DATA REPORT

Water Quality and Stream Invertebrate Assessment

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

(Fall 2008)

Report prepared by:

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Table of Contents

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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 2008.

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 (Lukas Clarke, Melissa Colwell and Mya Cormie). 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 35 student-hours to this project, including site visits, project proposal, field sampling, laboratory analyses, and oral and written presentations. Dr. Eric Demers contributed approximately 10 hours for project management and report compilation. Ms. Sarah Greenway provided 5 hours of laboratory support for this project.

Logistical support was provided by Fisheries and Oceans Canada (DFO) and the Regional District of Nanaimo. Funding for field expenses and analytical processing of water samples was provided by the BC Conservation Foundation, BC Living Rivers Trust Fund and Fisheries and Oceans Canada. ALS Laboratory (Vancouver, 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 the 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 habitat and pond habitat for spawning and rearing Pacific salmon and trout. The entire channel is dependent on surface flow from the Englishmen River.

To date, there has been limited environmental monitoring conducted on the C.W. Young Channel. Therefore, this report documents a water quality and stream invertebrate assessment conducted on the C.W. Young Channel, Englishman River, BC, during October-November 2008.

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 (October, November 2008);
- obtain water samples from each sampling station during two sampling events (October, November 2008) for detailed laboratory analyses; and,
- collect stream invertebrate samples at 3 sampling stations during one sampling event (October 2008) 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.

