DATA REPORT

Water Quality and Invertebrate Assessment

for the MB Channel, Englishman River, BC,

(Fall 2010)

Report prepared by:

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1. Background

This report documents a water quality and invertebrate assessment conducted on the MacMillan Bloedel (MB) Channel, Englishman River, BC, during November 2010.

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 (Tony Maestrello, Tom Mainella, James Russell). 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.

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, the Living Rivers - Georgia Basin / Vancouver Island program, and Fisheries and Oceans Canada. ALS Laboratory (Burnaby, BC) provided reduced rates on their analytical services for this project.

2. Introduction

The MB Channel is located on the southern bank of the Englishman River on Vancouver Island, BC, within the Englishmen River Regional Park and Conservation Area. It is approximately 6 km upstream from the Englishman River Estuary in Parksville Bay (Hawkes et al., 2008). The channel is approximately 950 metres long and provides off-channel and pond habitat for rearing Pacific salmon and trout. The channel is mainly dependent on surface flow from the Englishmen River.

This report documents a water quality and invertebrate assessment conducted on the MB Channel, Englishman River, BC, during November 2010.

Specific objectives for this study of the MB Channel included:

- establish 4 water quality sampling stations;
- obtain field measurements of water quality at the 4 sampling stations during two sampling events (early and late November 2010);
- obtain water samples from each sampling station during two sampling events (early and late November 2010) for detailed laboratory analyses; and,
- collect invertebrate samples at 3 sampling stations during one sampling event (early November 2010) for analysis at Vancouver Island University.

3. Methods

3.1. Study Site

This project was conducted at the MB Channel located along the Englishman River (Figure 1). The MB Channel was constructed in the 1990's by Fisheries and Oceans Canada (DFO) with support of MacMillan Bloedel (MB) (Hawkes et al., 2008). Surface flow from the Englishmen River is provided through an intake valve at the upstream (western) end of the channel. The channel was built to provide resident and anadromous salmonids with new spawning and juvenile rearing habitat.

3.1.1. Sampling Stations

Four stations were established on the MB Channel during November 2010 (Tables 1 and 2; Figure 1). The location of each station was chosen to provide adequate coverage for the length of the MB Channel. Stations were numbered from the upstream end to the downstream end of the channel. All stations were easily accessed via foot paths. Station 1 was located one metre downstream of the intake valve and served as a reference station for initial conditions at channel entry. Stations 2-3 were located at intervals along the channel. Station 4 was located just downstream of an access foot bridge, near the channel outlet. Site conditions were similar at all stations and consisted of moderate to steep banks, with open water of negligible flow.

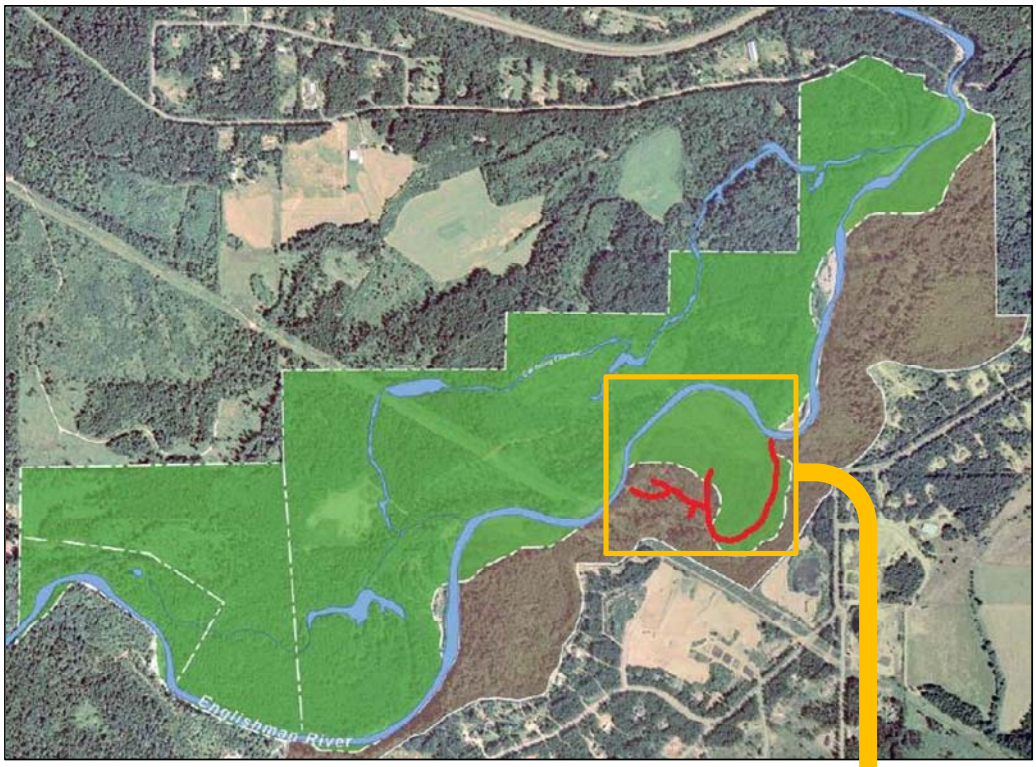
Table 1. Description of the sampling stations used for water quality and invertebrate assessments on the MB Channel during November 2010.

