was taken using a Hess sampler. Once samples were collected, they were preserved using ethanol and taken to the lab within 24hrs for data collection.

3.5.2. VIU Laboratory Analyses

Once at the lab, analysis took place using the Pacific Streamkeepers Procedures (DFO 1995). This included sorting of family or order and different taxa using a dissecting scope.

3.5.3. Quality Assurance / Quality Control

Triplicate samples were taken during the sampling event do assure a larger representative area. Diverse habitat units were chosen to sample from if possible to gather a greater invertebrate representation. 70% ethanol was used to prevent the deterioration of the invertebrates before the lab analysis. The Pacific Streamkeepers Procedures (DFO 1995) were used during the analysis. Each sample was inspected and counted by each team member. All identifications were made while inspecting invertebrates under a dissecting scope.

3.5.4. Data Analyses

The benthic invertebrate data collected was used to identify the general quality of the stream and the capacity for invertebrate life. The quality was assessed by calculating the Pollution Tolerance Index, EPT index, EPT to Total Ratio Index, Predominant Taxon Ratio Index, Overall Site Assessment Rating and The Shannon-Weiner Diversity index.

4.0 RESULTS AND DISCUSSION

4.1. General Field Conditions

Due to a large volume of rainfall occurring one day prior to the first sampling event (October 31, 2012), the average discharge was less during the second sampling event (November 21, 2012) (Figure 2). Average flow of the four stations during the first sampling event was 0.71m^3/s and 0.45m^3/s during the second sampling event. Average temperature during the first water sampling event was 10.7°C (Table 3). The second sampling event occurred during a cooler average temperature of 4.9°C (Environment Canada 2012).

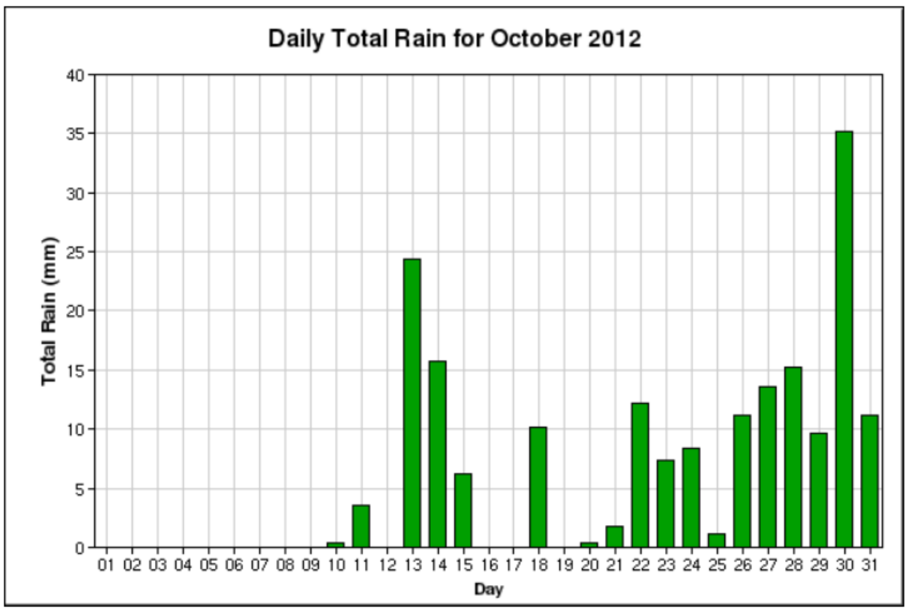

Figure 2. Daily total rainfall for October 2012 showing large spike occurring previous to and during the first sampling event (Environment Canada 2012).

Table 3. Average temperature and rainfall for site visits and sampling events (Environment Canada 2012).

	Oct 27	Oct 31	Nov 5	Nov 21
Temperature (°C)	8.2	10.7	9.4	4.9
Rainfall (mm)	13.6	11.2	0.6	4.8

Hydrological measurements taken on the sampling dates were used to calculate average velocity and flow for each sample station (Table 4) It was found that velocity was greater during the first sampling event in all stations except Lower Cottle 2. Discharge was greater in all stations during the first sampling event. As predicted, Lower Cottle 2 had the highest velocity on both dates due to the steep gradient heading towards Departure Bay. Lower Cottle 1, located in a recently developed area, had the greatest discharge for both sampling dates. This result may be due to flashiness around the site caused by the lack of a healthy riparian area.

Table 4. Velocity and flow at each station during both sampling dates.

Station	Velocity (m/sec)		Flow (m^3/sec)	
	Nov-21	Oct-31	Nov -21	Oct-31
North Cottle	0.79	0.36	0.09	0.06
Upper Cottle	0.71	0.39	0.61	0.23
Lower Cottle 1	0.47	0.30	1.41	0.88
Lower Cottle 2	0.81	0.97	0.72	0.61

4.2. Water Quality

4.2.1. Field Measurements

Average water temperature during the first sampling event, October 31, 2012, was 10.3°C and 7.4°C during the second sampling event occurring on November 21, 2012 (Appendix 3, Tables 1 & 2). Water temperature correlates with the air temperature in Nanaimo on both dates, cooling during the later sampling date (Environment Canada 2012).

Represented in Figure 3, dissolved oxygen increased on average from 11.4 mg/L to 12.6 mg/L between sampling events. Increased dissolved oxygen during the second event is comparative to the decrease in temperature. Dissolved oxygen was within the guidelines for freshwater fish and invertebrates (RISC 1998).

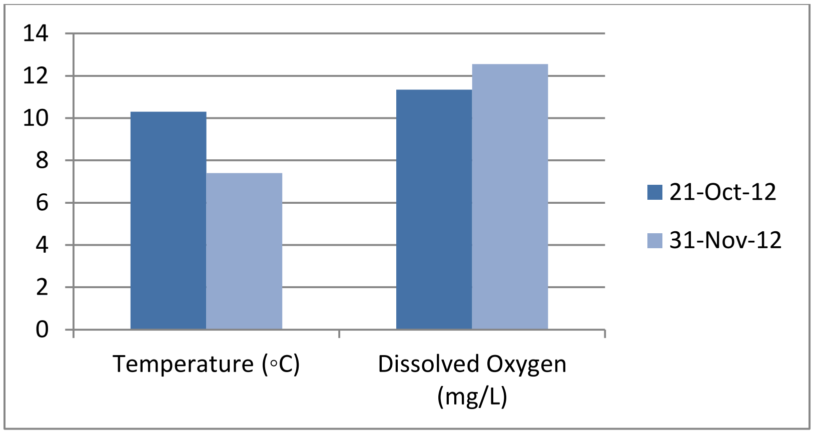

Figure 3. Average water temperature decreasing and dissolved oxygen increasing between sample dates October 31 and November 21, 2012.