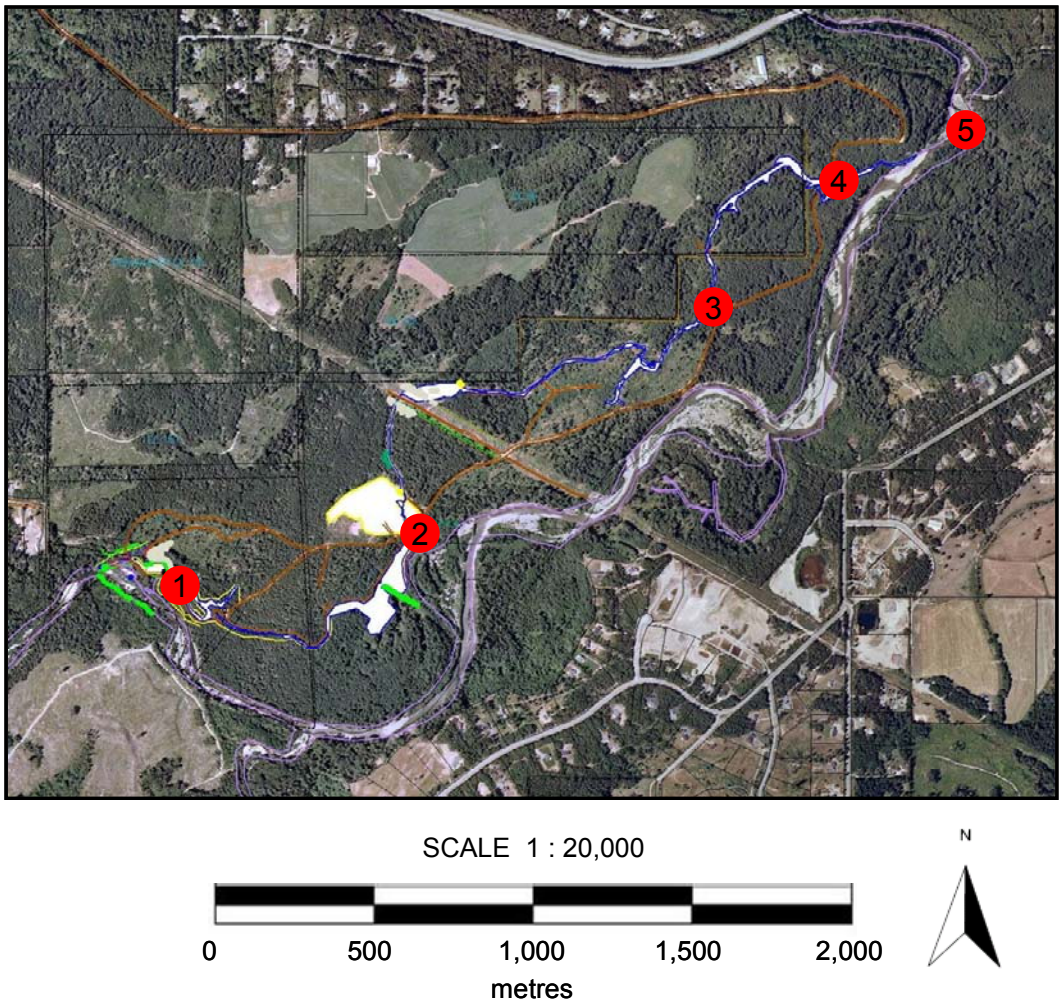

Figure 1. Approximate location of the sampling stations used for water quality and stream invertebrate assessments on the C.W. Young Channel, during October-November 2008. The C.W. Young Channel and Englishman River are outlined in blue and purple, respectively. Access roads are outlined in brown. Table 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 2008 (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. In addition, the station locations were based on channel inspection locations provided by DFO (see Table 1 for corresponding DFO inspection point numbering). 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 a 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, approximately 250 m downstream of 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 2008. Inspection point numbers refer to corresponding locations as identified by Fisheries and Oceans Canada (DFO).

Station	DFO Inspection Point No.	Distance from Upstream End (m)	General Location
1	2	0	Upstream channel entrance, 1 m downstream of steel pipe valve
2	5	1,250	Road crossing, start of 2007 channel extension
3	7	2,900	Channel section near access road
4	9	3,800	1 m upstream of steel sill structure
5	N/A	N/A	Main stem Englishman River, 250 m downstream of channel outlet

3.1.2. Sampling Schedule

Field sampling was conducted on 28 October and 18 November 2008. 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 October 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 28 October and 18 November 2008. At each sampling station, field measurements of water temperature (to the nearest 0.01 ^{o}C), dissolved

oxygen (to the nearest 0.01 mg/L), conductivity (to the nearest 1 μSiemens/cm) and pH (to the nearest 0.01 pH unit) were obtained with a YSI 556 MPS 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 2008. The symbols "O" or "N" indicate whether samples / measurements were taken during the October or November sampling events, respectively.

Station	Water Quality				Stream Invertebrates
	Field Measurements	VIU Analyses	ALS Lab Analyses	Microbiology	
1	O, N	O, N	O, N	O	O
2	O, N	O, N	O, N	O	---
3	O, N	O, N	O, N	O	O
4	O, N	O, N	O, N	O	O
5	O, N	O, N	---	O	---

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 Vancouver, 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^{o}C. Laboratory analyses were conducted at VIU within 24 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.

Quality control samples (one trip blank and one field blank) were also included during both sampling events 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. The field blank was prepared by transferring 500 ml of distilled water into a plastic bottle while in the field.

Table 3. Sampling containers and preservatives used for water quality samples taken at the C.W. Young Channel and Englishman River during October-November 2008. All containers and preservatives for analysis by ALS Laboratory were provided by ALS Laboratory, Vancouver, BC.

Analytical Parameters	Container	Preservative	Analysed by
Total hardness, total alkalinity, total suspended solids, reactive phosphorus, nitrate	500 ml plastic	None	VIU
Conductivity, pH, total hardness, total suspended solids	1 L plastic	None	ALS Laboratory
Anions, 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 hardness, total alkalinity, total suspended solids, reactive phosphorus and nitrate. Total hardness (as $CaCO_3$) was measured to the nearest 1 mg/L using a HACH HA-71A test kit. Total alkalinity (as $CaCO_3$) was measured to the nearest 0.1 mg/L using the HACH AL-DT digital titration method. Total suspended solids were measured to the nearest 1 mg/L using a HACH DR2800 Spectrophotometer (Method 8006). Reactive phosphorus (orthophosphate) was measured to the nearest 0.01 mg/L using a HACH DR2800 Spectrophotometer (Method 8048). Nitrate was measured to the nearest 0.01 mg/L using a HACH DR2800 Spectrophotometer (Method 8192).