Station	Distance from Upstream End (m)	General Location
1	0	Upstream channel entrance, 1 m downstream of steel pipe valve
2	150	Along main channel, between two small dead-end channels
3	300	50 m upstream of a beaver dam
4	600	5 m downstream of foot bridge, near channel outlet

3.1.2. Sampling Schedule

Field sampling was initially planned to include two events during early and late November 2010. Unfortunately, unusually cold weather conditions during late November 2010 caused the MB Channel to completely freeze over, rendering site conditions unsafe for field sampling. Consequently, this report only documents field sampling conducted on 3 November 2010. For this study, samples were collected for water quality analyses, microbiology and invertebrate assessment. Table 2 lists the specific activities conducted at each station. Photographs showing site conditions and sampling activities are included in Appendix 1 (including site conditions during late November 2010).

(A)



(B)

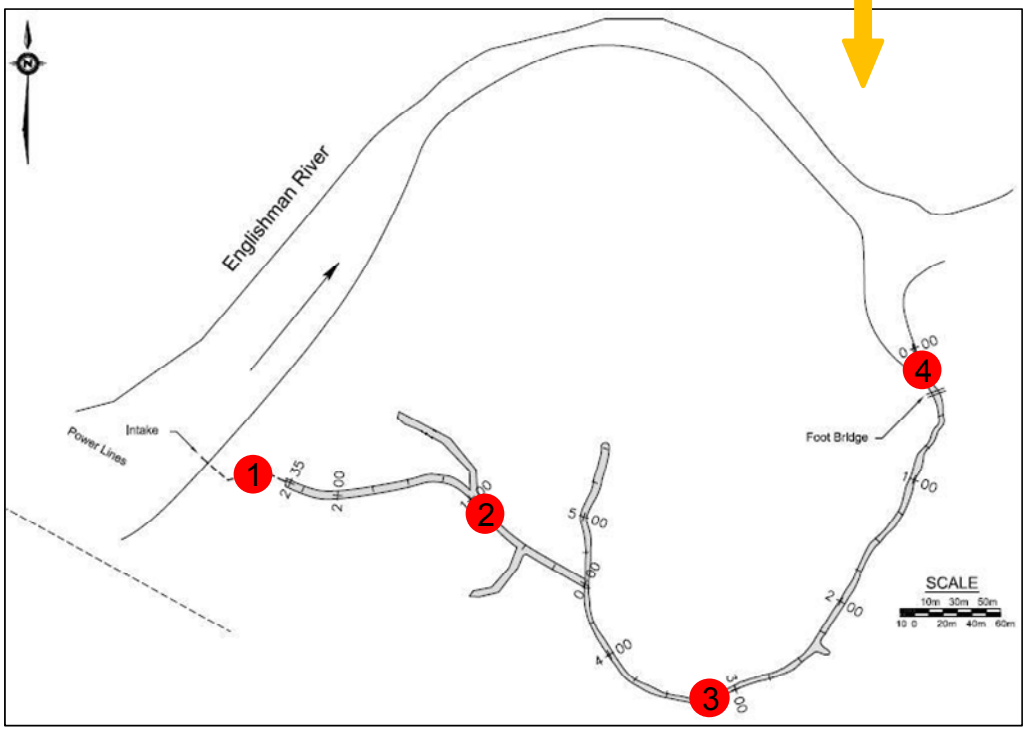


Figure 1. (A) Approximate location of the MB Channel (in red) in the Englishman River Regional Park and Conservation Area. This map was obtained from Lanarc Consultants and LGL (2008). (B) Approximate location of sampling stations along the MB Channel. This map was obtained from Fisheries and Oceans Canada. Table 1 provides details of the specific location of each station. Table 2 details the sampling activities conducted at each station. Map scale is approximated.