Conductivity ranged from 78-122µS/cm between both sampling events which is typical of a BC coastal stream (RISC 1998). A slight increase of conductivity was present on average during the second sampling event though the cause is unknown. During both sampling events, North Cottle received low conductivity comparative to the other stations.

The guideline for pH for freshwater aquatic life is 6.5-9.0. pH measured in Cottle Creek ranged from 7.6-8.0, fitting well within the guideline. On average, pH was measured to be slightly more basic during the second sampling event.

4.2.2. VIU Laboratory Analyses

Total suspended solids ranged from 1.48-10.60 NTU (Appendix 3, Tables 3 & 4). TSS decreased at most sampling stations between the first and second sampling events. The average TSS during the first sampling event was 8.6 NTU and 5.1 NTU during the second sampling event. Considering the first sampling took place during a large rainfall event, these results were anticipated. Certain sampling stations exhibited considerable variation. During the second sampling event, North Cottle had a TSS low of 1.48 NTU (Figure 4). In contrast, Lower Cottle 1 had a TSS high of 10.60 NTU during the first sampling event. The extreme TSS level of Lower Cottle 1 could possibly be explained by the current urban development occurring in proximity of the sample station causing siltation during high rainfall events.

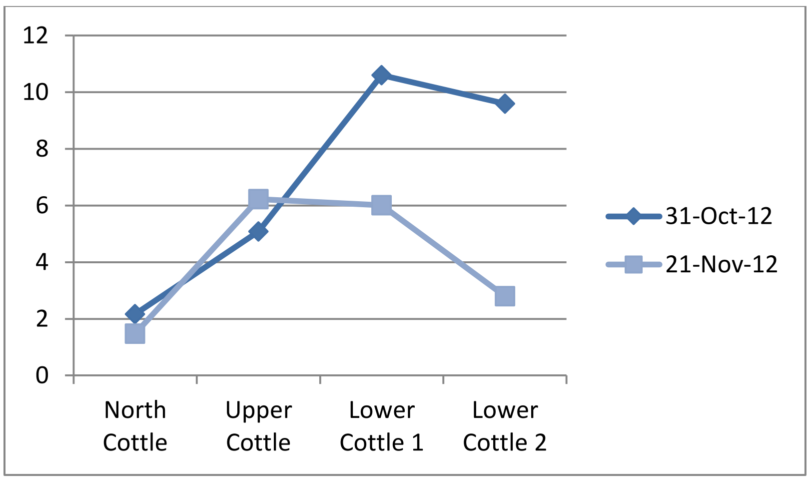

Figure 4. Turbidity (NTU) at each station during both sampling events.

Total alkalinity ($CaCO_3$) ranges from 16-42mg/L between both sampling events. Alkalinity between 10-20mg/L is considered moderate sensitivity and >20mg/L as low sensitivity. North Cottle during the second sampling event had an alkalinity of 16mg/L and therefore is of moderate sensitivity. All other samples taken at both events had an alkalinity of >20mg/L and fell into the low sensitivity category (RISC 1998).

During the VIU lab analysis it was found that all samples consisted of hard water. Total hardness ranged from 30-70mg/L during both sampling events and no pattern was obvious between stations and dates.

Reactive Phosphorus ranged from 0.04-0.15mg/L between both sampling dates. The BC Guidelines state that freshwater lakes with phosphorus >0.025mg/L are eutrophic. Anthropogenic sources of phosphorus are probable in the Cottle Creek system.

Nitrate in the Cottle Creek system ranged from 0.35-1.91mg/L. Surface water unaffected by anthropogenic sources should be less than 0.3mg/L. Nitrate guidelines for aquatic life is <200mg/L. Cottle Creek is well within the nitrate guideline for aquatic life, however, all samples are greater than 0.3mg/L so it is probable that some anthropogenic sources are present. Figure 5 shows high nitrate levels for the North Cottle samples in comparison to the other stations (RISC 1998).

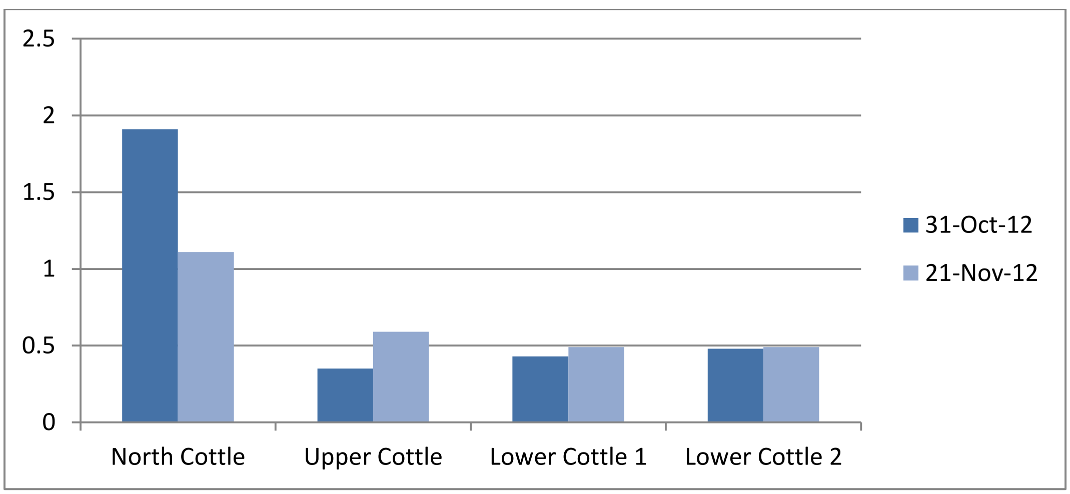

Figure 5. Nitrate (mg/L) content during both sampling events showing an increase at North Cottle.

4.2.3. ALS Laboratory Analyses

The ALS results for metals were compared with the Guidelines for Interpreting Water Quality Data in BC for aquatic life (RISC 1998) (see Appendix 4). All stations on both sampling dates exceeded the guidelines for aluminum (Table 5). Aluminum in Cottle Creek ranged from 0.21 - 0.80mg/L which is universally greater than the guideline of 0.1mg/L. Calcium in Cottle Creek ranged from 10.8 - 14.0mg/L. The Water Quality Guidelines state that calcium >8.0mg/L indicates "low acid sensitivity" in fresh water; therefore Cottle Creek has low acid sensitivity. During the second sampling event, all stations were above the guideline for copper of 0.006mg/L for the specific water hardness. During the first sampling event, all stations exhibited copper levels of <0.010mg/L while the second sampling event had levels ranging from 0.013 – 0.018mg/L, all above the copper guideline for aquatic life. Two stations during the first sampling event were above the aquatic life guideline for iron of 1.0mg/L. Lower Cottle 1 had an iron level of 1.91mg/L and Lower Cottle 2 had 1.90mg/L, both exceeding the guideline. All other metal content was below minimum detection limit or within the guidelines for aquatic life (RISC 1998).