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, total suspended solids, six anions and nutrients, 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. The inclusion of trip and field blanks provided means of detecting any widespread contamination resulting from the container (including caps) or field procedures.

3.2.6. Data Analyses – Comparison with Applicable Guidelines

Water quality results were compared with the provincial and federal 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) (BCMWLAP 1998a, 1998b). The guidelines from the Canadian Council of Ministers of the Environment were also used for water quality comparisons (CCME 2003). Both sets of guidelines were applicable to all sampling stations.

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 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

Water samples for total and fecal coliform enumeration were collected from each sampling station on 28 October 2008 (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 24 hours to Vancouver Island University for laboratory analysis.

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 10-ml volume of sample water was extracted from each sample bag with a sterile pipette and 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 10 ml of sterile water using the same filtration procedures. Each membrane filter (including the blank) was then transferred to a 100-mm 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.

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

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

3.4. Stream Invertebrates

3.4.1. Sampling Stations

Stream invertebrate samples were collected from stations 1, 3 and 4 on 28 October 2008 (Table 1; Figure 1). The sampling stations were selected based on hydrological characteristics, apparent substrate uniformity, space available for replicate samples and site access. At the time of sampling, all stations consisted of shallow riffles (water depth ~15-25 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

Discharge measurements for the C.W. Young Channel suggest that water levels were not at bankfull at the time of sampling. Measurements taken by Fisheries and Oceans Canada (DFO; M. Wright, unpublished data) on 30 October 2008 indicated discharge of 0.5 m^3/s and 0.3 m^3/s near Stations 1 and 4, respectively. The reduction in discharge with distance downstream was due to some water leaving the channel at a constructed spillway located midway along the channel.

Discharge measurements for the mainstem Englishman River were 2.8 m^3/s and 6.4 m^3/s on 28 October and 18 November 2008, respectively (real-time hydrometric data retrieved from Environment Canada, Water Survey: http://scitech.pyr.ec.gc.ca/waterweb/). A significant rainfall event occurred during 06-08 November 2008, when approximately 63 mm of precipitation fell within a 72 hour period (data for Comox Airport retrieved from http://www.theweathernetwork.com). Consequently, Englishman River discharge peaked at 120 m^3/s on 08 November 2008.

During this sampling program, weather conditions were sunny with clouds, no precipitation and air temperature of 6-8^oC. Average air temperature during the 10-day period prior to each sampling event was 6.8^oC for the October event and 8.5^oC for the November event.

4.1. Water Quality

4.1.1. Field Measurements and VIU Laboratory Analyses

Water temperature averaged 6.3^oC and 7.6^oC during the October and November sampling events, respectively (Table 5). The increase in water temperature between events reflected the warmer air temperature during the 10-day period prior to the November event. All dissolved oxygen levels were above the minimum guideline of 9.0 mg/L for early fish life stages (RISC 1998), except for station 5 on the mainstem Englishman River (8.70 mg/L). During the October and November sampling events, dissolved oxygen concentrations were at 100-111% and 73-93% saturation, respectively.

Mean conductivity decreased from 89 to 62 µS/cm between the October and November sampling events, likely as a result of dilution due to increased discharge. Slight variability among station may indicate differential surface inflow and groundwater seepage along the length of the channel. Water pH was near neutral throughout this study, and averaged 7.24 and 6.94 during the October and November sampling events, respectively.

Table 5. Field measurements taken from five stations on the C.W. Young Channel and Englishman River on 28 October and 18 November 2008.