3.2. Water Quality

3.2.1. Field Measurements

A water quality sampling event was conducted on 3 November 2010. 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 invertebrate sampling activities conducted at each station on the MB Channel during 3 November 2010.

Station	Water Quality				Invertebrates
	Field Measurements	VIU Analyses	ALS Lab Analyses	Microbiology	
1	X	X	X	X	X
2	X	X	X	X	---
3	X	X	X	X	X
4	X	X [1]	---	X	X

Note: [1] A duplicate sample was collected at station 4 for analysis at the VIU Laboratory.

3.2.2. Water Sampling

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). A duplicate sample was collected at station 4 for analysis at the VIU Laboratory. Samples were obtained while standing on the channel bank or within the 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 48 hours of sampling.

Samples for analysis by ALS Laboratory were collected from stations 1-3 (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 channel bank or within the 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.

Table 3. Sampling containers and preservatives used for water quality samples taken at the MB Channel on 3 November 2010. 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 1 FAU (Formazin attenuation units) using a HACH DR2000 Spectrophotometer (Method 8006).

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. Duplicate sampling provided an estimate of the overall precision associated with the field technique and laboratory analysis.

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 3 November 2010 (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. Invertebrates

3.4.1. Sampling Stations

Invertebrate samples were collected from stations 1, 3 and 4 on 3 November 2010 (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 open water (water depth ~50-100 cm), with negligible water flow, and primarily sand and silt substrate.

3.4.2. Invertebrate Sampling

At each station, three replicate samples (triplicates) were obtained using a D-frame dip net. Invertebrate samples were taken by "kick-and-sweep" of the substrate over a 0.5-m^2 sampling area (approximate) during 1 minute. The content of the 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 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

Average air temperature during the 10-day period prior to each planned sampling event was 9.4^{o}C and 0.4 ^{o}C for the early and late November sampling events, respectively (data for Nanaimo Airport retrieved from http://climate.weatheroffice.gc.ca). Total rainfall during the 10-day period of 25 October to 3 November was 39 mm. Total precipitation during the 10-day period of 15-24 November included 24 mm of rain and 32 cm of snow, with 24 cm of snow on 19 November 2010. As a result of the unusually cold weather conditions during mid to late November, the second sampling event scheduled for 24 November was cancelled due to unsafe site conditions, which included slippery banks and approximately 5-10 cm of ice over the entire channel length. Therefore, only results from the 3 November 2010 sampling event are presented.

4.1. Water Quality

4.1.1. Field Measurements and VIU Laboratory Analyses

Water temperature on 3 November 2010 ranged from 9.4 to 10.2 ^{o}C (Table 5). As previously mentioned, the entire surface of the MB Channel was frozen on 24 November 2010, which suggests that water flow was negligible through the MB Channel.

Dissolved oxygen levels on 3 November 2010 ranged from 5.3 to 8.9 mg/L (Table 5), which were below the minimum guideline of 9.0 mg/L for early fish life stages (RISC 1998). These dissolved oxygen concentrations represented saturation levels of 47-79%. The negligible water flow in the MB Channel likely contributed to these reduced oxygen saturation levels.

Conductivity ranged from 46 to 84 µS/cm and increased from upstream to downstream stations (Table 5). Although an increase in conductivity with distance downstream along the channel is expected, the magnitude of the increase over the relatively short length of the channel suggests potential groundwater intrusion along the channel. This is not unexpected since the eastern portion of the MB Channel was initially built as a groundwater channel (Sheng at al., 1998).

Field measurements of pH ranged from 6.35 to 6.74 during this study (Table 5). Total alkalinity ranged from 11.0 to 27.2 mg/L and generally increased from upstream to downstream stations. The increase in alkalinity with distance downstream along the channel corresponds to the increase in conductivity noted earlier. Overall, total alkalinity suggests "moderate" to "low" sensitivity to acidification as defined by RISC (1998). Turbidity ranged from 1.0 and 4.0 FAU 3 November 2010.

A comparison of the water quality results from the duplicate samples taken at station 4 indicates that most values were within ±6% of each other.

Table 5. Field measurements and laboratory results (VIU Laboratory) for water samples taken from four stations on the MB Channel during 3 November 2010. VIU Laboratory results for station 4 represent the average of duplicate samples.

