DATA REPORT

Water Quality and Stream Invertebrate Assessment

for the C.W. Young Channel, Englishman River, BC,

(Fall 2011)

Report prepared by:

Students of Vancouver Island University RMOT 306 (Environmental Monitoring)

Nicole Boss, Jacquelyn Morris, Olivia Van Jarrett

and

Dr. Eric Demers (Vancouver Island University)

25 January 2012

Table of Contents

Disclaimer Note:

This report is a compilation of a class project at Vancouver Island University. Neither Vancouver Island University, nor any of its employees or students, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or for any third party use or the results of such use of any information disclosed.

1. Background

This report documents a water quality and stream invertebrate assessment conducted on the C.W. Young Channel, Englishman River, BC, during October-November 2011.

This study was undertaken by 3rd year undergraduate students attending the Environmental Monitoring (RMOT 306) course at Vancouver Island University (VIU), offered as part of the Bachelor of Natural Resources Protection (Nicole Boss, Jacquelyn Morris, Olivia Van Jarrett). Students worked under the supervision of the course instructor, Dr. Eric Demers (Vancouver Island University). This report was compiled by Dr. Eric Demers based on a student group report.

VIU students contributed approximately 100 student-hours to this project, including site visits, project proposal, field sampling, laboratory analyses, and oral and written presentations. Dr. Eric Demers contributed approximately 12 hours for project management and report compilation.

Logistical support was provided by the Regional District of Nanaimo (RDN) and Fisheries and Oceans Canada (DFO). Funding for field expenses and analytical processing of water samples was provided by the Regional District of Nanaimo and Fisheries and Oceans Canada. ALS Laboratory (Burnaby, BC) provided reduced rates on their analytical services for this project.

2. Introduction

The C.W. Young Channel is located on the northern bank of the Englishman River on Vancouver Island, BC, within Englishmen River Regional Park. It is approximately 7 km upstream from the Englishman River Estuary in Parksville Bay and begins just below the Morison Creek confluence (Hawkes et al., 2008). The channel is approximately 4,100 metres long and provides off-channel and pond habitat for spawning and rearing Pacific salmon and trout. The entire channel is dependent on surface flow from the Englishmen River.

This report documents a water quality and stream invertebrate assessment conducted on the C.W. Young Channel, Englishman River, BC, during October-November 2011.

Specific objectives for this study of the C.W. Young Channel included:

- establish 5 water quality sampling stations;
- obtain field measurements of water quality at the 5 sampling stations during two sampling events (30 October and 20 November 2011);
- obtain water samples from each sampling station during two sampling events (30 October and 20 November 2011) for detailed laboratory analyses; and,
- collect stream invertebrate samples at 3 sampling stations during one sampling event (30 October 2011) for analysis at Vancouver Island University.

3. Methods

3.1. Study Site

This project was conducted at the C.W. Young Channel located along the Englishman River (Figure 1). The original C.W. Young Channel was constructed in 1992 by Fisheries and Oceans Canada (DFO). In 2007, the C.W. Young Channel was lengthened by another 2 km, with the outlet of the channel a few hundred metres upstream of the Top Bridge Crossing. This brought the total length of constructed side channel habitat in the Englishman River to 4,100 m (Hawkes et al., 2008). The channel was built to provide resident and anadromous salmonids with new spawning and juvenile rearing habitat.

