SUMMARY REPORT

Water Quality and Stream Invertebrate Assessments

for Richards Creek, North Cowichan, BC,

2008-2015

Report prepared by:

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Based on annual projects conducted by:

Students of Vancouver Island University RMOT 306 (Environmental Monitoring)

01 April 2016

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1. Background

Vancouver Island University (VIU) has conducted yearly water quality and stream invertebrate assessments on Richards Creek, BC, since 2008. These projects have been 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. Students worked under the supervision of the course instructors, Dr. Eric Demers and Dr. John Morgan (Vancouver Island University).

This report summarizes water quality and stream invertebrate results for Richards Creek for the 8-year period between 2008 and 2015. This report was compiled by Dr. Eric Demers based on yearly student group reports. Some of the data presented here have been summarized in previous annual reports (see VIU 2009, 2010, 2011, 2012).

Logistical support and funding for analytical processing of water samples was provided by Fisheries and Oceans Canada (DFO). ALS Laboratory (Burnaby, BC) provided reduced rates on their analytical services for these projects.

VIU students contributed approximately 1,000 student-hours to these projects, including site visits, project proposal, field sampling, laboratory analyses, and oral and written presentations. Dr. Eric Demers and Dr. John Morgan contributed approximately 100 hours for project management and report compilation.

2. Introduction

Richards Creek is located in the Somenos Basin, near the city of Duncan, B.C. It is approximately 9.2 km long and flows south-westerly from Crofton Lake to Somenos Lake. Richards Creek provides year round rearing and spawning habitat for salmonids. However, agricultural activities combined with low gradients and low summer flows in the lower reaches of Richards Creek have contributed to elevated nutrient loads and hypoxic water conditions (Guimond and Sheng, 2005).

This report summarizes water quality and stream invertebrate results for Richards Creek for the 8-year period between 2008 and 2015. Yearly assessments were conducted each fall, during similar time periods between late October and mid-November. Specific objectives for these yearly studies of Richards Creek included:

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

3. Methods

3.1. Study Site

Yearly assessments were conducted on Richards Creek located in the District of North Cowichan, north of the City of Duncan, BC (Figure 1). Richards Creek flows southeasterly from Crofton Lake to Richards Trail, then southwesterly, emptying into the northeast end of Somenos Lake. The upstream half of Richards Creek flows through residential areas and riparian forest, while the downstream half flows through agricultural lands. The Cowichan Valley Regional District (CVRD) regulates flow from the Crofton Lake reservoir into Richards Creek.

3.1.1. Sampling Stations

Four stations were established on Richards Creek, and these stations were used consistently from 2008 to 2015 (Tables 1 and 2; Figure 1). The location of each station was chosen to provide adequate coverage for the length of Richards Creek. Stations were numbered from upstream (Station 1) to downstream (Station 4). All stations were easily accessed via foot paths or road crossings. Station 1 was located at a culvert crossing on Escarpment Way, approximately 2.3 km downstream of Crofton Lake. Station 2 was located at the end of Rice Road on Innisvale Farm. Station 3 was located at a culvert crossing on Richards Trail, at the east corner of Pastula Farm. Station 4 was located at a road bridge on Herd Road, approximately 2.0 km upstream of Somenos Lake. Stations 1-3 consisted of shallow and gentle riffle sections, while station 4 was deep and steep-sided.

Table 1. Description of the sampling stations used for water quality and stream invertebrate assessments on Richards Creek during 2008-2015. All northing and easting coordinates were obtained from Google Earth®, and are based on zone 10U.

Station	UTM Coordinates		Approximate Distance from Crofton Lake (km)	General Location
	Northing	Easting		
1	5409420	452560	2.3	Escarpment Way crossing
2	5408622	452083	3.5	End of Rice Road, weir and water depth gauge
3	5408795	451331	4.2	Richards Trail crossing
4	5407637	450282	7.2	Herd Road crossing