	Field Measurements				VIU Laboratory	
Station	**Temperature (^{o}C)**	**Dissolved Oxygen (mg/L)**	**Conductivity (µS/cm)**	**pH**	**Total Alkalinity (mg/L $CaCO_3$)**	**Turbidity (FAU)**
1	9.80	7.20	46	6.62	11.0	1
2	10.20	8.90	56	6.51	18.8	4
3	9.40	6.60	74	6.35	27.2	3
4	10.00	5.30	84	6.74	25.2	3

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).

The conductivity measurements from ALS Laboratories were consistent with the field measurements obtained with the electronic probe and differed by <8%.

Total hardness followed similar trends as conductivity, namely a general increase from upstream to downstream stations. Total hardness was below or near 60 mg/L indicating "soft water" as defined by RISC (1998).

Field measurements of pH (range: 6.35-6.74) were generally lower and more variable than the ALS Laboratories results (range: 7.75-7.77). This discrepancy possibly reflects improper calibration, differences in air space content among sampling containers and/or time elapsed between sampling and laboratory analysis.

Ammonia, nitrate and nitrite levels were all below detection limits at all stations. Orthophosphate was below or near detection limit (i.e., ≤0.001 mg/L) at all stations. Total phosphorus levels ranged from 0.0029 to 0.0098 mg/L. Overall, total phosphorus levels were within the low range typical of "oligotrophic" (<0.010 mg/L) waters 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 MB Channel during 3 November 2010. All values are expressed in mg/L unless specified otherwise. The values enclosed in boxes exceeded at least one of the applicable water quality guidelines. See additional notes on the next page.

	BC Water Quality Guidelines [a]		Station		
	BC Max	BC 30-day Mean			
Variable	mg/L	mg/L	1	2	3
General/Physical					
Conductivity (µS/cm)			42.9	51.7	74.0
Hardness, Total			16.2	18.2	30.5
pH (pH units)	6.5 - 9.0		7.77	7.75	7.77
Nutrients					
Ammonia-N	8.18 [b]	1.57 [b]	<0.005	<0.005	<0.005
Nitrate (as N)	31.3	3	<0.005	<0.005	<0.005
Nitrite (as N)	0.06 [c]	0.02 [c]	<0.001	<0.001	<0.001
Ortho Phosphate (as P)			<0.001	<0.001	0.004
Total Phosphorus			0.0031	0.0029	0.0098
Total Metals					
Aluminum (Al) [m]	0.10 [d]	0.05 [d]	<0.20	<0.20	<0.20
Antimony (Sb) [m]	0.02		<0.20	<0.20	<0.20
Arsenic (As) [m]	0.005		<0.20	<0.20	<0.20
Barium (Ba)	5	1	<0.010	<0.010	<0.010
Berylium (Be)	0.0053		<0.005	<0.005	<0.005
Bismuth (Bi)			<0.20	<0.20	<0.20
Boron (B)	1.2		<0.10	<0.10	<0.10
Cadmium (Cd) [m]	0.00001 [e]		<0.010	<0.010	<0.010
Calcium (Ca)			5.22	5.91	8.95
Chromium (Cr) [m]	0.001 [f]		<0.010	<0.010	<0.010
Cobalt (Co) [m]	0.11	0.004	<0.010	<0.010	<0.010
Copper (Cu) [m]	0.004 [g]	0.002 [g]	<0.010	<0.010	<0.010
Iron (Fe)	1.0		0.270	0.033	0.335
Lead (Pb) [m]	0.008 [h]	0.004 [h]	<0.050	<0.050	<0.050
Lithium (Li)	0.87	0.096	<0.010	<0.010	<0.010
Magnesium (Mg)			0.76	0.84	1.97
Manganese (Mn)	0.719 [i]	0.676 [i]	0.016	<0.005	0.040
Molybdenum (Mo)	2	1	<0.030	<0.030	<0.030
Nickel (Ni) [m]	0.025 [j]		<0.050	<0.050	<0.050
Phosphorus (P)			<0.30	<0.30	<0.30
Potassium (K)	373		<2.0	<2.0	<2.0
Selenium (Se) [m]		0.002	<0.20	<0.20	<0.20
Silicon (Si)			2.74	2.53	5.01
Silver (Ag) [m]	0.0001 [k]	0.00005 [k]	<0.010	<0.010	<0.010
Sodium (Na)			2.5	2.6	3.3
Strontium (Sr)			0.021	0.025	0.034
Thallium (Tl) [m]	0.0003		<0.20	<0.20	<0.20
Tin (Sn)			<0.030	<0.030	<0.030
Titanium (Ti)	2		<0.010	<0.010	<0.010
Vanadium (V) [m]	0.006		<0.030	<0.030	<0.030
Zinc (Zn)	0.033 [l]	0.0075 [l]	<0.005	<0.005	<0.005