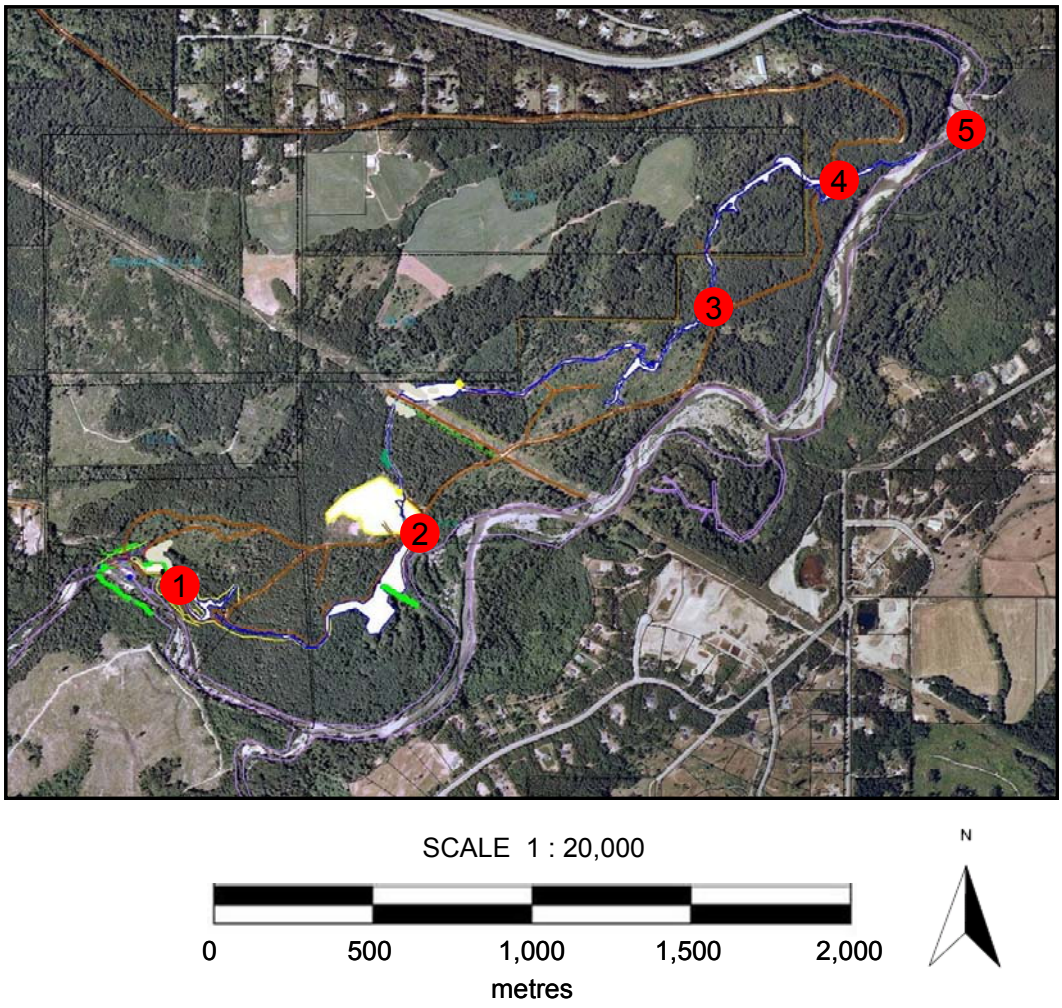

Figure 1. Approximate location of the sampling stations used for water quality and stream invertebrate assessments on the C.W. Young Channel, during October-November 2011. The C.W. Young Channel and Englishman River are outlined in blue and purple, respectively. Access roads are outlined in brown. Table 1 provides details of the specific location of each station. Table 2 details the sampling activities conducted at each station. This map was obtained from Hawkes et al. (2008). Map scale is approximated.

3.1.1. Sampling Stations

Five stations were established on the C.W. Young Channel and Englishman River, during October-November 2011 (Tables 1 and 2; Figure 1). The location of each station was chosen to provide adequate coverage for the length of the C.W. Young Channel. Stations were numbered from the upstream end to the downstream end of the channel. All stations were easily accessed via foot paths or access road crossings. Station 1 was located one metre downstream of the steel valve at the upstream entrance into the channel and served as a reference station for initial conditions at channel entry. Stations 2-4 were located at intervals along the channel. Station 5 was located on the main stem Englishman River, near the channel outlet. This station served as a reference to compare spatial changes that occur within the channel and in the main river channel.

Table 1. Description of the sampling stations used for water quality and stream invertebrate assessments on the C.W. Young Channel and Englishman River, during October-November 2011.

Station	Distance from Upstream End (m)	General Location
1	0	Upstream channel entrance, 1 m downstream of steel pipe valve
2	1,250	Road crossing, start of 2007 channel extension
3	2,900	Channel section near access road
4	3,800	3 m upstream of steel sill structure
5	N/A	Main stem Englishman River, near channel outlet

3.1.2. Sampling Schedule

Field sampling was conducted on 30 October and 20 November 2011. For this study, samples were collected for water quality analyses, microbiology and stream invertebrate assessment. Table 2 lists the specific activities conducted at each station during each sampling event. Microbiology and stream invertebrate assessments were only completed during the first sampling event. Photographs showing site conditions and sampling activities are included in Appendix 1.

3.2. Water Quality

3.2.1. Field Measurements

Water quality sampling events were conducted on 30 October and 20 November 2011. At each sampling station, field measurements of water temperature (to the nearest 0.1^{o}C) and dissolved oxygen (to the nearest 0.1 mg/L) were obtained with an Oxyguard Handy Polaris electronic probe. The electronic probe was placed directly in the channel water.

Table 2. Water quality and stream invertebrate sampling activities conducted at each station on the C.W. Young Channel and Englishman River, during October-November 2011. The symbols "A" or "B" indicate whether samples / measurements were taken during the early or late November sampling events, respectively.

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

Note: [1] Basic hydrological measurements were only collected at station 2 during the early November sampling event.

Basic hydrological measurements were taken at station 3 on 30 October 2011. Water velocity (in m/s) was measured along a 5-m stream length. An orange was dropped slightly upstream of the stream length and allowed to float downstream through the stream length. A stopwatch was used to measure the travel time of the ball between the upstream and downstream ends of the stream length. The average travel time from 5 passes was used to calculate average water velocity.

Stream wetted widths were measured with a metered tape to the nearest 0.1 m, and wetted depths were measured (along the same wetted widths) with a meter stick to the nearest 0.01 m. Total cross-sectional areas (in m^2) were calculated as the sum of the areas of cross-section polygons. Stream discharge (in m^3/s) was obtained as the product of mean water column velocity and cross sectional area.