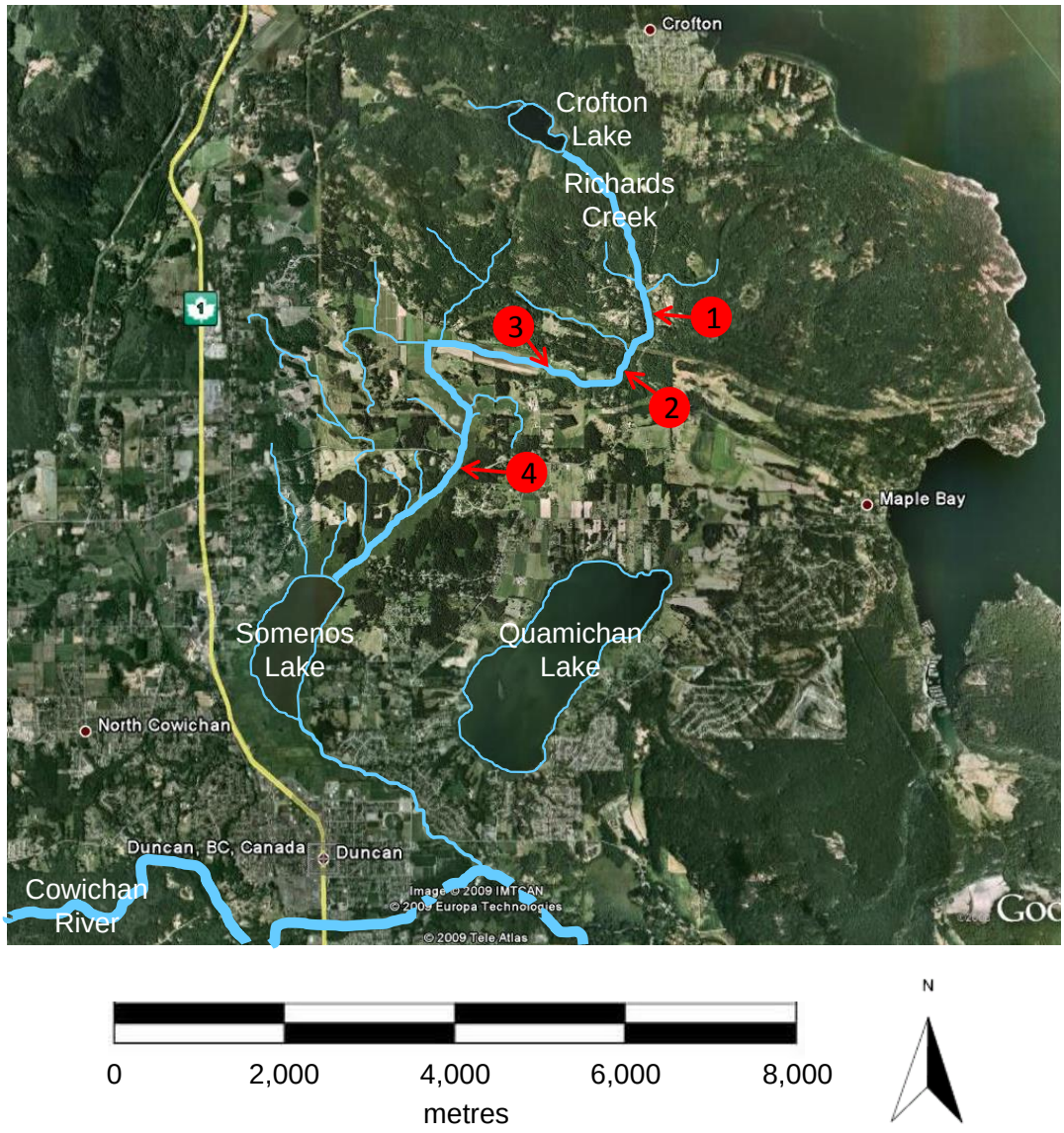

Figure 1. Approximate location of the sampling stations used for water quality and stream invertebrate assessments on Richards Creek during 2008-2015. Table 1 provides details of the specific location of each station. Table 2 details the sampling activities conducted at each station. This map was obtained from Google Earth. Map scale is approximated.

3.1.2. Sampling Schedule

Field sampling was conducted twice each fall during 2008 to 2015. The first sampling event was conducted during late October or early November (date range: 27 October to 3 November; median date: 30 October). The second sampling event was conducted during mid-November (date range: 17-24 November; median date: 20 November). The first sampling event was usually representative of lower flow conditions, although this varied in some years due to weather conditions. For simplicity, in this report, the first and second sampling events are referred to as the "late October" and "mid-November" sampling events, respectively.

Each year, 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 late October sampling event.

Table 2. Water quality and stream invertebrate sampling activities conducted at each station on Richards Creek, during 2008-2015. The symbols "A" or "B" indicate whether samples / measurements were taken during the late October or mid-November sampling events, respectively. ALS Lab analyses, microbiology and stream invertebrates were not conducted at the same stations each year (see parentheses).

Station	Water Quality				Stream Invertebrates
	Field Measurements	VIU Analyses	ALS Lab Analyses	Microbiology	
1	A, B	A, B	A, B (All years)	A (All years)	A
2	A, B	A, B	A, B (2008-2010, 2012)	A (All years)	A
3	A, B	A, B	A, B (All years)	A (All years)	A
4	A, B	A, B	A, B (All except 2012)	A (All except 2012)	---

3.2. Water Quality

3.2.1. Field Measurements

Water quality sampling was conducted during both sampling events each year (late October and mid-November). 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 YSI 556 MPS or Oxyguard Handy Polaris electronic probe. The electronic probe was placed directly in the channel water.

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^{o}C. Laboratory analyses were conducted at VIU within 72 hours of sampling.

Samples for analysis by ALS Laboratory were collected from 3-4 stations during both sampling events, and the actual stations used varied between years (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 72 hours for laboratory analyses at ALS Laboratory.

Table 3. Sampling containers and preservatives used for water quality samples taken at Richards Creek, during 2008-2015. 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. Total alkalinity was not measured in 2013. Turbidity was measured to the nearest 0.01 NTU (Nephelometric Turbidity Units) using a HACH 2100 Potable Turbidimeter. Turbidity was not measured in 2008.

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, pH, total hardness, nutrients (ammonia, nitrite, nitrate, orthophosphate and total phosphorus), and total metals (31 metals). Total phosphorus was not measured in 2008.

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 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 aquatic life. The BC Water Quality Guidelines are the maximum allowable concentration (for potential acute 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 included aluminum, 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 all sampling stations during the first sampling event in late October (Table 2), except in 2012 when samples were collected from stations 1-3. 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 72 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. Each membrane filter 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. A red or blue colony represents a total coliform "positive" result. A blue colony specifically represents fecal coliform, while a red colony represents non-fecal coliform. 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 during the first sampling event in late October (Table 1; Figure 1). Samples were taken each year from stations 1, 2 and 3. 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, each station typically 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 (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 contents were transferred into the sample jar. Samples were stored in a cooler and transported to Vancouver Island University, where laboratory analyses were completed within 72 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 dissection 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

River discharge can significantly affect water quality results through the differential transport of dissolved and suspended solids. Unfortunately, no yearly discharge measurements are available for Richards Creek. As a surrogate, Figure 2 shows discharge for the Cowichan River to provide an indication of regional patterns in precipitation and discharge within the watershed.