Table 5. ALS results for metals that exceed the Guideline for Interpreting Water Quality Data for aquatic life. The average is taken for each site between both sampling dates.

	Guideline					
Station	Aluminum <0.1mg/L		Copper <0.006mg/L*		Iron <1.0mg/L	
	31-Oct-12	21-Nov-12	31-Oct-12	21-Nov-12	31-Oct-12	21-Nov-12
Upper Cottle	0.28	0.21	<0.010	0.018	0.972	0.676
Lower Cottle 1	0.80	0.27	<0.010	0.014	1.91	0.754
Lower Cottle 2	0.78	0.28	<0.010	0.013	1.90	0.707

*Dependent on hardness.

The ALS results from each sampling date were compared with each other. Differences between sites were also examined. Many parameters were greater during the first sampling event due to the large rainfall event. Parameters that were greater during the first event included: total hardness, conductivity, pH, orthophosphate, phosphorus, calcium, iron, magnesium, manganese, sodium and titanium. Parameters showing little to no change between sampling dates were silicon, nitrate and nitrite. Ammonia was the only parameter tested that was greater during the second sampling event. All parameters not mentioned in this paragraph were below the detection limit. There were no obvious trends between sample sites other than aluminum during the first sampling event. Lower Cottle 1 had 0.80mg/L of aluminum and Lower Cottle 2 had 0.78mg/L of aluminum. Upper Cottle's aluminum content of 0.28mg/L was much closer to the guideline (0.1mg/L) and to the content during the second sampling event which ranged from 0.21 – 0.28mg/L. This data suggests that somewhere between Upper Cottle and Lower Cottle 1, there is either a point source or non-point source for aluminum entering the system (RISC 1998).

4.2.4. Quality Assurance / Quality Control

A comparison was made between the results from the VIU analysis and the ALS analysis to determine accuracy of the VIU analysis assuming that the ALS data is accurate (Table 6 & 7). Percent error was calculated between the two data sets to determine accuracy of the VIU analysis. Percent error ranged from 0 - 400%, however, 24 out of the 30 comparisons were less than 20% error. In fact, approximately half of comparisons resulted in percent error less than 10%. The greatest error occurred during the second sampling event in testing phosphorus. The VIU phosphorus data ranged from 300 – 333% error compared to ALS data suggesting contamination of the samples. The largest error was hardness for the Lower Cottle 2 sample. The VIU data stated a total hardness of 70mg/L $CaCO_3$ while the ALS data stated 49mg/L resulting in a 400% error.

Table 6. Comparing VIU and ALS data from the first sampling event, October 31, 2012. ALS data is rounded for ease of comparison. See Appendix 4 for exact data.

Station	Total Hardness (mg/L)		Phosphorus (mg/L)		Nitrate (mg/L)		Conductivity (µS/cm)		pH	
	VIU	ALS	VIU	ALS	VIU	ALS	VIU	ALS	VIU	ALS
Upper Cottle	51	52	0.15	0.03	0.35	0.39	120	134	7.7	7.8
Lower Cottle 1	51	52	0.06	0.06	0.46	0.46	122	137	7.6	7.8
Lower Cottle 2	70	49	0.06	0.05	0.48	0.55	117	132	7.7	7.8

Table 7. Comparing VIU and ALS data from the second sampling event, November 21, 2012. ALS data is rounded for ease of comparison. See Appendix 4 for exact data.

Station	Total Hardness (mg/L)		Phosphorus (mg/L)		Nitrate (mg/L)		Conductivity (µS/cm)		pH	
	VIU	ALS	VIU	ALS	VIU	ALS	VIU	ALS	VIU	ALS
Upper Cottle	45	47	0.13	0.03	0.59	0.45	105	121	7.7	7.8
Lower Cottle 1	38	40	0.08	0.02	0.49	0.48	94	107	7.9	7.7
Lower Cottle 2	39	40	0.08	0.02	0.49	0.52	90	109	8.0	7.7

Replicate water samples were taken once per sampling event for the VIU analysis. It was found that there was variation between replicate samples. Replicate samples from Lower Cottle 1 taken October 31, 2012, demonstrated an average percent difference of 12%. Average percent difference between Upper Cottle replicate samples taken November 21, 2012, was 21%.

Trip blanks were used as QA/QC measures during both sampling events. Contamination was present in both blanks. Contamination occurred in all parameters except hardness during both lab analysis events.

4.3. Microbiology

4.3.1. VIU Laboratory Analysis

Fecal coliforms were present in all microbiology samples taken (Table 8) (see Appendix 3, Tables 5, 6 & 7 for calculations). CFU per 100ml ranged from 465-767. Upper Cottle had substantial amounts of fecal coliforms in comparison to Lower Cottle 1 and Lower Cottle 2. Lower Cottle 2 had 19% fecal coliforms and Lower Cottle 1 had a comparable 13%. Upper Cottle however, presented an 86% fecal coliform count. Reasons for high fecal content in Upper Cottle is unknown, however, there was evidence of adjacent home owners having farm animals such as chickens.

Table 8. Coliforms present in the Cottle Creek system. Samples taken October 31, 2012.

SAMPLE	TOTAL COLIFORM	FECAL COLIFORM	% FECAL COLIFORM	NON-COLIFORM
Upper Cottle	767	656	86	0
Lower Cottle 1	465	61	13	0
Lower Cottle 2	575	111	19	0

4.4. Stream Invertebrate Communities

4.4.1. Total Density

Triplicate invertebrate samples were taken at three stations resulting in a total area sampled of $0.81m^2$. 486 individual invertebrates were counted in the VIU lab, in which 64% came from the Upper Cottle samples (Figure 6). Upper Cottle had a density of 1156 invertebrates per square metre; Lower Cottle 1 had a density of 485 per square metre; and 159 per square metre for Lower Cottle 2. High variability of densities between sites could be attributed to the varying substrates, flow rates and stream velocities.