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 MB Channel contained some coliform bacteria (Table 7). Total coliform counts were variable between stations, with a range of 8-188 CFU / 100 ml. The proportion of total coliform made up of *E. coli* bacteria was also variable between stations (range: 0-18%). Overall, the observed total coliform levels were similar to a study conducted at the C.W. Young Channel on the Englishman River during Fall 2010 (<300 CFU / 100 ml) (VIU, 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 four stations on the MB Channel on 3 November 2010. All values are expressed as number of bacteria per 100 ml.

Station	Total Coliform	*E. coli*	% *E. coli*
1	8	0	0.0%
2	188	12	6.4%
3	88	8	9.1%
4	92	16	17.4%
Filtration blank	0	0	–

4.3. Invertebrates

A total of 86 invertebrates representing 12 broad taxonomic groups were counted at three stations on the MB Channel on 3 November 2010 (Table 8; Figure 2; Appendix 2). Animal density was relatively low at all stations (6-32 animals/m^2). Overall, scud (amphipod) and aquatic worm (oligochaete) were the most common taxonomic group encountered.

Site assessment ratings ranged from 2.0-2.5 suggesting "marginal" invertebrate community abundance and diversity. It is important to note that the Pacific Streamkeepers procedures used in this study are designed for use in moving water. Since the MB Channel represents a negligible flow habitat, the low animal density and site assessment ratings observed should be interpreted with caution.

Table 8. Abundance and density of invertebrates obtained from triplicate samples taken on 3 November 2010 at three stations on the MB 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	1	0	3
	Mayfly Nymph	0	1	5
	Stonefly Nymph	1	3	0
Category 2 Somewhat Pollution Intolerant	Aquatic Beetle	0	0	1
	Aquatic Sowbug	1	3	0
	Dragonfly Nymph	0	0	1
	Scud (Amphipod)	0	13	19
Category 3 Pollution Tolerant	Aquatic Worm (oligochaete)	3	7	5
	Midge Larva (chironomid)	3	1	2
	Pouch and Pond Snails	0	0	10
	True Bug Adult	0	1	0
	Water Mite	0	0	2
	Total Abundance	9	29	48
	Density (number / m^2)	6	19	32
	Site Assessment Rating	2.00	2.00	2.50

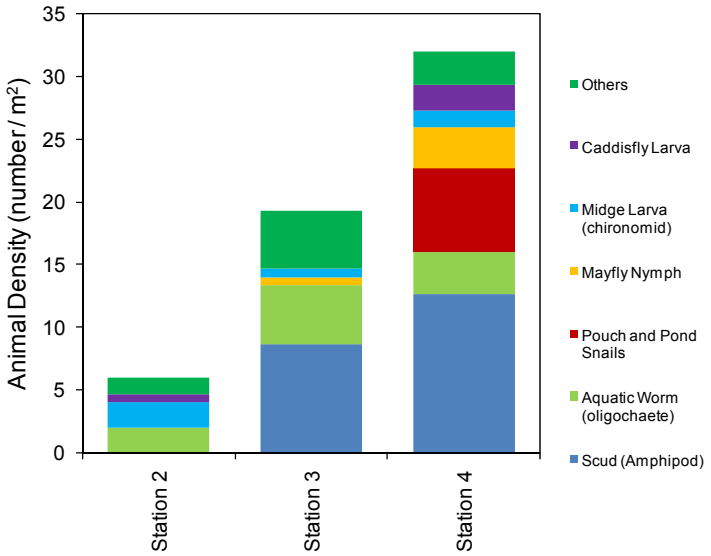


Figure 2. Density of invertebrates obtained from triplicate samples taken on 3 November 2010 at three stations on the MB Channel. The "Other" category includes stonefly nymph, aquatic sowbug, water mite, aquatic beetle, dragonfly nymph, and true bug adult. Data are summarized in Table 8 and Invertebrate Survey Field Data Sheets are included in Appendix 2.