Station	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH
		28 October 2008		
1	6.08	13.76	82	7.44
2	5.29	13.34	80	7.35
3	6.89	12.28	74	6.97
4	6.11	12.40	123	7.18
5	6.95	13.51	86	7.24
		18 November 2008		
1	7.32	11.22	62	7.31
2	7.61	10.63	61	6.70
3	7.56	10.02	59	6.67
4	7.59	9.40	68	6.79
5	7.83	8.70	61	7.23

Total hardness and total alkalinity were similar throughout this study, and both declined between the October and November sampling events (Table 6). Mean total alkalinity was above 20 mg/L during October, indicating "low acid sensitivity" as defined by RISC (1998). During November, total alkalinity ranged from 14.7 to 22.8 mg/L, indicating "moderate" to "low acid sensitivity". During both sampling events, station 4 had the highest alkalinity levels. Total suspended solids remained low near minimum detection limits during both sampling events.

During both sampling events, reactive phosphorus levels were highly variable and were higher at upstream stations 1-2 relative to stations 3-5. Mean nitrate levels increased from 0.07 to 0.15 mg/l between the October and November sampling events. Potential contamination of samples for both reactive phosphorus and nitrate may have occurred as suggested by the general correlation between water sample results and results for the trip and field blanks.

Table 6. Laboratory results for water samples taken from five stations on the C.W. Young Channel and Englishman River on 28 October and 18 November 2008.

Station	Total Hardness (mg/L $CaCO_3$)	Total Alkalinity (mg/L $CaCO_3$)	Total Suspended Solids (mg/L)	Reactive Phosphorus (mg/L)	Nitrate (mg/L)
		28 October 2008			
1	29	21.9	3	0.50	0.07
2	25	22.0	1	0.69	0.06
3	26	20.6	1	0.09	0.04
4	45	43.0	1	0.07	0.14
5	27	22.7	1	0.02	0.05
Trip Blank	---	---	<1	0.06	0.06
Field Blank	---	---	<1	0.03	0.05
		18 November 2008			
1	28	14.7	1	0.25	0.16
2	29	18.7	1	0.14	0.16
3	31	19.9	1	0.11	0.14
4	30	22.8	1	0.12	0.16
5	24	17.8	2	0.10	0.12
Trip Blank	---	---	<1	0.12	0.16
Field Blank	---	---	<1	0.08	0.12

4.1.2. ALS Laboratory Analyses

Water quality results were compared to the BC Provincial water quality guidelines and the federal CCME guidelines for the protection of aquatic life (Table 7).

The pH measurements from ALS Laboratories were less variable (7.33-7.62) than field measurements obtained with the electronic probe. Field measurements were generally lower than the ALS Laboratories results. This discrepancy possibly reflects improper calibration, differences in air space content among sampling containers and/or time elapsed between sampling and laboratory analysis.

Table 7. Laboratory results (ALS Laboratory) for water samples taken from 4 stations at the C.W. Young Channel on 28 October and 18 November 2008. All values are expressed in mg/L unless specified otherwise. No water samples were analysed for station 5 during either sampling event. No values exceeded the applicable water quality guidelines. See additional notes on the next page.