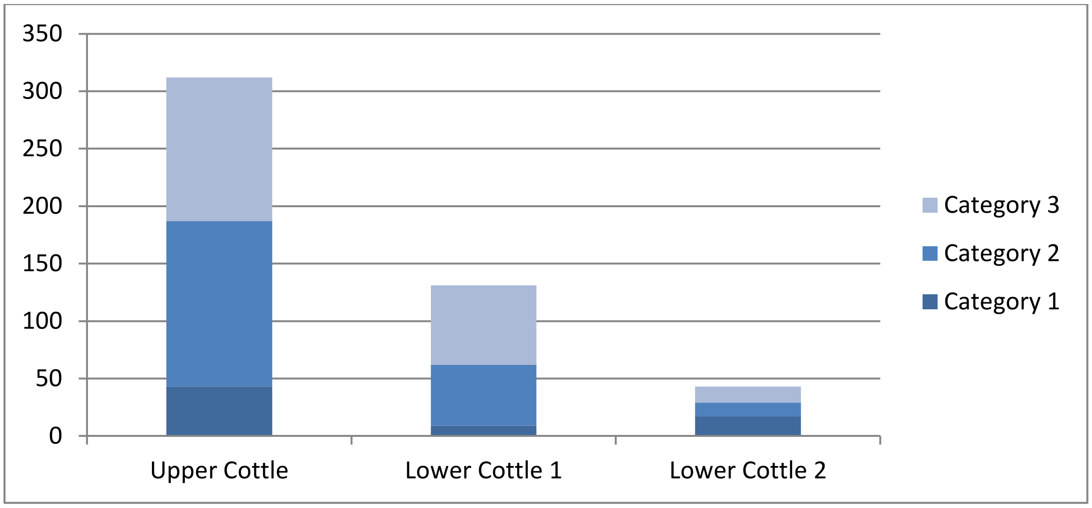

Figure 6. Categories of benthic invertebrates present at each station. Category 1 as low pollution tolerance; category 2 as moderate pollution tolerance; and category 3 as high pollution tolerance.

4.4.2. Taxon Richness and Diversity

In the VIU lab, invertebrates were sorted into the three categories of pollution tolerance. Variation of the dominant category was found within each sample site. Category 2 was largest in Upper Cottle and category 3 was largest in Lower Cottle 1. Category 1, or pollution intolerant species, was the largest group found at Lower Cottle 2. EPT index for Upper Cottle and Lower Cottle 2 was 7 which is considered “acceptable”. Lower Cottle 1 had “marginal” EPT index of 3 (Table 9).

For each sample site, a Shannon-Weiner Index was calculated. Lower Cottle 2 achieved the greatest value of 0.888 and Lower Cottle 1 in the middle with 0.754 (Table 10) (see Appendix 3, Tables 8, 9 & 10 for calculations). Although Upper Cottle had the highest density of benthic invertebrates, the site received the lowest of the Shannon-Weiner Diversity Index of 0.729.This low diversity score could be attributed to the high clam counts found in Upper Cottle completing 41% of the total invertebrates. Freshwater clam was also the predominant species found at Lower

Cottle 2, however only totaled to 26% of the sample while EPT species encompassed a high of 40%. 43% of Lower Cottle 1 consisted of aquatic worms which is consistent with the site's low velocities and silty substrate.

Although Lower Cottle 2 was found to have the lowest density and abundance of invertebrates, the site received the "healthiest" overall stream assessment rating of 3.24 out of 4.00. Upper Cottle and Lower Cottle 1 both received a stream assessment rating of 2.75.

Table 9. Site assessment ratings for invertebrate communities. Sample taken November 5, 2012.

STATION	Pollution Tolerance Index	EPT Index	EPT to total ratio index	Predominant taxon ratio index
Upper Cottle	Good	Acceptable	Poor	Acceptable
Lower Cottle 1	Good	Marginal	Poor	Good
Lower Cottle 2	Good	Acceptable	Marginal	Good

Table 10. Comparing invertebrate diversity parameters between sites. Sample taken November 5, 2012.

Station	Shannon-Weiner Index	Abundance	Density (organisms per m^2)	Predominant Taxon	Pollution Tolerance Index	EPT Index	EPT to Total Ration Index	Predominant Taxon Ratio Index	Site Assessment Rating
Upper Cottle	0.729	312	1156	Clam	45	7	0.14	0.41	2.75/4.00
Lower Cottle 1	0.754	131	485	Aquatic Worm	34	3	0.069	0.43	2.75/4.00
Lower Cottle 2	0.888	43	159	Clam	33	7	0.4	0.26	3.25/4.00

5.0 CONCLUSIONS AND RECOMMENDATIONS

The Cottle Creek Environmental Monitoring Project, completed fall, 2012, confirmed variation of habitat quality between sample sites. The Cottle Creek system flows through diverse ecosystem types and land use areas; however was found to have overall "good" stream health. Results showed that stream health deteriorated downstream as Lower Cottle Creek courses through roadways, new development areas and urban neighbourhoods. The data collected from Lower Cottle 1, represents the effects of development on an urban stream. Loss of the riparian area caused siltation resulting in high turbidity and depleting aquatic invertebrate habitat. Although a majority of the Cottle system is protected by the municipal Linley Valley (Cottle Lake) Park, portions are still at risk of future urban development.

Our recommendations include continuing similar studies in consecutive years to monitor changes to the Cottle Creek system. More conclusive data for North Cottle Creek is needed, including benthic invertebrate and microbiology samples. Long term conclusive data on fecal coliform content for Upper Cottle would also be an asset. Ongoing data is needed to further the assessment of short and long term changes of Cottle Creek.