3.2.2. Water Sampling

During each sampling event, two sets of water samples were collected for laboratory analyses: one set was transported for analysis at Vancouver Island University (VIU), and another set was shipped for analysis by ALS Laboratory, in Burnaby, BC.

Water samples for analysis at VIU were collected from all stations (Table 2). At each station, a clean pre-labelled 500-ml plastic bottle was rinsed 3 times and then used to collect a water sample (Table 3). Samples were obtained while standing on the stream bank or within the stream channel by immersing the containers just below the water surface while facing upstream. Care was taken not to disturb the bottom sediments. All water samples were kept in a cooler and stored at approximately 4^oC. Laboratory analyses were conducted at VIU within 48 hours of sampling.

Samples for analysis by ALS Laboratory were collected from stations 1-4 during both sampling events (Table 2). At each station, water samples were collected in three clean laboratory-supplied and pre-labelled sample containers (Table 3). All samples were obtained while standing on the stream bank or within the stream channel by directly immersing the containers just below the water surface while facing upstream. Care was taken not to disturb the bottom sediments. Samples for analysis of nutrients and total metals were preserved with laboratory-supplied sulphuric acid and nitric acid, respectively. Bottles with preservatives were inversed five times for adequate mixing. All water samples were stored in a cooler on site, and shipped with ice packs within 48 hours for laboratory analyses at ALS Laboratory.

A quality control sample (trip blank) was also included during the November sampling event for analysis at the VIU Laboratory. The trip blank was prepared at the VIU Laboratory and consisted of distilled water placed in a 500-ml plastic bottle. The trip blank bottle was transported to the sampling stations, but remained unopened.

Table 3. Sampling containers and preservatives used for water quality samples taken at the C.W. Young Channel and Englishman River during October-November 2011. All containers and preservatives for analysis by ALS Laboratory were provided by ALS Laboratory, Burnaby, BC.

Analytical Parameters	Container	Preservative	Analysed by
Total alkalinity, turbidity	500 ml plastic	None	VIU
Conductivity, pH, total hardness	1 L plastic	None	ALS Laboratory
Nutrients	250 ml amber glass	Sulphuric acid	ALS Laboratory
Total metals	250 ml plastic	Nitric acid	ALS Laboratory

3.2.3. VIU Laboratory Analyses

Water samples transported to Vancouver Island University were analysed for total alkalinity and turbidity. Total alkalinity (as $CaCO_3$) was measured to the nearest 0.1 mg/L using the HACH AL-DT digital titration method. Turbidity was measured to the nearest 0.01 NTU (Nephelometric Turbidity Units) using a HACH 2100 Potable Turbidimeter.

3.2.4. ALS Laboratory Analyses

Water samples submitted for external analyses were processed as per ALS Laboratory standard analytical procedures. The analytes were: conductivity, total hardness, pH, nutrients (ammonia, nitrite, nitrate, orthophosphate and total phosphorus), and total metals (31 metals).

3.2.5. Quality Assurance / Quality Control

Throughout this study, measures were taken to ensure that potential contamination of water samples was minimized. This included using only clean and rinsed containers, preserving samples as prescribed by the analytical laboratory, and storing collected samples in well-labelled containers.

3.2.6. Data Analyses – Comparison with Applicable Guidelines

Water quality results were compared with the applicable provincial water quality guidelines for the protection of freshwater life. The BC Water Quality Guidelines are the maximum allowable concentration (for potential acute effects) and the 30-day average concentration (for potential chronic effects). All guidelines were obtained from the BC Ministry of Environment, Water Protection Division (http://www.env.gov.bc.ca/wat/wq/).

It is important to note that for some metal parameters, analytical detection limits were above applicable guidelines. These include aluminium, antimony, arsenic, cadmium, chromium, cobalt, copper, lead, nickel, selenium, silver, thallium and vanadium. For these metals, measured values reported to be below method detection limits cannot be assumed to be below the applicable guidelines.

3.3. Microbiology

3.3.1. Field Sampling

Water samples for total and fecal coliform enumeration were collected from each sampling station on 30 October 2011 (Table 2). At each station, a sterile pre-labelled 120-ml Whirl-Pak® bag was used to collect a 100-ml water sample by directly immersing the bag by hand just below the water surface while facing upstream. All samples were stored in a cooler with ice packs and transported within 48 hours to Vancouver Island University for laboratory analysis.

3.3.2. Laboratory Analyses

In the laboratory, water samples were tested for total coliform and fecal coliform (*Escherichia coli* or *E. coli*) using the m-coliBlue24 membrane filtration method (Millipore Corporation). A 25-ml volume of sample water was filtered through a 47-µm membrane filter (marked with 3-mm gridlines) using a vacuum pump. The filtration apparatus was then rinsed with approximately 5 ml of sterile water. A filtration blank was also completed with 25 ml of sterile water using the same filtration procedures. Each membrane filter (including the blank) was then transferred to a Petri plate containing an absorbent pad saturated with m-ColiBlue24 broth. All membrane filters were incubated at 37°C for 20 hours (until bacterial colonies were clearly visible).