Discharge in the Cowichan River was typically near the median levels expected at the time of sampling. Exceptions included high discharge levels during the late October sampling events in 2009, 2010 and 2014, and during the mid-November sampling event in 2009. The high discharge event in mid-November 2009 corresponded with exceptional flooding in the Cowichan and

Somenos watersheds. Richards Creek was observed to overflow at numerous locations during that period.

It is important to note that water flow into Richards Creek is controlled at the outlet of the Crofton Lake reservoir. Therefore, fluctuations in discharge rates in Richards Creek and the Cowichan River may not be significantly correlated.

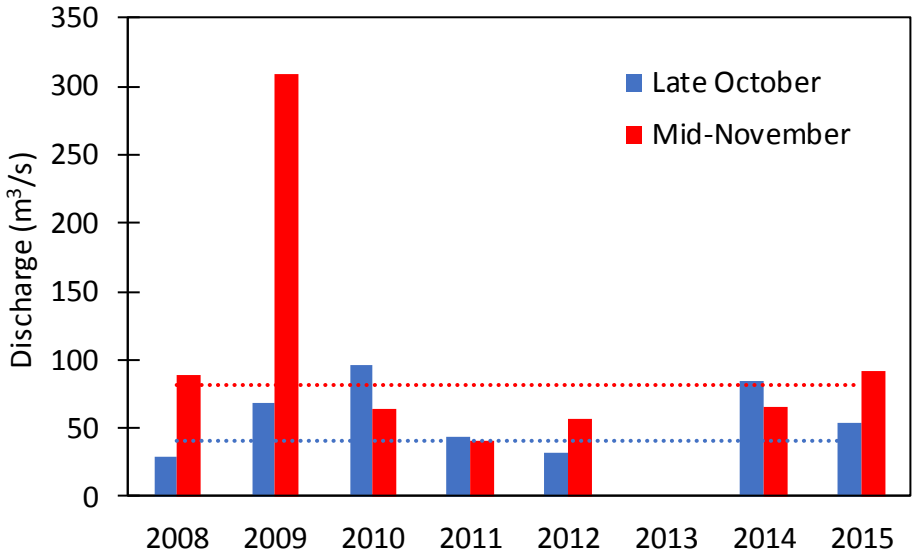

Figure 2. Discharge (m^3/s) measurements for the Cowichan River at the time of sampling during 2008-2015. The bars display the discharge level on the same dates for the late October (blue) and mid-November (red) sampling events, respectively. The dashed lines display the 51-year median discharge (1964-2012) on 30 October (blue) and 20 November (red), respectively. Hydrometric data retrieved from Environment Canada, Water Survey for station 08HA011 (https://wateroffice.ec.gc.ca/).

4.1. Water Quality

In this section, time series for each water quality parameter are presented and described for the 8-year period between 2008 and 2015. Spatial trends among sampling stations are also shown and described where they existed, although some parameters did not exhibit any spatial trend. All water quality data are available in Appendix A (Tables A.1 to A.8).

4.1.1. Water temperature

Water temperature varied between years due to variation in ambient air temperature (Figure 3), although water temperature fluctuations were more pronounced during the mid-November sampling events. Average water temperature ranged from 6.8 to 10.4°C during late October and from 2.2 to 8.6°C during mid-November.

There was little temperature variation among stations (not shown), with a range consistently <0.7°C between the warmest and coldest station (as shown by small error bars in Figure 3).

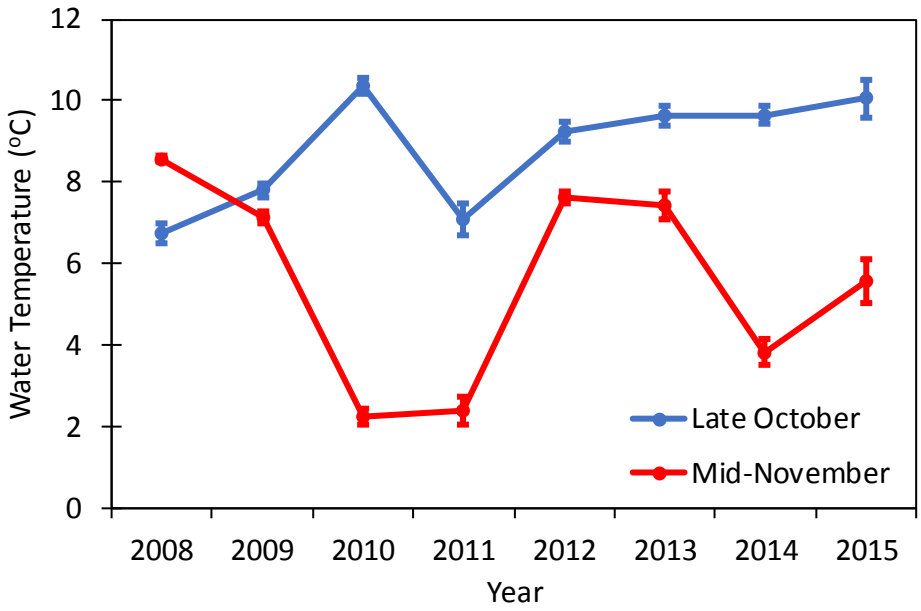

Figure 3. Water temperature (°C) measured during two sampling events in 2008-2015 in Richards Creek. Points show average temperature from four sampling stations. Sampling events were conducted in late October (blue) and mid-November (red) each year. Error bars represent ±1 standard error.

4.1.2. Dissolved oxygen

Dissolved oxygen concentrations varied greatly between and within years (Figure 4). Some of the variation was attributed to variation in water temperature between years. Average dissolved oxygen levels ranged from 7.7 to 12.4 mg/L during late October and from 7.9 to 12.3 mg/L during mid-November.