6.0 REFERENCES

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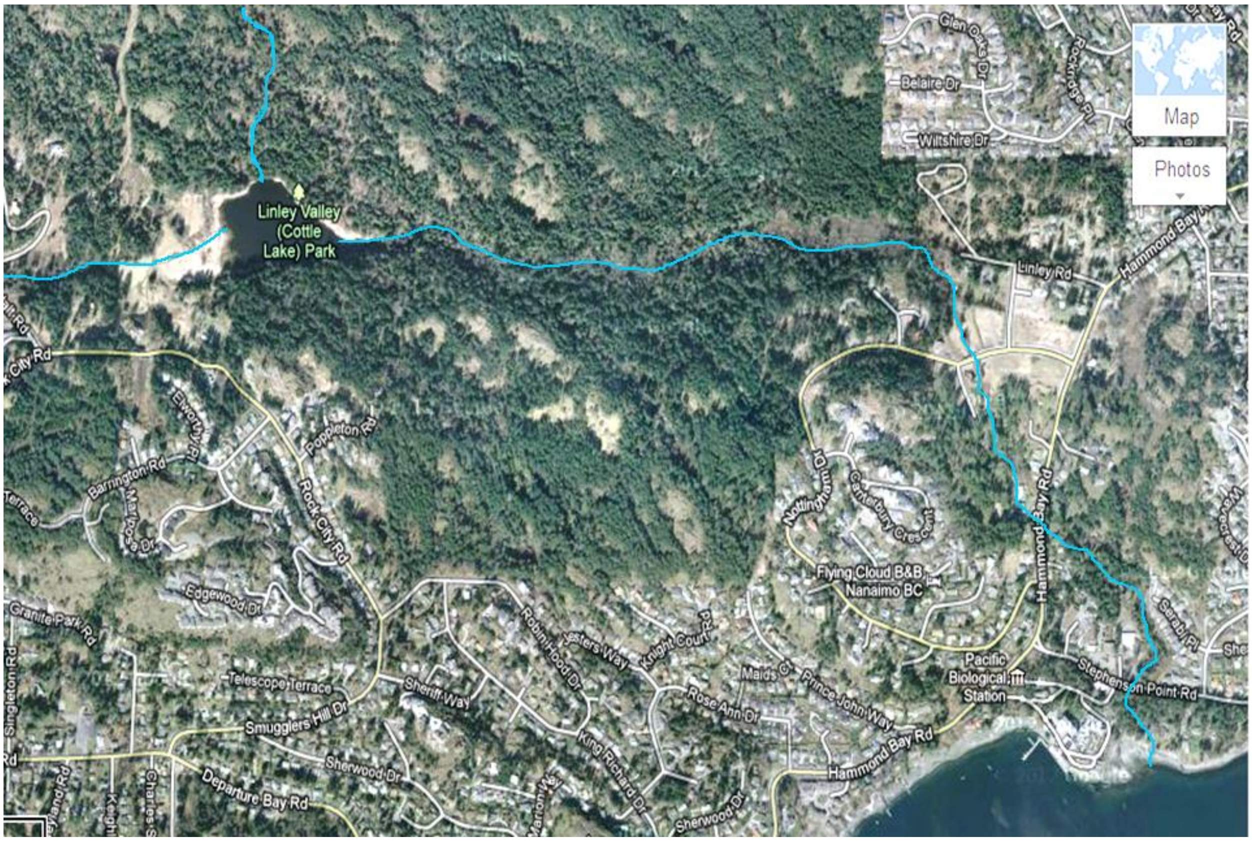
7.0 APPENDICES

APPENDIX 1: MAPS



Map 1. Satellite image of the Cottle Creek water system located in Linley Valley. North Cottle Creek flows into Cottle Lake from the North. Upper Cottle Creek flows into Cottle Lake from the West. Lower Cottle Creek flows out of Cottle Lake, through an urban area and discharges into Departure Bay (Google Maps 2012).

Map 2. Lower Cottle Creek flowing through a recently developed area (Cottle Estates). The Lower Cottle 1 sample station is located on the north side of the Nottingham Drive Bridge (Google Maps 2012).

APPENDIX 2: FIGURES

Figure 1. Sample site "Lower Cottle 1" at Nottingham Drive, taken overlooking the site from the bridge. Photo taken at 11:10, October 20, 2012.

Figure 2. Sample site "North Cottle," 100 metres downstream from Burma Road. Photo taken at 12:15, October 20, 2012.

Figure 3. Sample site “Lower Cottle 2” at Stephenson Point Road. Photo taken at 11:30, October 20, 2012.

Figure 4. Sample site “Upper Cottle” at Landalt Road. Photo taken at 11:50, October 20, 2012.

APPENDIX 3: TABLES

Table 1. In field data from the first sampling event on October 31, 2012.

Station	Temperature (◦C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH
NC	10.8	11.28	91	7.6
UC	10.0	11.61	120	7.7
LC1	10.1	11.36	122	7.6
LC2	10.3	11.30	117	7.7

Table 2. In field data from the second sampling event on November 21, 2012.

Station	Temperature (◦C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH
NC	7.8	12.36	78	7.9
UC	7.4	12.58	105	7.7
LC1	7.1	12.51	94	7.9
LC2	7.4	12.77	90	8.0

Table 3. VIU laboratory data from the first sampling event. Analyzed October 31, 2012.

Station	Total Hardness (mg/L $CaCO_3$)	Total Alkalinity (mg/L $CaCO_3$)	Total Suspended Solids (NTU)	Reactive Phosphorus (mg/L)	Nitrate (mg/L)
NC	30	24.0	2.17	0.08	1.91
UC	51	38.4	5.08	0.15	0.35
LC1	51	38.8	10.60	0.06	0.46
LC1(Replicate)	51	37.2	10.60	0.10	0.40
LC2	70	39.2	9.60	0.06	0.48
Trip Blank	BDL	8.0	0.15	0.10	0.06

Table 4. VIU laboratory data from the second sampling event. Analyzed November 21, 2012.

Station	Total Hardness (mg/L $CaCO_3$)	Total Alkalinity (mg/L $CaCO_3$)	Total Suspended Solids (NTU)	Reactive Phosphorus (mg/L)	Nitrate (mg/L)
NC	32	16.0	1.48	0.04	1.11
UC	44	36.0	5.11	0.14	0.68
UC(Replicate)	46	38.4	7.33	0.11	0.49
LC1	38	26.0	6.01	0.08	0.49
LC2	39	42.0	6.59	0.08	0.49
Trip Blank	BDL	4.0	2.30	0.05	0.05

Table 5. Coliform counts for the Upper Cottle microbiology sample. Taken October 31, 2012.

SQUARE #	RED	BLUE	CLEAR
1	1	8	0
2	2	4	0
3	0	5	0
4	2	4	0
5	0	8	0
6	1	12	0
7	2	4	0
8	0	8	0
9	2	7	0
10	1	5	0
TOTAL	11	65	0
AVERAGE	1.1	6.5	0
CFU/100ml	111	656	0

Table 6. Coliform counts for the Lower Cottle 1 microbiology sample. Taken October 31, 2012.

SQUARE #	RED	BLUE	CLEAR
1	3	1	0
2	3	0	0
3	5	1	0
4	5	0	0
5	4	1	0
6	4	0	0
7	4	1	0
8	3	1	0
9	5	0	0
10	4	1	0
TOTAL	40	6	0
AVERAGE	4.0	0.6	0
CFU/100ml	404	61	0

Table 7. Coliform counts for the Lower Cottle 2 microbiology sample. Taken October 31, 2012.

SQUARE #	RED	BLUE	CLEAR
1	9	1	0
2	6	2	0
3	3	3	0
4	2	2	0
5	5	0	0
6	3	1	0
7	4	0	0
8	4	1	0
9	6	1	0
10	4	0	0
TOTAL	46	11	0
AVERAGE	4.6	1.1	0
CFU/100ml	464	111	0

Table 8. Calculations for Shannon-Weiner Index for Upper Cottle.

Common Name	**Column C**	**pi (C/T)**	**ln(pi)**	**pi* ln(pi)**
Caddisfly Larva	9	0.029	-3.54	-0.103
Mayfly Nymph	11	0.035	-3.35	-0.117
Stonefly Nymph	23	0.074	-2.60	-0.192
Clam	127	0.407	-0.90	-0.366
Cranefly Larva	14	0.045	-3.10	-0.140
Damselfly Larva	1	0.003	-5.81	-0.017
Dragonfly Larva	1	0.003	-5.81	-0.017
Amphipod	1	0.003	-5.81	-0.017
Aquatic Worm	36	0.115	-2.16	-0.248
Blackfly Larva	62	0.199	-1.61	-0.320
Midge Larva	27	0.087	-2.44	-0.212
TOTAL	312	- - -	- - -	-1.749
-(-1.179)/ln(11) = 0.729				

Table 9. Calculations for Shannon-Weiner Index for Lower Cottle 2.