Upon completion of the incubation period, membrane filters were then examined for bacterial colonies under a dissection microscope (16X magnification). A red or blue colony represents a

total coliform "positive" result (Table 4). A blue colony specifically represents an *E. coli* "positive" result. A clear or white colony represents a total coliform negative result.

All colonies present on a membrane filter were counted and expressed as CFU (colony forming units) per 100-ml of sample water.

Table 4. Possible outcomes of the m-coliBlue24 membrane filtration method.

Bacteria Type	Positive Result	Negative Result
Total coliform	Red or blue colony	Clear or white colony No colony
E. coli	Blue colony only	Non-blue colony

3.4. Stream Invertebrates

3.4.1. Sampling Stations

Stream invertebrate samples were collected from stations 1, 3 and 4 on 30 October 2011 (Table 1; Figure 1). The sampling stations were selected based on hydrological characteristics, apparent substrate uniformity, space available for replicate samples, safety and site access. At the time of sampling, all stations consisted of shallow riffles (water depth ~10-25 cm), with water velocity of ~0.5-1.0 m/s, and primarily sand and gravel substrate.

3.4.2. Invertebrate Sampling

At each station, three replicate samples (triplicates) were obtained using a Hess sampler and procedures as per the Pacific Streamkeepers procedures (Taccogna and Munro 1995). Each site was approached by walking from downstream. The cylindrical, 34-cm diameter Hess sampler was hand-pressed into the substrate to isolate a circular 0.09-m^2 sampling area. All stones and debris 5 cm or larger within the sampling area were held under water in front of the collecting net and rubbed gently by hand to dislodge invertebrates. Cleaned stones and debris were then placed downstream of the sampling area. The streambed was then gently agitated to a depth of 5 cm to loosen any remaining invertebrates. The content of the collecting net was then transferred in a 125-ml plastic sample jar. The net was carefully inspected to ensure all content was transferred into the sample jar. Samples were stored in a cooler and transported to Vancouver Island University, where laboratory analyses were completed within 24 hours of sampling.

3.4.3. VIU Laboratory Analyses

Laboratory procedures and identification also followed the Pacific Streamkeepers procedures (Taccogna and Munro 1995). The triplicate samples from each station were combined into a single composite sample per station. The contents of all invertebrate sample jars from a station were poured into a shallow white tray. Invertebrates were sorted into apparent taxonomic

groups. Identification to the appropriate taxonomic level (as prescribed by the Pacific Streamkeepers procedures) was confirmed using a dissecting microscope. The number of invertebrates and the number of distinguishable subgroups within each broad taxonomic group were recorded on a Pacific Streamkeeper Invertebrate Survey Field Data Sheet. From these records, various useful metrics were calculated for each station, including: total density (number per m^2), total number of taxonomic groups, predominant taxonomic group, Pollution Tolerance Index, EPT (Ephemeroptera-Plecoptera-Trichoptera) Index, EPT to Total Ratio Index, Predominant Taxon Ratio Index, and overall Site Assessment Rating.

4. Results

The discharge measurement (Table 5) and field observations for the C.W. Young Channel suggests that water level was near bankfull during both sampling events.

Average air temperature during the 10-day period prior to each sampling event was 7.5°C and 2.7 °C for the October and November sampling events, respectively (data for Nanaimo Airport retrieved from http://climate.weatheroffice.gc.ca). Total rainfall during the 10-day period prior to the October and November sampling events were 27 mm and 31 mm, respectively.

4.1. Water Quality

4.1.1. Field Measurements and VIU Laboratory Analyses

Water temperature averaged 9.0°C and 2.2°C during the October and November sampling events, respectively (Table 5). The decrease in water temperature reflected a concurrent decrease in air temperature between sampling events. During both sampling events, all dissolved oxygen levels were above the minimum guideline of 9.0 mg/L for early fish life stages (RISC 1998). Overall, dissolved oxygen concentrations were >84% saturation.

Total alkalinity ranged averaged 24.0 and 18.3 mg/L during the October and November sampling events, respectively (Table 5). Overall, total alkalinity was near or above 20 mg/L during both sampling events, indicating "moderate" to "low acid sensitivity" as defined by RISC (1998).

Turbidity averaged 0.67 and 1.57 NTU during the October and November sampling events, respectively (Table 5).

Laboratory analysis of the trip blank did not indicate any sign of gross contamination.

Table 5. Field measurements and laboratory results (VIU Laboratory) for water samples taken from five stations on the C.W. Young Channel and Englishman River during October-November 2011. Discharge measurements were only collected at station 3 during the October sampling event.