Much of the variation in yearly dissolved oxygen can be explained by variation in concentrations between sampling stations (Figure 5). Dissolved oxygen levels were similar at stations 1-3 (average: 10.9-12.1 mg/L). However, dissolved oxygen concentrations were consistently lower at station 4 (Herd Road crossing), with average levels of 4.0 and 6.2 mg/L during the late October and mid-November sampling events, respectively. These low dissolved oxygen concentrations at station 4 suggest that hypoxic conditions existed during most years, possibly due to reduced water movement and/or elevated ecosystem respiration.

Dissolved oxygen levels were usually above the minimum guideline of 9.0 mg/L for early fish life stages (RISC 1998) (Figure 4) at stations 1-3, but consistently below the guideline at station 4. Overall, dissolved oxygen concentrations were always >90% saturation at stations 1-3. However, average dissolved oxygen saturation levels were 34.1 and 48.4% at station 4 during the late October and mid-November sampling events, respectively.

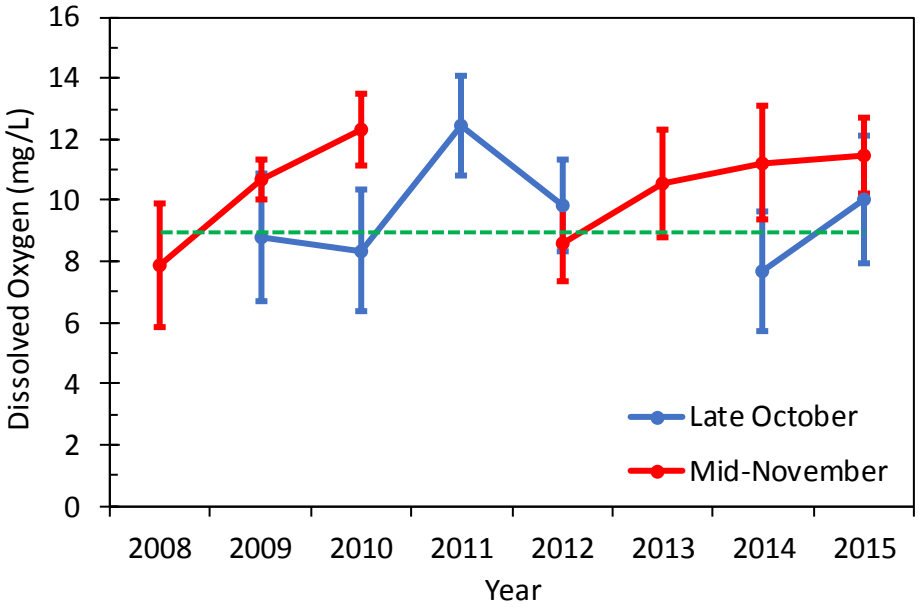

Figure 4. Dissolved oxygen concentrations (mg/L) measured during two sampling events in 2008-2015 in Richards Creek. Points show average concentrations from four sampling stations. Sampling events were conducted in late October (blue) and mid-November (red) each year. The green dashed line represents the minimum guideline of 9.0 mg/L for early fish life stages. Error bars represent ±1 standard error. No results are available for late October 2008 and 2013, and for mid-November 2011.

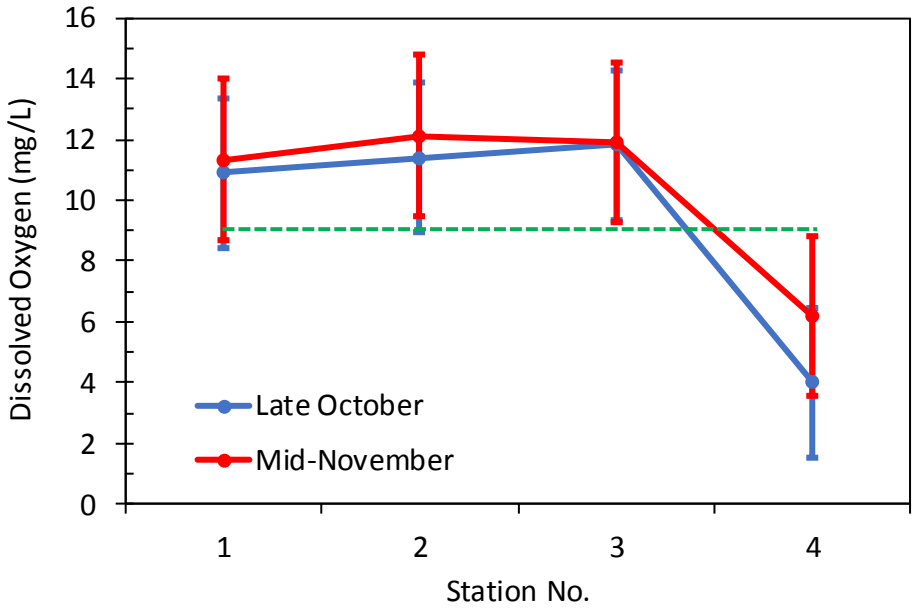

Figure 5. Dissolved oxygen concentrations (mg/L) measured at four stations during two sampling events in Richards Creek. Points show average concentrations between 2008 and 2015. Sampling events were conducted in late October (blue) and mid-November (red) each year. Error bars represent ±1 standard error.