Common Name	**Column C**	**pi (C/T)**	**ln(pi)**	**pi* ln(pi)**
Caddisfly Larva	3	0.070	-2.66	-0.186
Mayfly Nymph	5	0.116	-2.15	-0.249
Stonefly Nymph	9	0.210	-1.56	-0.328
Clam	11	0.256	-1.36	-0.348
Cranefly Larva	1	0.023	-3.77	-0.087
Aquatic Worm	5	0.116	-2.15	-0.249
Blackfly Larva	1	0.023	-3.77	-0.087
Midge Larva	8	0.186	-1.68	-0.312
TOTAL	43	- - -	- - -	-1.846
-(-1.846)/ln(8) = 0.888				

Table 10. Calculations for Shannon-Weiner Index for Lower Cottle 1.

Common Name	**Column C**	**pi (C/T)**	**ln(pi)**	**pi* ln(pi)**
Caddisfly Larva	5	0.038	-3.27	-0.124
Mayfly Nymph	1	0.008	-4.83	-0.039
Stonefly Nymph	3	0.023	-3.77	-0.087
Clam	23	0.176	-1.74	-0.306
Cranefly Larva	11	0.084	-2.48	-0.208
Dragonfly Larva	1	0.008	-4.83	-0.039
Amphipod	18	0.137	-1.99	-0.273
Aquatic Worm	57	0.435	-0.83	-0.361
Midge Larva	12	0.092	-2.39	-0.220
TOTAL	131	- - -	- - -	-1.657
-(-1.657)/ln(9) = 0.754				

APPENDIX 4: ALS RESULTS TABLES

Project	ENVIRONMENTAAL MONITORING COURSE
Report To	John Morgan, Vancouver Island University
ALS File No.	First Sample: L1233439, Second Sample: L1241956
Date Received	05-Nov-12 13:05, 26-Nov-12 10:45
Date	15-Nov-12, 05-Dec-12

RESULTS OF ANALYSIS

Sample ID	UPPER COTTLE CREEK 1	LOWER COTTLE CREEK 1	LOWER COTTLE CREEK 2	UPPER COTTLE CREEK	LOWER COTTLE CREEK 1	LOWER COTTLE CREEK 2
Date Sampled	31-OCT-12	31-OCT-12	31-OCT-12	21-NOV-12	21-NOV-12	21-NOV-12
Time Sampled	10:45	11:40	11:10	11:30	12:15	12:50
ALS Sample ID	L1233439-7	L1233439-8	L1233439-9	L1241956-7	L1241956-8	L1241956-9
Matrix	Water	Water	Water	Water	Water	Water
Physical Tests						
Conductivity	134	137	132	121	107	109
Hardness (as CaCO3)	52.5	52.0	49.2	46.6	40.0	40.0
pH	7.80	7.81	7.83	7.75	7.70	7.73
Anions and Nutrients						
Ammonia, Total (as N)	0.0172	<0.0050	0.0057	0.0208	0.0109	0.0117
Nitrate (as N)	0.391	0.458	0.553	0.454	0.480	0.515
Nitrite (as N)	0.0031	0.0011	0.0013	0.0018	0.0012	0.0013
Orthophosphate-Dissolved (as P)	0.0062	0.0010	0.0019	0.0034	<0.0010	0.0013
Phosphorus (P)-Total	0.0333	0.0569	0.0543	0.0254	0.0189	0.0197
Total Metals						
Aluminum (Al)-Total	0.28	0.80	0.78	0.21	0.27	0.28
Antimony (Sb)-Total	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Arsenic (As)-Total	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Barium (Ba)-Total	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Beryllium (Be)-Total	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bismuth (Bi)-Total	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Boron (B)-Total	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cadmium (Cd)-Total	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Calcium (Ca)-Total	14.0	13.7	13.1	12.6	10.8	10.9
Chromium (Cr)-Total	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cobalt (Co)-Total	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Copper (Cu)-Total	<0.010	<0.010	<0.010	0.018	0.014	0.013
Iron (Fe)-Total	0.972	1.91	1.90	0.676	0.754	0.707

Lead (Pb)-Total	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lithium (Li)-Total	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Magnesium (Mg)-Total	4.28	4.33	4.01	3.70	3.14	3.14
Manganese (Mn)-Total	0.176	0.266	0.267	0.132	0.0962	0.0797
Molybdenum (Mo)-Total	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Nickel (Ni)-Total	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Phosphorus (P)-Total	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Total	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Selenium (Se)-Total	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Silicon (Si)-Total	5.20	5.21	4.97	5.23	5.48	5.38
Silver (Ag)-Total	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Sodium (Na)-Total	8.0	8.8	8.5	6.9	7.1	7.3
Strontium (Sr)-Total	0.0596	0.0572	0.0530	0.0498	0.0411	0.0406
Thallium (Tl)-Total	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Tin (Sn)-Total	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Titanium (Ti)-Total	0.019	0.055	0.056	0.014	0.019	0.021
Vanadium (V)-Total	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zinc (Zn)-Total	<0.0050	<0.0050	0.0107	<0.0050	<0.0050	<0.0050

APPENDIX 5: INVERTEBRATE DATA SHEETS

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Cottle Creek		Date: 5-Nov-12	
Station Name: Upper Cottle		Flow status: Low	
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 9	EPT4 2
	Mayfly Nymph (EPT)	EPT2 11	EPT5 2
	Stonefly Nymph (EPT)	EPT3 23	EPT6 3
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 43	D1 7
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel	127	3
	Cranefly Larva	14	2
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva	1	1
	Dragonfly Larva	1	1
	Fishfly Larva		
	Amphipod (freshwater shrimp)	1	1
	Watersnipe Larva		
Sub-Total		C2 144	D2 8
Category 3	Aquatic Worm (oligochaete)	36	4
	Blackfly Larva	62	2
	Leech		
	Midge Larva (chironomid)	27	2
Pollution Tolerant	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 125	D3 8
TOTAL		CT 312	DT 23

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

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

S1
312

DENSITY: Invertebrate density per total area sampled:

S1 312 ÷ 0.27 m^2 = S2 1156 / m^2

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

S3
Clam

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 7 + 2 x 8 + 8 =	45

EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor	EPT4 + EPT5 + EPT6	S5
>8	5-8	2-4	0-1	2 + 2 + 3 =	7