Station	Field Measurements			VIU Laboratory	
	Discharge (m^3/s)	Temperature (^oC)	Dissolved Oxygen (mg/L)	Total Alkalinity (mg/L $CaCO_3$)	Turbidity (FAU)
		30 October 2011			
1		9.7	10.7	21.2	0.33
2		8.2	10.3	22.8	0.60
3	1.2	8.3	10.2	24.8	0.93
4		8.9	10.2	25.6	1.08
5		9.9	11.1	25.6	0.39
		20 November 2011			
1		2.1	12.6	16.4	1.49
2		1.9	12.1	19.2	2.64
3		2.3	11.9	15.2	1.75
4		2.5	11.4	24.0	0.83
5		2.3	12.6	16.4	1.49

4.1.2. ALS Laboratory Analyses

Water quality results from ALS Laboratories were compared to the BC Provincial water quality guidelines for the protection of aquatic life (Table 6).

Conductivity ranged from 59.8 to 71.5 µS/cm during this study, and the highest levels were measured at station 4 during both sampling events.

Total hardness ranged from 22.0 to 27.1 mg/L as $CaCO_3$ during this study, and followed a similar trend as conductivity where the highest levels occurred at station 4 during both sampling events. Total hardness was below 60 mg/L during both sampling events, indicating "soft water" as defined by RISC (1998).

Water pH averaged 7.90 and 7.68 during the October and November sampling events, respectively, and there was no consistent trend among station or between sampling events.

All nutrient levels were below applicable guidelines. Total ammonia ranged from below detection limit (i.e., <0.005 mg/L) to 0.046 mg/L during this study, and there was a general increase with distance downstream. Nitrate concentrations increased between the October (average: 0.014 mg/L) and November sampling events (average: 0.045 mg/L). The highest nitrate levels were observed at station 4 during both sampling events (0.025 and 0.058 mg/L, respectively). Nitrite levels were at or below the detection limit during this study (i.e., <0.001 mg/L).

Orthophosphate was mainly below or near detection limit (i.e., ≤0.003 mg/L) during the October sampling event, but increased during the November sampling event when levels reached 0.012 mg/L at station 4. During both sampling events, total phosphorus levels increased with distance downstream, and increased between the October (average: 0.010 mg/L) and November sampling events (average: 0.013 mg/L). Overall, total phosphorus levels were deemed "oligotrophic" (<0.010 mg/L) at stations 1-2 and "mesotrophic" (0.010-0.025 mg/L) at stations 3-4 as defined by RISC (1998).

All metal concentrations were below the applicable water quality guidelines and/or below detection limits.

Table 6. Laboratory results (ALS Laboratory) for water samples taken from 4 stations at the C.W. Young Channel during 10 October and 20 November 2011. All values are expressed in mg/L unless specified otherwise. See additional notes on the next page.

	BC Water Quality Guidelines [a]		30 October 2011				20 November 2011			
	BC Max	BC 30-day Mean								
Variable	mg/L	mg/L	1	2	3	4	1	2	3	4
General/Physical										
Conductivity (µS/cm)			63.4	62.5	64.0	71.5	61.4	60.2	59.8	67.9
Hardness, Total			22.4	22.7	22.6	27.1	22.5	22.1	22.0	26.3
pH (pH units)	6.5 - 9.0		8.01	7.86	7.85	7.86	7.68	7.66	7.66	7.73
Nutrients										
Ammonia-N	11.2 [b]	1.85 [b]	<0.0050	0.0181	0.0385	0.0374	<0.0050	0.0188	0.0404	0.0456
Nitrate (as N)	31.3	3	0.0080	0.0101	0.0118	0.0253	0.0355	0.0430	0.0449	0.0582
Nitrite (as N)	0.06 [c]	0.02 [c]	<0.0010	<0.0010	<0.0010	0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Ortho Phosphate (as P)			<0.0010	<0.0010	0.0030	0.0027	<0.0010	0.0057	0.0137	0.0119
Total Phosphorus			0.0021	0.0065	0.0122	0.0181	0.0023	0.0096	0.0192	0.0197
Total Metals										
Aluminum (Al) [m]	0.10 [d]	0.05 [d]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Antimony (Sb) [m]	0.02		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Arsenic (As) [m]	0.005		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Barium (Ba)	5	1	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Berylium (Be)	0.0053		<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bismuth (Bi)			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Boron (B)	1.2		<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cadmium (Cd) [m]	0.00001 [e]		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Calcium (Ca)			7.65	7.72	7.58	8.44	7.59	7.43	7.34	8.15
Chromium (Cr) [m]	0.001 [f]		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cobalt (Co) [m]	0.11	0.004	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Copper (Cu) [m]	0.004 [g]	0.002 [g]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron (Fe)	1.0		0.036	0.162	0.191	0.358	0.041	0.088	0.114	0.178
Lead (Pb) [m]	0.012 [h]	0.004 [h]	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lithium (Li)	0.87	0.096	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Magnesium (Mg)			0.81	0.84	0.89	1.46	0.86	0.86	0.90	1.44
Manganese (Mn)	0.78 [i]	0.70 [i]	<0.0050	0.0065	0.0096	0.0107	<0.0050	<0.0050	0.0054	0.0072
Molybdenum (Mo)	2	1	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Nickel (Ni) [m]	0.025 [j]		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Phosphorus (P)			<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	373		<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Selenium (Se) [m]		0.002	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Silicon (Si)			2.39	2.53	2.53	3.08	2.75	2.72	2.75	3.23
Silver (Ag) [m]	0.0001 [k]	0.00005 [k]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Sodium (Na)			3.1	3.0	3.0	3.2	3.3	3.2	3.2	3.4
Strontium (Sr)			0.030	0.030	0.029	0.032	0.031	0.030	0.029	0.031
Thallium (Tl) [m]	0.0003		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Tin (Sn)			<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Titanium (Ti)	2		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Vanadium (V) [m]	0.006		<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zinc (Zn)	0.033 [l]	0.0075 [l]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050