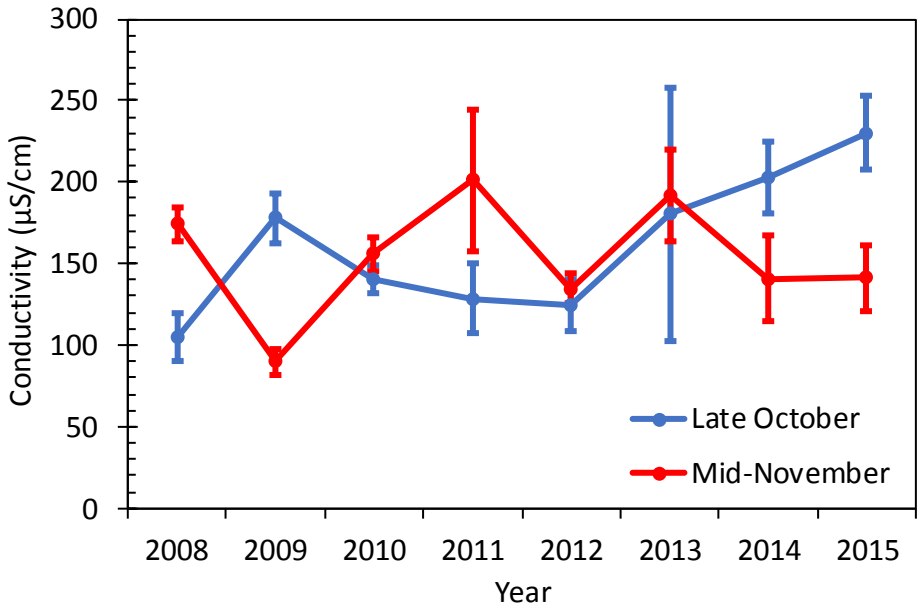

Figure 6. Conductivity (µS/cm) measured during two sampling events in 2008-2015 in Richards Creek. Points show average conductivity from 3-4 sampling stations. Sampling events were conducted in late October (blue) and mid-November (red) each year. Error bars represent ±1 standard error.

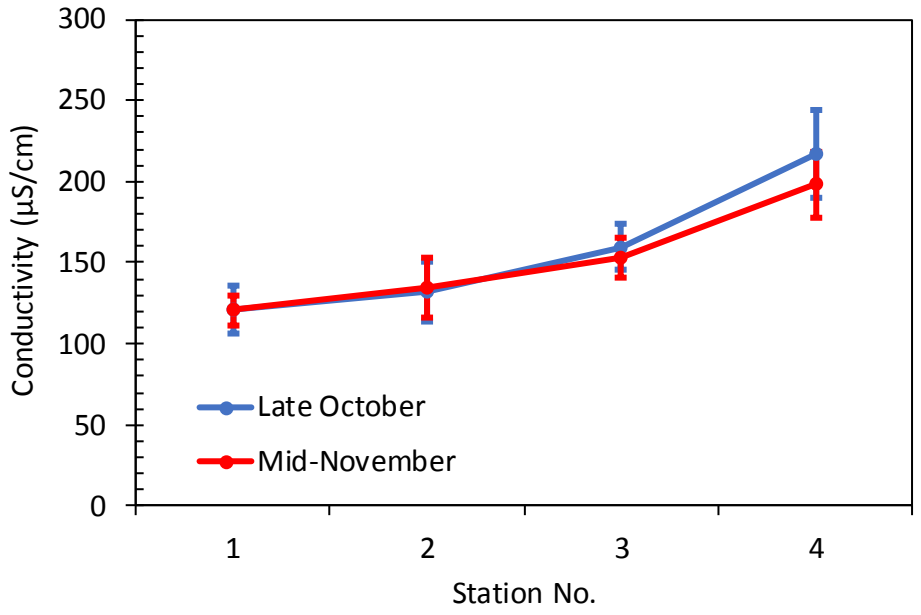

Figure 7. Conductivity (µS/cm) measured at four stations during two sampling events in Richards Creek. Points show average concentrations between 2008 and 2015. Sampling events were conducted in late October (blue) and mid-November (red) each year. Error bars represent ±1 standard error.

4.1.3. Conductivity

Conductivity varied greatly between and within years (Figure 6). Overall, average conductivity ranged from 105 to 230 µS/cm during late October and from 90 to 201 µS/cm during mid-November. There was no clear association between conductivity and regional discharge patterns in the Cowichan River, and it is unclear if conductivity was correlated with discharge in Richards Creek since no discharge measurements are available.

Conductivity increased by an average of 87 µS/cm with distance downstream between station 1 and station 4 (Figure 7). The highest conductivity levels were consistently observed at station 4. Also, conductivity increased by an average of 23 µS/cm between stations 2 and 3, and 52 µS/cm between stations 3 and 4. These increases represent rates of 32.5 µS/cm and 17.2 µS/cm per creek km, respectively, whereas conductivity increased by a more moderate 12.2 µS/cm between stations 1 and 2 (rate: 8.1 µS/cm per creek km). The higher rates of increase in conductivity between stations 2-4 suggest that sources of dissolved ions exist along this section of the creek.

4.1.4. pH

Average pH levels were near neutral throughout this study (Figure 8), and ranged from 7.2 to 7.9. pH generally increased by an average of 0.2 pH units between the late October and mid-November sampling events. There was no clear temporal trend in pH. Average pH levels were similar at stations 1-3 (average: 7.5-7.7), and slightly lower at station 4 (Herd Road crossing), with average levels of 7.1 and 7.4 during the late October and mid-November sampling events, respectively. Overall, pH levels were well within the aquatic life criteria of 6.5-9.0 (RISC 1998).