	BC Water Quality Guidelines [a]			28 October 2008				18 November 2008			
	BC Max	BC 30-day Mean	CCME [b]								
Variable	mg/L	mg/L	mg/L	1	2	3	4	1	2	3	4
General/Physical											
Conductivity (µS/cm)				80.7	78.1	72.4	121	62.4	63	59.6	68.4
Hardness, Total				28.0	26.7	25.5	49.7	22.9	22.3	21.9	26.4
pH (pH units)	6.5 - 9.0		6.5 - 9.0	7.38	7.52	7.55	7.33	7.61	7.60	7.56	7.62
Total Suspended Solids				<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Nutrients											
Bromide (Br)				<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	600	150		10.6	9.89	8.87	9.08	5.7	5.43	5.09	5.33
Fluoride (F)	0.2 [c]			<0.020	<0.020	<0.020	0.029	<0.020	<0.020	<0.020	<0.020
Nitrate (as N)	200	40	13	0.01	<0.0050	<0.0050	0.07	0.04	0.03	0.03	0.04
Nitrite (as N)	0.18 [d]	0.09 [d]	0.06	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0013
Sulfate (SO_4)	100			1.460	1.390	1.280	2.010	1.580	1.540	1.460	1.550
Total Metals											
Aluminum (Al) [n]	0.10 [e]	0.05 [e]	0.10 [e]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Antimony (Sb) [n]	0.02			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Arsenic (As) [n]	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) [n]	0.00001 [f]		0.00001 [f]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Calcium (Ca)				9.7	9.1	8.2	12.6	7.7	7.5	7.3	8.1
Chromium (Cr) [n]	0.001 [g]		0.001 [g]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cobalt (Co) [n]	0.11	0.004		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Copper (Cu) [n]	0.004 [h]	0.002 [h]	0.002 [h]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron (Fe)	0.3		0.3	<0.030	0.123	0.091	0.259	0.058	0.123	0.133	0.146
Lead (Pb) [n]	0.011 [i]	0.004 [i]	0.001 [i]	<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)				0.9	0.9	1.2	4.4	0.9	0.9	0.9	1.5
Manganese (Mn)	0.78 [j]	0.70 [j]		<0.0050	0.012	0.009	0.016	<0.0050	0.007	0.006	0.005
Molybdenum (Mo)	2	1	0.073	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Nickel (Ni) [n]	0.025 [k]		0.025 [k]	<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) [n]		0.002	0.001	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Silicon (Si)				2.00	1.98	2.02	4.69	2.68	2.63	2.65	3.18
Silver (Ag) [n]	0.0001 [l]	0.00005 [l]	0.0001	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Sodium (Na)				4.5	4.3	3.8	4.5	3.3	3.1	3.0	3.2
Strontium (Sr)				0.038	0.037	0.030	0.041	0.032	0.030	0.028	0.031
Thallium (Tl)	0.0003	0.0008		<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) [n]	0.006	0.02		<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zinc (Zn)	0.033 [m]	0.0075 [m]		<0.0050	<0.0050	<0.0050	0.006	<0.0050	<0.0050	<0.0050	<0.0050

Table 7. (Continued)

NOTES:

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

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

[b] Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines (WQGs) compiled from CCME (2003).

[c] Fluoride guideline is 0.2 mg/L for hardness < 50 mg/L.

[d] Nitrite guideline is dependent on chloride concentration. Guideline range shown is based on chloride concentration ≥ 4 mg/L.

[e] Aluminum guidelines for pH ≥ 6.5.

[f] The BC maximum cadmium guideline is $0.001 * 10^{\{0.86 [\log(\text{hardness})] - 3.2\}}$ mg/L. Guideline shown is based on hardness of 22-50 mg/L.

[g] Chromium guideline is for the more toxic Chromium VI. The guideline for Chromium VI is 0.0089 mg/L.

[h] The BC maximum copper guideline is [0.000094(hardness) + 2] mg/L. The BC 30-day mean copper guideline is 0.002 µg/L for hardness < 50 mg/L. The CCME guideline for copper is 0.002 mg/L at hardness of 1-120 mg/L. Guidelines shown are based on hardness of 22-50 mg/L.

[i] The BC maximum lead guideline is $0.001 * e^{\{1.273 [\ln(\text{hardness})] - 1.46\}}$ mg/L. The BC 30-day mean lead guideline is $0.001 * [3.31 + e^{\{1.273 [\ln(\text{hardness})] - 4.704\}}]$ mg/L. The CCME guideline for lead is 0.001 mg/L for hardness of 0-60 mg/L. Guidelines shown are based on hardness of 22-50 mg/L.

[j] The BC maximum manganese guideline is 0.01102 * (hardness) + 0.54 mg/L. The BC 30-day mean manganese guideline is 0.0044 * (hardness) + 0.605 mg/L. Guidelines shown are based on hardness of 27-50 mg/L.