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	(9 + 11 + 23) / 312=	0.14

SECTION 3 - DIVERSITY

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

S7
23

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	127 / 312 =	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
Marginal	2
Poor	1

Assessment	Rating	
Pollution Tolerance Index	R1	4
EPT Index	R2	3
EPT To Total Ratio	R3	1
Predominant Taxon Ratio	R4	3

Average Rating
Average of R4, R5, R6, R8
2.75

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Cottle Creek	Date:	5-Nov-12
Station Name:	Lower Cottle 1	Flow status:	Low

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 5	EPT4 1
	Mayfly Nymph (EPT)	EPT2 1	EPT5 1
	Stonefly Nymph (EPT)	EPT3 3	EPT6 1
Pollution Intolerant	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 9	D1 3
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel	23	3
	Cranefly Larva	11	3
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva	1	1
	Fishfly Larva		
	Amphipod (freshwater shrimp)	18	2
	Watersnipe Larva		
Sub-Total		C2 53	D2 9
Category 3	Aquatic Worm (oligochaete)	57	5
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	12	2
	Planarian (flatworm)		
Pollution Tolerant	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 69	D3 7
TOTAL		CT 131	DT 19

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

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

S1	131

DENSITY: Invertebrate density per total area sampled:

S1 131 ÷ 0.27 'm^2 =

S2	485 / m^2

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

S3	Aquatic Worm

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 3 + 2 x 9 + 7 =	34

EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor	EPT4 + EPT5 + EPT6	S5
>8	5-8	2-4	0-1	1 + 1 + 1 =	3

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	(5 + 1 + 3) / 131=	0.069

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	Col. C for S3 / CT	S8
<0.40	0.40-0.59	0.60-0.79	0.80-1.0	57 / 131 =	0.43

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	2
EPT To Total Ratio	R3	1
Predominant Taxon	R4	4

Average Rating
Average of R4, R5, R6, R8
2.75

		Ratio	

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Cottle Creek		Date: 5-Nov-12
Station Name: Lower Cottle 2		Flow status: Low
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 3	EPT4 2
	Mayfly Nymph (EPT)	EPT2 5	EPT5 2
	Stonefly Nymph (EPT)	EPT3 9	EPT6 3
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 17	D1 7
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel	11	3
	Cranefly Larva	1	1
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)		
	Watersnipe Larva		
Sub-Total		C2 12	D2 4
Category 3	Aquatic Worm (oligochaete)	5	1
	Blackfly Larva	1	1
	Leech		
	Midge Larva (chironomid)	8	2
Pollution Tolerant	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 14	D3 4
TOTAL		CT 43	DT 15

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

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

S1: 43

DENSITY: Invertebrate density per total area sampled:

S1 43 ÷ 0.27 m^2 = S2: 159 / m^2

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

S3: Clam

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 7 + 2 x 4 + 4 =

S4: 33

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6
2 + 2 + 3=

S5: 7

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
(3 + 5 + 9) / 43=

S6: 0.4

SECTION 3 - DIVERSITY

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

S7: 15

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
11 / 43 =

S8: 0.26

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.

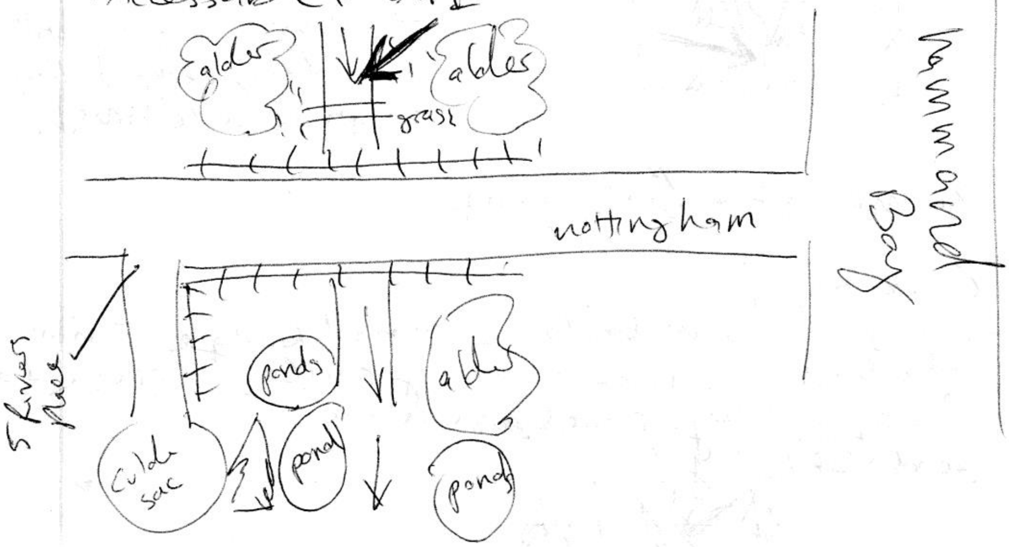
Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

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

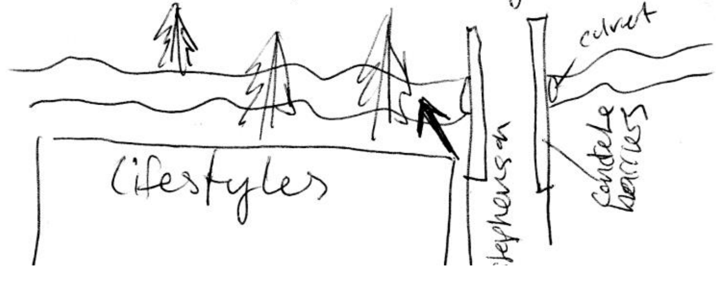
Average Rating
Average of R4, R5, R6, R8
3.25

APPENDIX 6: FIELD NOTES

(1) Nottingham.
PA - easy @bridge, public, very warm pathways
→ riparian → alders, young, very open. couple coni
downstream of bridge
→ water but no flow.
→ muddy, not pebbly
→ SAFE
→ Accessable + SAFE

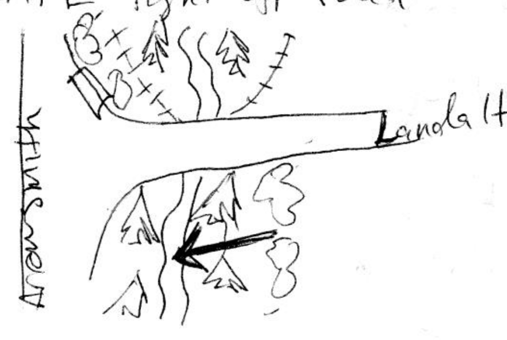


(3) ~~Stevens~~ Stephenson Rd
Park at Lifestyles gym. → Shale + rocks
→ very accessable + SAFE
Stronger Flow into culvert
Bankful depth = low
decent cover; large trees, cedars, maples, Firs
lots of invasive species - ivy, daphi