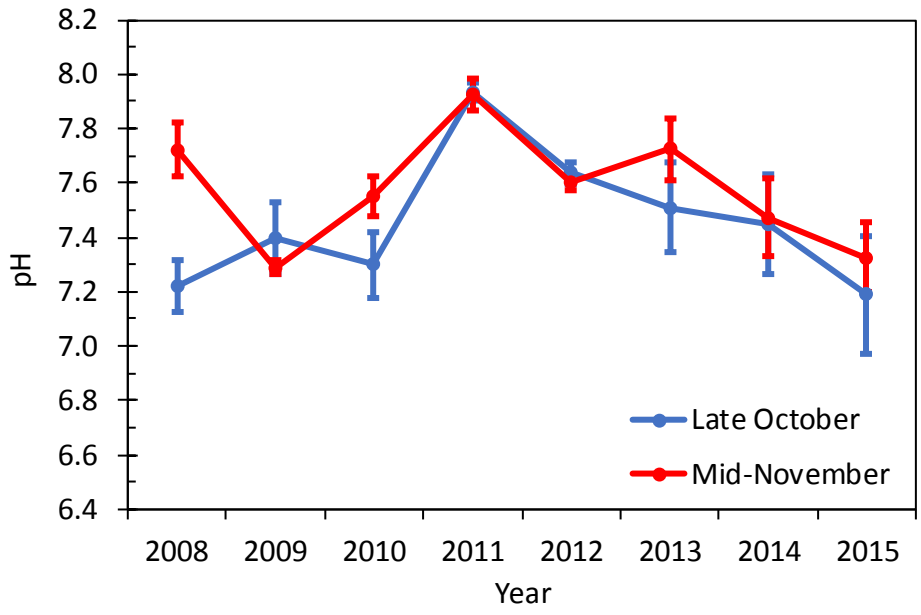

Figure 8. Water pH measured during two sampling events in 2008-2015 in Richards Creek. Points show average pH from 3-4 sampling stations. Sampling events were conducted in late October (blue) and mid-November (red) each year. Error bars represent ±1 standard error.

4.1.5. Total alkalinity

Total alkalinity ranged from 19 to 53 mg/L as $CaCO_3$ during late October and from 14 to 50 mg/L as $CaCO_3$ during mid-November (Figure 9). There was no clear temporal trend in alkalinity. Alkalinity increased by an average of 10 mg/L as $CaCO_3$ with distance downstream between station 1 and station 4 (not shown). Overall, most alkalinity levels were within the ranges for "low" (>20 mg/L as $CaCO_3$) sensitivity to acidification (RISC 1998).

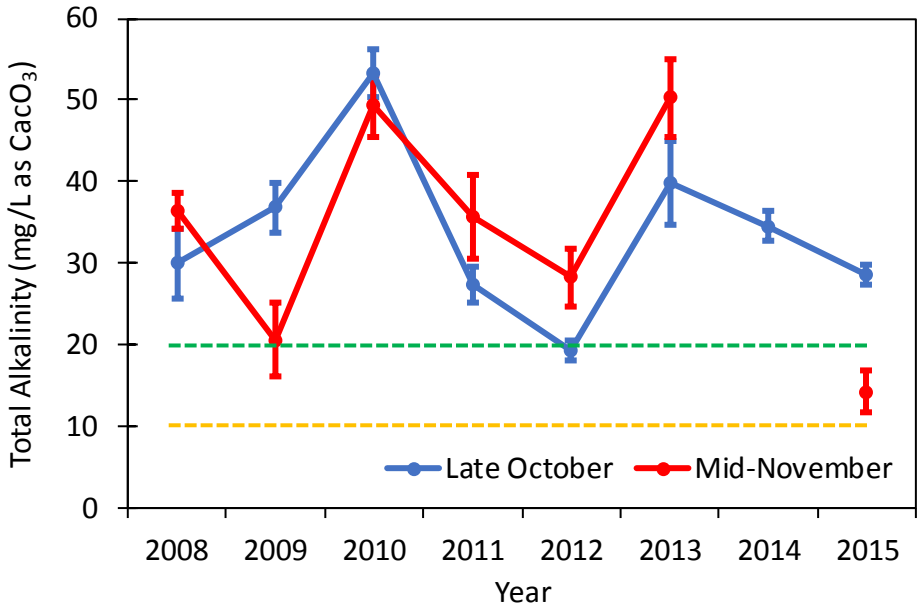

Figure 9. Total alkalinity (mg/L as $CaCO_3$) measured during two sampling events in 2008-2015 (except 2013) in Richards Creek. Points show average alkalinity from 4 sampling stations. Sampling events were conducted in late October (blue) and mid-November (red) each year. The green and orange dashed lines represent the maximum levels for high (10 mg/L) and moderate (20 mg/L) acid sensitivity. Error bars represent ±1 standard error. No results are available for mid-November 2014.

4.1.6. Hardness

Hardness ranged from 39 to 82 mg/L as $CaCO_3$ during late October and from 32 to 75 mg/L as $CaCO_3$ during mid-November (Figure 10). Hardness increased by an average of 31 mg/L as $CaCO_3$ with distance downstream between station 1 and station 4 (Figure 11). Hardness changed little within station between the late October and mid-November sampling events.

Overall, hardness levels were consistently below 60 mg/L as $CaCO_3$ at station 1-3, indicating "soft water" as defined by RISC (1998).

There were significant positive relationships between conductivity, alkalinity and hardness (see Appendix B, Figure B.1). These correlations were expected since each of these parameters represent measures of dissolved ions.