[k] Nickel guideline is 0.025 mg/L for hardness of 0-60 mg/L.

[l] The BC maximum silver guideline is 0.0001 mg/L for hardness ≤100 mg/L. The BC 30-day mean silver guidelines is 0.00005 mg/L for hardness ≤100 mg/L.

[m] The BC maximum zinc guideline is 0.033 mg/L for hardness ≤90 mg/L. The BC 30-day mean zinc guidelines is 0.0075 mg/L for hardness ≤90 mg/L.

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

The conductivity measurements from ALS Laboratories were consistent with the field measurements obtained with the electronic probe and differed by <2%. Similarly, total hardness measurements from ALS Laboratories were consistent with the VIU laboratory results, including higher values for station 4. All total suspended solids results were below detection limits during both sampling events.

All anion levels were well below applicable guidelines. Nitrate levels from ALS Laboratories were significantly lower than the VIU laboratory results, although in both cases overall levels were low and below applicable guidelines.

All total metal concentrations were below the applicable water quality guidelines during both sampling events. With the exception of iron, most metals with applicable guidelines were below minimum detection limits. Although analytical detection limits were above applicable guidelines for some metal parameters, there was no apparent trends suggesting potential metal contamination.

4.2. Microbiology

All samples collected from the C.W. Young Channel and Englishman River contained some coliform bacteria (Table 8). In the C.W. Young Channel, total coliform counts increased from upstream to downstream. Overall, the observed total coliform levels were relatively low compared to levels typical for streams in urban / agricultural areas (e.g., Millstone River, Nanaimo, October 2008: 440-4,800 colonies per 100 ml; RMOT 360, unpublished data). None of the samples contained *E. coli* bacteria.

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

Table 8. Total coliform and *E. coli* counts from water samples taken at five stations on the C.W. Young Channel and Englishman River on 28 October 2008. All values are expressed as number of bacteria per 100 ml. No samples were collected on 18 November 2008.

Station	Total Coliform	*E. coli*	% *E. coli*
1	20	0	0
2	80	0	0
3	100	0	0
4	270	0	0
5	140	0	0
Filtration blank	0	0	–

4.3. Stream Invertebrates

A total of 679 stream invertebrates representing 12 broad taxonomic groups were counted at three stations on the C.W. Young Channel on 28 October 2008 (Table 9; Figure 2; Appendix 2). Animal density averaged 838 animals/m^2, with a range of 670-1,000 animals/m^2. Overall, mayfly nymph was the most common taxonomic group, although aquatic worms (oligochaetes) and scuds (amphipods) were the dominant taxa at Stations 1 and 4.

Site assessment ratings ranged from 3.0-3.5 suggesting "acceptable" to "good" invertebrate community abundance and diversity. The consistent representation of pollution-sensitive mayfly nymphs, stonefly nymphs and caddisfly larvae (EPT taxa: 40-56% of total abundance) indicates generally "favourable" environmental conditions. These findings are encouraging since a large section of the channel was artificially created in 2007, suggesting relatively rapid colonization.

Table 9. Abundance and density of stream invertebrates obtained from triplicate samples taken on 28 October 2008 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.

Pollution Tolerance	Invertebrate Taxa	Station 1	Station 3	Station 4
Category 1 Pollution Intolerant	Caddisfly larva	30	18	3
	Mayfly nymph	97	95	63
	Stonefly nymph	24	38	25
	Gilled snail			4
Category 2 Somewhat Pollution Intolerant	Aquatic sowbug (Isopod)			3
	Cranefly larva	19	16	5
	Scud (Amphipod)			72
Category 3 Pollution Tolerant	Aquatic Worm (Oligochaete)	98	13	42
	Leech			3
	Flatworm (Planarian)	1		
	Midge larva (Chironomid)		1	8
	Water mite	1		
	Total Abundance	270	181	228
	Density (number / m^2)	1,000	670	844
	Site Assessment Rating	3.50	3.25	3.00