④ Landalt Rd ③ Arrowsmith

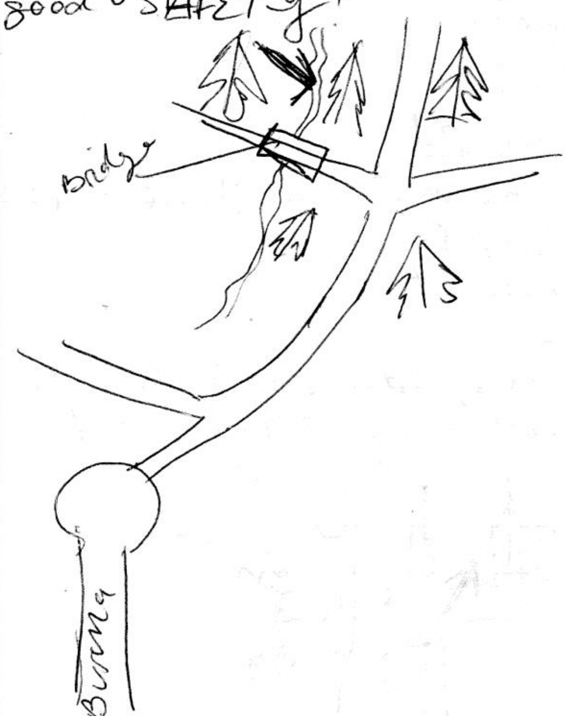
→ easy access @ Landalt + Arrowsmith Road.
→ Lots of cover, mid age maples, cedars, alders, ferns
→ SAFE right off road



→ no trail to station
→ slope / from road, maple
→ gravel + silt,
→ skunk cabbage
→ flow = half of bankful width, very shallow
→ sparse underbrush

② Burma st + Linly point.

Creek dry!
→ easy access on trails. station + bridge 5 mins in
little slope, Lots of cover by conifer, dense + dark
Rocky + silty. root exposure etc.
good SAFETY!



October 31, 2012
Raining, cold

Upper Cottle @ Landalt Rd 10:30 am

water quality → D.O. 11.61 mg/L, 102.6 %
Temp 10°C
Conductivity 120 ms/cm
pH 7.7

Hydrology Measurements
→ Depth (25, 50, 75%) 0.12m, 0.22m, 0.08m
Wetted Width 6.1m
Velocity per 5m 7.1s, 6.0s, 8.1s

ave depth: 0.14 m
ave velocity: 7.07 s / 5 m = 0.71 m/s
ave dishcharge: 6.1m × 0.14m × 0.71m/s = 0.61 m^3/s

Lower Cottle 2 @ Nottingham 11:15 am

Water Quality → D.O. 11.3mg/L, 104.5%
Temp 10.3°C
Conductivity 117ms/cm
pH 7.7

Hydrology Measurements
→ Depth (25, 50, 75%) 0.23m, 0.35m, 0.25m
Wetted Width 3.25m
Velocity per 5m 7.9s, 3.5s, 7.2s

ave. depth: 0.28m
ave. velocity: 6.2s / 5m = 0.81 m/s
ave. discharge: 3.25m × 0.28m × 0.81m/s = 0.72m^3/sec

Lower Cottle 1

Water Quality → D.O. 11.36 mg/L, 100.5%

Temp. 10.1 °C

Conductivity 122 ms/cm

pH 7.6

Hydrology Measurements

→ Depth (25, 50, 75%) 0.83 m, 0.88 m, 0.8 m

Wetted Width 3.6 m

Velocity per 5m 10s, 8s, 14s

ave. Depth 0.84 m

ave. Velocity 10.7s/5m = 0.47 m/sec

ave. Discharge 3.6m × 0.84m × 0.47m/s = $1.41 m^3/s$

North Cottle

Water Quality → D.O. 11.28 mg/L, 101.7%

Temp. 10.8 °C

Conductivity 91 ms/cm

pH 7.6

Hydrology Measurments

→ Depth (25, 50, 75%) 0.13m, 0.13m, 0.06m

Wetted Width 1m

Velocity per 5m 7s, 5s, 7s

ave. Depth 0.11 m

ave. Velocity 6.3s/5m = 0.79 m/sec

ave. Discharge 1m × 0.11m × 0.79 m/s = $0.09 m^3/sec$

November 21st, 2012
Clear, cold

Upper Cottle @ Landalt Rd. 11:15
water quality → D.O. 12.58 mg/L, 103.7%
Temp. 7.4°C
Conductivity 105 ms/cm
pH 7.7
Hydrology Measurements
→ Depth (25, 50, 75%) 0.19m, 0.06m, 0.05m
Wetted Width 5.9m
Velocity per 5m 15.6s, 7.8s, 15s

ave. Depth: 0.1m
ave. velocity: 12.8s / 5m = 0.39m/s
ave Discharge: 5.9m × 0.1m × 0.39m/s = 0.23m³/s

Lower Cottle2 @ Nottingham 11:45
Water Quality → D.O. 12.77mg/L, 105.8%
Temp. 7.4°C
conductivity 90 mS/cm
pH 8.0
Hydrology Measurments
→ Depth (25, 50, 75%) 0.2m, 0.3m, 0.1m
Wetted Width 3.2m
velocity per 5m 7.3s, 3.4s, 4.8s

ave. Depth: 0.2m
ave. Velocity: 5.2s/5m = 0.96m/sec
ave. Discharge: 3.2m × 0.2m × 0.96m/s = 0.61

Lower Cottle 1 12:12

Water Quality → D.O. 12.51 mg/L, 103.1%

Temp. 7.1°C

Conductivity 94 ms/cm

pH 7.9

Hydrology Measurements

→ Depth (25, 50, 75%) 0.78m, 0.9m, 0.78m

Wetted width 3.6m

Velocity per 5m 33s, 8.3s, 8.5s

ave. Depth: 0.82m

ave. velocity: 16.6s/5m = 0.30m/sec

ave. Discharge: 3.6m × 0.82m × 0.30m/s = 0.88 m^3/sec

North Cottle 12:45

Water Quality → D.O. 12.36 mg/L, 103.9%

Temp. 7.8°C

Conductivity 78 ms/cm

pH 7.9

Hydrology Measurements

→ Depth (25, 50, 75%) 0.16m, 0.15m, 0.15m

Wetted Width 1.1

Velocity per 5m 16s, 9.6s, 16.2s

ave. Depth: 0.15m

ave. Velocity: 13.9 sec/5m = 0.36 m/s

ave. Discharge: 1.1m × 0.15m × 0.36m/s = 0.06 m^3/Sec