5. Acknowledgements

The authors would like to acknowledge Joan Michel (Parks and Trails Coordinator, Recreation and Parks Department, Regional District of Nanaimo), Margaret Wright and Mel Sheng (Fisheries and Oceans Canada), and James Craig (BC Conservation Foundation) for their 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 – Brittany Brooks, Daniel Clark, Amy Godkin, Doug Gow, Alysha Hile, Simon Johnson, Brennan Krantz, Craig McCulloch, Janel McNish, Kate Parsons and Kris Taekema. 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, Living Rivers - Georgia Basin / Vancouver Island program, 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

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7. Appendices

APPENDIX 1. Photographs showing site conditions at each sampling station on the MB Channel.

Photo 1. Northward view of the MB Channel near station 1 on 3 November 2010.

Photo 2. Eastward view of the MB Channel near station 2 on 3 November 2010.

APPENDIX 1. (Continued)

Photo 3. Upstream view towards station 3 from the beaver dam near on the MB Channel on 3 November 2010.

Photo 4. Northward view from the foot bridge of the MB Channel near station 4 on 3 November 2010. The Englishman River is visible in the background through the vegetation.

APPENDIX 1. (Continued)

Photo 5. Site conditions of the MB Channel near station 4 on 24 November 2010.

Photo 6. Site conditions at the foot bridge of the MB Channel near station 4 on 24 November 2010.

APPENDIX 2. Invertebrate Survey Field Data Sheet completed for triplicate invertebrate samples collected at stations 1, 3 and 4 on the MB Channel on 3 November 2010.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: MB Channel		Date: 3 November 2010
Station Name: **Station 1**		Flow status: Negligible
Sampler Used: Dipnet	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.5 x 3 = 1.5 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)	1	1
	Mayfly Nymph (EPT)		
	Stonefly Nymph (EPT)	1	1
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		2	2
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug	1	1
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)		
	Watersnipe Larva		
Sub-Total		1	1
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	3	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	3	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		6	2
TOTAL		9	5

APPENDIX 2. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 9

DENSITY: Invertebrate density per square metre:

9 ÷ 1.5 = 6

PREDOMINANT TAXON:
Invertebrate group with the highest number counted (Col. C): Aquatic Worm (oligochaete), Midge Larva (chironomid)

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 2 + 2 x 1 + 2 = 10

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1 + 0 + 1 = 2

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

(1 + 0 + 1) / 9 = 0.22

SECTION 3 - DIVERSITY

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

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

3 / 9 = 0.33

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	1
EPT Index	2
EPT To Total Ratio	1
Predominant Taxon Ratio	4

Average Rating
2.00

APPENDIX 2. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: MB Channel		Date: 3 November 2010
Station Name: **Station 3**		Flow status: Negligible
Sampler Used: Dipnet	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.5 x 3 = 1.5 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)	1	1
	Stonefly Nymph (EPT)	3	1
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		4	2
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug	3	1
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	13	2
	Watersnipe Larva		
Sub-Total		16	3
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	7	2
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	1	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult	1	1
	Water Mite		
Sub-Total		9	4
TOTAL		29	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**: 29

DENSITY: Invertebrate density per square metre:

29 ÷ 1.5 = 19

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 __2__ + 2 x __3__ + __4__ = 16

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

__0__ + __1__ + __1__ = 2

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 + 1 + 3) / 29 = 0.14

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
<0.40	0.40-0.59	0.60-0.79	0.80-1.0

Col. C for S3 / CT

13 / 29 = 0.45

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	1
Predominant Taxon Ratio	3

Average Rating
2.00

APPENDIX 2. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: MB Channel		Date: 3 November 2010
Station Name: **Station 4**		Flow status: Negligible
Sampler Used: Dipnet	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.5 x 3 = 1.5 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	2
	Mayfly Nymph (EPT)	5	2
	Stonefly Nymph (EPT)		
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		8	4
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle	1	1
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva	1	1
	Fishfly Larva		
	Scud (amphipod)	19	2
	Watersnipe Larva		
Sub-Total		21	4
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	5	2
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	2	1
	Planarian (flatworm)		
	Pouch and Pond Snails	10	2
	True Bug Adult		
	Water Mite	2	1
Sub-Total		19	6
TOTAL		48	14

APPENDIX 2. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 48

DENSITY: Invertebrate density per square metre:

48 ÷ 1.5 = 32

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 4 + 2 x 4 + 6 = 26

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

2 + 2 + 0 = 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	0.50-0.74	0.25-0.49	<0.25

(EPT1 + EPT2 + EPT3) / CT

(3 + 5 + 0) / 48 = 0.17

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 14

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

19 / 48 = 0.40

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	1
Predominant Taxon Ratio	3

Average Rating
2.50