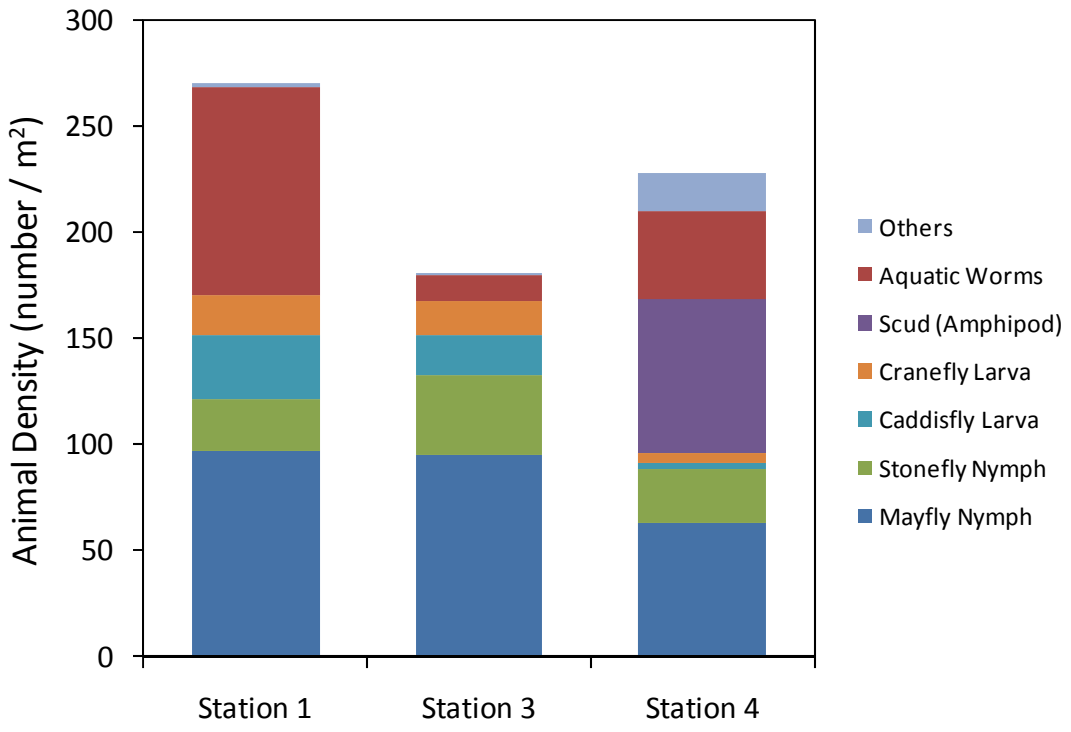

Figure 2. Density of stream invertebrates obtained from triplicate samples taken on 28 October 2008 at three stations on the C.W. Young Channel. The "Other" category includes gilled snail, aquatic sowbug (Isopod), leech, flatworm (planarian), midge larva (chironomid), and water mite. Data are summarized in Table 9 and Invertebrate Survey Field Data Sheets are included in Appendix 2.

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7. Appendices

APPENDIX 1. Photographs showing site conditions and sampling activities conducted on the C.W. Young Channel during 28 October 2008.

Photo 1. Mya Cormie and Lukas Clarke obtaining field measurements of water quality at Station 5 located on the main channel of the Englishman River.

Photo 2. Lukas Clarke collecting a water sample at Station 5 located on the main channel of the Englishman River.

APPENDIX 1. (Continued)

Photo 3. Melissa Colwell and Lukas Clarke obtaining a stream invertebrate sample with a Hess sampler at Station 3 located on the C.W. Young Channel.

Photo 4. Large woody debris forming a small pool at Station 3 located on the C.W. Young Channel.

APPENDIX 1. (Continued)

Photo 5. Example of large woody debris installed near Station 3 on the C.W. Young Channel to create habitat for juvenile salmonids.