Table 6. (Continued)

NOTES:

Results are expressed as mg/L except for pH and conductivity.
"<" means less than the detection limit.

[a] BC Water Quality Guidelines (WQG) compiled from
http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html
http://www.env.gov.bc.ca/wat/wq/BCguidelines/working.html

[b] Total ammonia guideline is dependent on water temperature and pH of tested water.

[c] Nitrite guideline is for chloride concentration < 2 mg/L.

[d] Aluminum guidelines for pH ≥ 6.5.

[e] The maximum cadmium guideline is $0.001 * 10^{\{0.86 [\log(\text{hardness})] - 3.2\}}$ mg/L.

[f] Chromium guideline is for the more toxic Chromium VI.

[g] The maximum copper guideline is 0.001 * [0.094(hardness) + 2] mg/L.
The 30-day mean copper guideline is for hardness < 50 mg/L.

[h] The maximum lead guideline is $0.001 * e^{\{1.273 [\ln(\text{hardness})] - 1.46\}}$ mg/L.
The 30-day mean lead guideline is $0.001 * [3.31 + e^{\{1.273 [\ln(\text{hardness})] - 4.704\}}]$ mg/L.

[i] The maximum manganese guideline is 0.01102 * (hardness) + 0.54 mg/L.
The 30-day mean manganese guideline is 0.0044 * (hardness) + 0.605 mg/L.

[j] Nickel guideline is for hardness < 60 mg/L.

[k] Silver guidelines are for hardness < 100 mg/L.

[l] Zinc guidelines are for hardness < 90 mg/L.

[m] Analytical detection limits were above applicable guidelines for these metals.

4.2. Microbiology

All samples collected from the C.W. Young Channel and Englishman River contained some coliform bacteria (Table 7). Total coliform counts increased with distance downstream within the C.W. Young channel, with a range of 176-2,370 CFU / 100 ml. The proportion of total coliform made up of *E. coli* bacteria was relatively low at all stations (range: 0-5%). Overall, the observed total coliform levels were higher during this study compared to previous studies conducted during Fall 2008-2010 (VIU, 2009, 2010, 2011).

The filtration blank completed with sterile water did not produce any bacterial colonies.

Table 7. Total coliform and *E. coli* counts from water samples taken at five stations on the C.W. Young Channel and Englishman River on 30 October 2011. All values are expressed as number of bacteria per 100 ml. No samples were collected on 20 November 2011.

Station	Total Coliform	*E. coli*	% *E. coli*
1	176	0	0.0%
2	392	20	5.1%
3	686	28	4.1%
4	2370	60	2.5%
5	936	24	2.6%
Filtration blank	0	0	–

4.3. Stream Invertebrates

A total of 518 stream invertebrates representing 10 broad taxonomic groups were counted at three stations on the C.W. Young Channel on 30 October 2011 (Table 8; Figure 2; Appendix 2). Animal density decreased with distance downstream, with the highest level was observed at station 1 (1,096 animals/m^2). Mayfly nymphs was the most common taxonomic group encountered.

Site assessment ratings ranged from 2.5-3.5 suggesting "acceptable" to "good" invertebrate community abundance and diversity. Pollution-sensitive mayfly nymphs, stonefly nymphs and caddisfly larvae were abundant at stations 1 and 3 (EPT taxa: 59-98% of total abundance), but not at station 4. Salmon spawning activities observed at station 4 may have resulted in significant substrate disturbance to affect stream invertebrate density and diversity.

Table 8. Abundance and density of stream invertebrates obtained from triplicate samples taken on 30 October 2011 at three stations on the C.W. Young Channel. Overall site assessment ratings are also provided for each station (out of a maximum rating of 4.00). Invertebrate Survey Field Data Sheets are included in Appendix 2. No samples were collected on 20 November 2011.