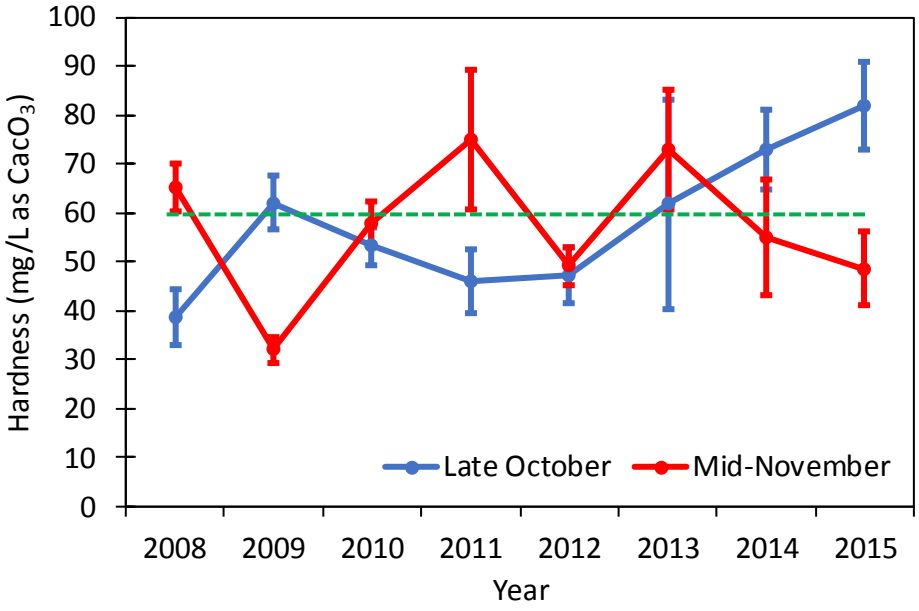

Figure 10. Hardness (mg/L as $CaCO_3$) measured during two sampling events in 2008-2015 in Richards Creek. Points show average hardness from 3-4 sampling stations. Sampling events were conducted in late October (blue) and mid-November (red) each year. The green dashed lines represent the maximum levels for soft water (60 mg/L). Error bars represent ±1 standard error.

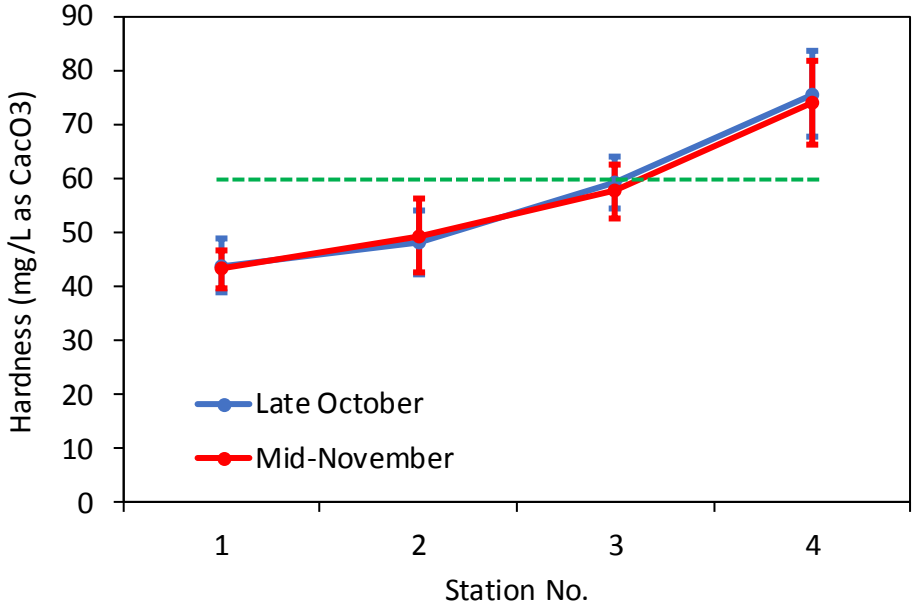

Figure 11. Hardness (mg/L as $CaCO_3$) measured at five stations during two sampling events in Richards Creek. Points show average concentrations between 2008 and 2015. Sampling events were conducted in late October (blue) and mid-November (red) each year. The green dashed lines represent the maximum levels for soft water (60 mg/L). Error bars represent ±1 standard error.

4.1.7. Turbidity

Turbidity levels were highly variable between 2009 and 2015 (Figure 12). Overall, average turbidity ranged from 1.6 to 11.0 NTU during late October and from 1.4 to 4.0 NTU during mid-November. Turbidity decreased by an average of 1.3 NTU between the late October and mid-November sampling events. The high average turbidity in late October 2010 resulted from elevated levels at stations 1-3 (10-11 NTU). Elevated turbidity is often associated with high discharge, where shear stress increases and causes the mobilization of suspended solids. However, it is difficult to explain the variation observed in turbidity levels since no discharge measurements are available for Richards Creek.

Average turbidity increased by an average of 1.2 NTU with distance downstream between station 1 and station 4 (not shown).