Photo 6. Salmon carcasses present near Station 2 on the C.W. Young Channel.

APPENDIX 1. (Continued)

Photo 7. Example of salmon carcass found on bank of the C.W. Young Channel.

Photo 8. Salmon carcasses found in a pool near Station 2 on the C.W. Young Channel.

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 28 October 2008.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	C.W. Young Channel, Englishman River		Date: 28 October 2008
Station Name:	**Station 1**		Flow status: Low
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)	30	3
	Mayfly Nymph (EPT)	97	3
	Stonefly Nymph (EPT)	24	2
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		151	8
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	19	2
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)		
	Watersnipe Larva		
Sub-Total		19	2
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	98	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
	Planarian (flatworm)	1	1
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite	1	1
Sub-Total		100	3
TOTAL		270	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**: 270

DENSITY: Invertebrate density per square metre:

270 ÷ 0.27 = 1000

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	22-17	16-11	<11

3 x D1 + 2 x D2 + D3

3 x __8__ + 2 x __2__ + __3__ = 31

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

__3__ + __3__ + __2__ = 8

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	0.50-0.75	0.25-0.50	0-0.25

(EPT1 + EPT2 + EPT3) / CT

(__30_ + __97_ + __24_) / _270_= 0.56

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
0-0.40	0.40-0.60	0.60-0.80	0.80-1.0

Col. C for S3 / CT

__98_ / _270_ = 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:	C.W. Young Channel, Englishman River	Date:	28 October 2008
Station Name:	**Station 3**	Flow status:	Low

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)	18	2
	Mayfly Nymph (EPT)	95	2
	Stonefly Nymph (EPT)	38	1
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		151	5
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	16	2
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)		
	Watersnipe Larva		
Sub-Total		16	2
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	13	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	1	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		14	2
TOTAL		181	9

APPENDIX 2. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 181

DENSITY: Invertebrate density per square metre:

181 ÷ 0.27 = 670

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C): Mayphly 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	22-17	16-11	<11

3 x D1 + 2 xD2 + D3

3 x __5__ + 2 x __2__ + __2__ = 21

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

__2__ + __2__ + __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	0.50-0.75	0.25-0.50	0-0.25

(EPT1 + EPT2 + EPT3) / CT

(__18_ + __95_ + __38_) / _181_= 0.83

SECTION 3 - DIVERSITY

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

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

Good	Accpetable	Marginal	Poor
0-0.40	0.40-0.60	0.60-0.80	0.80-1.0

Col. C for S3 / CT

__95_ / _181_ = 0.52

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	3

Average Rating
3.25

APPENDIX 2. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	C.W. Young Channel, Englishman River	Date:	28 October 2008
Station Name:	**Station 4**	Flow status:	Low

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)	3	1
	Mayfly Nymph (EPT)	63	2
	Stonefly Nymph (EPT)	25	1
	Dobsonfly (hellgrammite)		
	Gilled Snail	4	1
	Riffle Beetle		
	Water Penny		
Sub-Total		95	5
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug	3	1
	Clam, Mussel		
	Cranefly Larva	5	2
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	72	2
	Watersnipe Larva		
Sub-Total		80	5
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	42	1
	Blackfly Larva		
	Leech	3	1
	Midge Larva (chironomid)	8	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		53	3
TOTAL		228	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**: 228

DENSITY: Invertebrate density per square metre:

228 ÷ 0.27 = 844

PREDOMINANT TAXON:

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

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x __5__ + 2 x __5__ + __3__ = 28

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

__1__ + __2__ + __1__ = 4

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	0.50-0.75	0.25-0.50	0-0.25

(EPT1 + EPT2 + EPT3) / CT

(__3_ + __63_ + __25_) / _228_= 0.40

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
0-0.40	0.40-0.60	0.60-0.80	0.80-1.0

Col. C for S3 / CT

__72_ / _228_= 0.32

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	2
EPT To Total Ratio	2
Predominant Taxon Ratio	4

Average Rating
3.00