Pollution Tolerance	Invertebrate Taxa	Station 1	Station 3	Station 4
Category 1 Pollution Intolerant	Caddisfly Larva	38	3	0
	Mayfly Nymph	76	157	14
	Stonefly Nymph	61	10	1
Category 2 Somewhat Pollution Intolerant	Gilled Snail	0	0	9
	Cranefly Larva	4	0	0
	Scud (amphipod)	0	0	2
	Watersnipe Larva	1	0	0
Category 3 Pollution Tolerant	Aquatic Worm (oligochaete)	107	1	17
	Midge Larva (chironomid)	4	0	6
	Water Mite	5	2	0
	Total Abundance	296	173	49
	Density (number / m^2)	1,096	641	181
	Site Assessment Rating	3.50	2.75	2.50

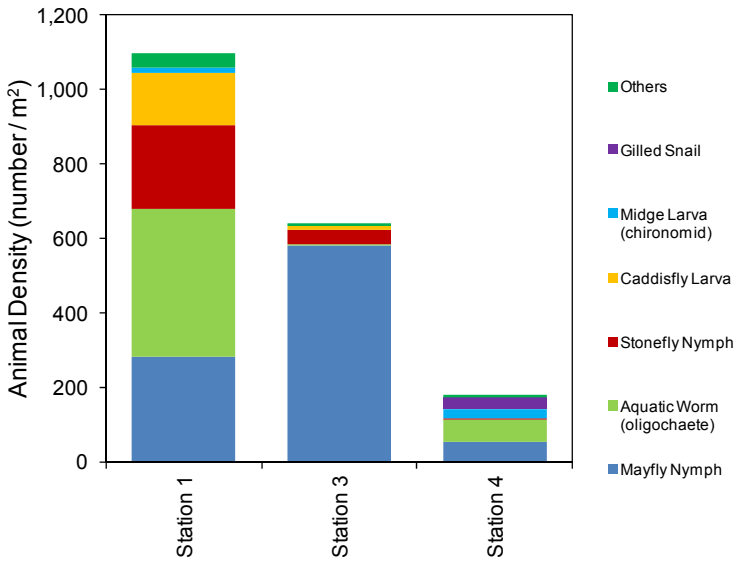

Figure 2. Density of stream invertebrates obtained from triplicate samples taken on 30 October 2011 at three stations on the C.W. Young Channel. The "Other" category includes cranefly larvae, amphipod, watersnipe larvae and water mite. Data are summarized in Table 8 and Invertebrate Survey Field Data Sheets are included in Appendix 2.

5. Acknowledgements

The authors would like to thank Joan Michel (Parks and Trails Coordinator, Recreation and Parks Department, Regional District of Nanaimo) for facilitating site access and logistic support. We would like to acknowledge Margaret Wright (Fisheries and Oceans Canada) for continued support in facilitating this and other monitoring projects. Additional support was provided by students attending the Environmental Monitoring (RMOT 306) course at Vancouver Island University – Melissa Dorey, Greg Faasse, Sarah Gordon, Greg Haider, Josiah Klassen, Alina Koch, Braeden Lattanzi, Hayley McCabe, Heather McCubbin, Nik McEwan, Dan McNeill, Steph Righi, Clayton Smith and Chris White. The Resource Management Officer Technology (RMOT) and Biology Departments at Vancouver Island University provided some laboratory supplies, equipment, vehicle and covered fuel expenses. The Regional District of Nanaimo and Fisheries and Oceans Canada provided funding for analytical processing of water samples. ALS Laboratory provided reduced rates on some of their analytical services for this project and other projects conducted as part of the Environmental Monitoring course.

6. References

Hawkes, V.C., M. Gaboury, and J.D. Fenneman. 2008. Management Plan for the Englishman River Regional Park, A Conservation Area along the River Corridor: Inventory of Natural Resources. LGL Project EA1988. Unpublished report by LGL Limited environmental research associates for Regional District of Nanaimo, Nanaimo, BC.

RISC. 1998. Guidelines for Interpreting Water Quality Data. Resources Information Standards Committee, Victoria, BC.

Taccogna, G., and K. Munro (eds). 1995. The Streamkeepers Handbook: a Practical Guide to Stream and Wetland Care. Salmonid Enhancement Program, Dept. Fisheries and Oceans, Vancouver, BC.

Vancouver Island University (VIU: L. Clarke, M. Colwell, M. Cormie, and E. Demers). 2009. Water Quality and Stream Invertebrate Assessment for the C.W. Young Channel, Englishman River, BC (Fall 2008). Data Report.

Vancouver Island University (VIU: Loni Arman, Lisa Somers, Brad Wiest, and E. Demers). 2010. Water Quality and Stream Invertebrate Assessment for the C.W. Young Channel, Englishman River, BC (Fall 2009). Data Report.

Vancouver Island University (VIU: Simon Johnson, Brennan Krantz, Kris Taekema, and E. Demers). 2011. Water Quality and Stream Invertebrate Assessment for the C.W. Young Channel, Englishman River, BC (Fall 2010). Data Report.

7. Appendices

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

Photo 1. Cross-channel view taken from the right bank at station 1 on 30 October 2011, showing the discharge end of the intake pipe into the C.W. Young side channel.

Photo 2. Cross-channel view taken from the right bank at station 2 on 30 October 2011, immediately downstream of the culvert outlet.

APPENDIX 1. (Continued)

Photo 3. Cross-channel view taken from the right bank at station 3 on 30 October 2011, showing abundant large woody debris in the channel.

Photo 4. Cross-channel view taken from the right bank at station 4 on 30 October 2011, downstream of the steel sill fence near the downstream end of the channel.

APPENDIX 1. (Continued)

Photo 5. Downstream view of the channel near sampling location 5 on 30 October 2011, showing the confluence with the Englishman River mainstem.

APPENDIX 2. Invertebrate Survey Field Data Sheet completed for triplicate stream invertebrate samples collected at stations 1, 3 and 4 on the C.W. Young Channel during 30 October 2011.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: CW Young		Date: 30 October 2011
Station Name: **Station 1**		Flow status: Moderate
Sampler Used: Hess	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.09 x 3 = 0.27 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1 Pollution Intolerant	Caddisfly Larva (EPT)	38	2
	Mayfly Nymph (EPT)	76	3
	Stonefly Nymph (EPT)	61	2
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		175	7
Category 2 Somewhat Pollution Tolerant	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	4	1
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)		
	Watersnipe Larva	1	1
Sub-Total		5	2
Category 3 Pollution Tolerant	Aquatic Worm (oligochaete)	107	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	4	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite	5	2
Sub-Total		116	4
TOTAL		296	13

APPENDIX 2. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 296

DENSITY: Invertebrate density per square metre:

296 ÷ 0.27 = 1096

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C): Aquatic Worm (oligochaete)

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x 7 + 2 x 2 + 4 = 29

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

2 + 3 + 2 = 7

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

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

(EPT1 + EPT2 + EPT3) / CT

(38 + 76 + 61) / 296 = 0.59

SECTION 3 - DIVERSITY

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

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

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

Col. C for S3 / CT

107 / 296 = 0.36

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
Accpetable	3
Marginal	2
Poor	1

Assessment	Rating
Pollution Tolerance Index	4
EPT Index	3
EPT To Total Ratio	3
Predominant Taxon Ratio	4

Average Rating
3.50

APPENDIX 2. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: CW Young		Date: 30 October 2011
Station Name: **Station 3**		Flow status: Moderate
Sampler Used: Hess	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.09 x 3 = 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)	3	1
	Mayfly Nymph (EPT)	157	3
	Stonefly Nymph (EPT)	10	1
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		170	5
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)		
	Watersnipe Larva		
Sub-Total		0	0
Category 3	Aquatic Worm (oligochaete)	1	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
	Planarian (flatworm)		
Pollution Tolerant	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite	2	1
Sub-Total		3	2
TOTAL		173	7

APPENDIX 2. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 173

DENSITY: Invertebrate density per square metre:

173 ÷ 0.27 = 641

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C): Mayfly Nymph (EPT)

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x 5 + 2 x 0 + 2 = 17

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1 + 3 + 1 = 5

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

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

(EPT1 + EPT2 + EPT3) / CT

(3 + 157 + 10) / 173 = 0.98

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 7

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

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

Col. C for S3 / CT

163 / 287 = 0.91

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
Accpetable	3
Marginal	2
Poor	1

Assessment	Rating
Pollution Tolerance Index	3
EPT Index	3
EPT To Total Ratio	4
Predominant Taxon Ratio	1

Average Rating
2.75

APPENDIX 2. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	CW Young		Date:	30 October 2011
Station Name:	**Station 4**		Flow status:	Moderate
Sampler Used:	Number of replicates	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates		
Hess	3	0.09 x 3 =	0.27	m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1 **Pollution Intolerant**	Caddisfly Larva (EPT)		
	Mayfly Nymph (EPT)	14	2
	Stonefly Nymph (EPT)	1	1
	Dobsonfly (hellgrammite)		
	Gilled Snail	9	1
	Riffle Beetle		
	Water Penny		
Sub-Total		24	4
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	2	1
	Watersnipe Larva		
Sub-Total		2	1
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	17	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	6	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		23	2
TOTAL		49	7

APPENDIX 2. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 49

DENSITY: Invertebrate density per square metre:

49 ÷ 0.27 = 181

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C): Aquatic Worm (oligochaete)

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x __4__ + 2 x __1__ + __2__ = 16

EPT INDEX: Total number of EPT taxa.

Good	Accpetable	Marginal	Poor
>8	5-8	2-5	0-1

EPT4 + EPT5 + EPT6

__0__ + __2__ + __1__ = 3

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

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

(EPT1 + EPT2 + EPT3) / CT

(0 + 14 + 1) / 49 = 0.31

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 7

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

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

Col. C for S3 / CT

17 / 49 = 0.35

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
Accpetable	3
Marginal	2
Poor	1

Assessment	Rating
Pollution Tolerance Index	2
EPT Index	2
EPT To Total Ratio	2
Predominant Taxon Ratio	4

Average Rating
2.50