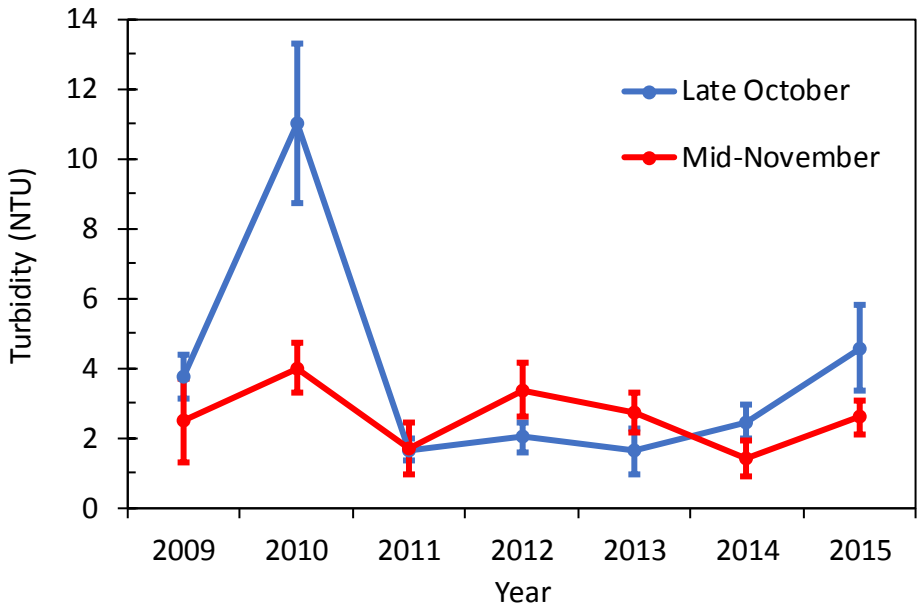

Figure 12. Turbidity levels (NTU) measured during two sampling events in 2009-2015 in Richards Creek. Points show average turbidity from 4 sampling stations. Sampling events were conducted in late October (blue) and mid-November (red) each year. Error bars represent ±1 standard error. No results are available for 2008.

4.1.8. Nitrate

Nitrate concentrations were generally more variable during the late October than the mid-November sampling events (Figure 13). From 2008 to 2013, nitrate levels ranged from 0.08 to 0.98 mg/L during late October, but higher levels were observed during 2014 and 2015 (1.54 and 2.15 mg/L, respectively). Nitrate levels were less variable during mid-November and ranged from 0.29 to 0.81 mg/L. Nitrate concentrations decreased by an average of 0.21 mg/L between the late October and mid-November sampling events. Nitrate concentrations increased by an average of 0.30 mg/L with distance downstream between station 1 and station 4 (Figure 14).

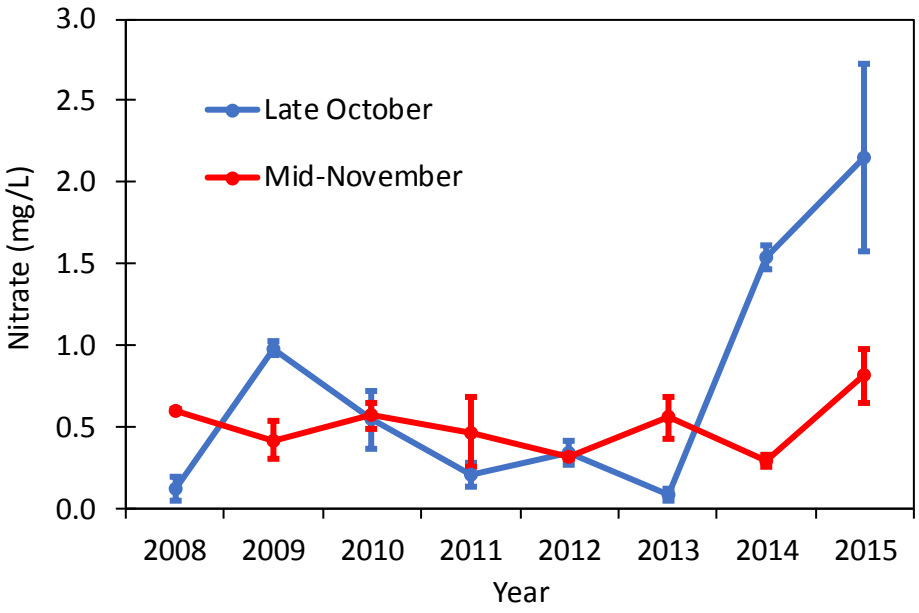

Figure 13. Nitrate concentrations (mg/L) measured during two sampling events in 2008-2015 in Richards Creek. Points show average concentrations from 3-4 sampling stations. Sampling events were conducted in late October (blue) and mid-November (red) each year. Error bars represent ±1 standard error.

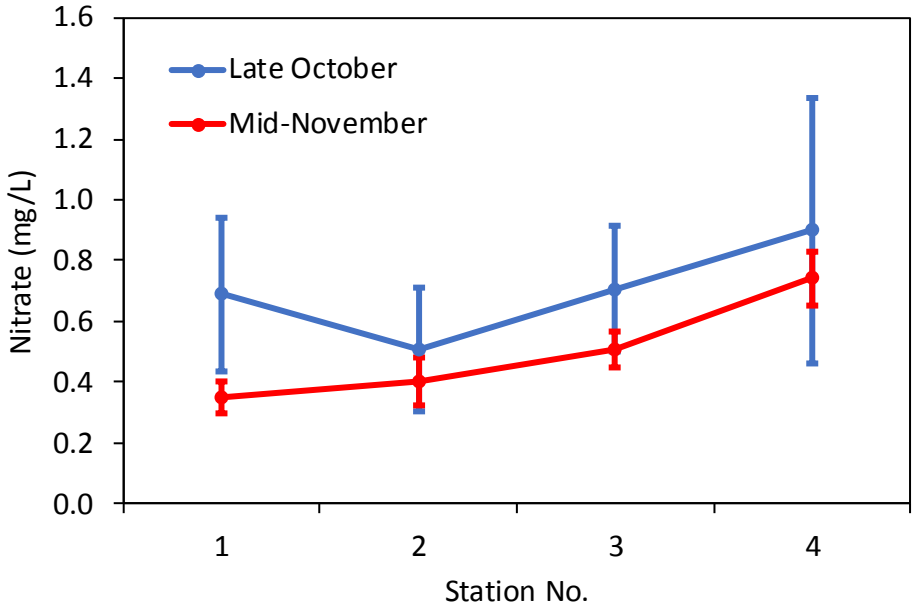

Figure 14. Nitrate concentrations (mg/L) measured at four stations during two sampling events in Richards Creek. Points show average levels between 2008 and 2015. Sampling events were conducted in late October (blue) and mid-November (red) each year. Error bars represent ±1 standard error.

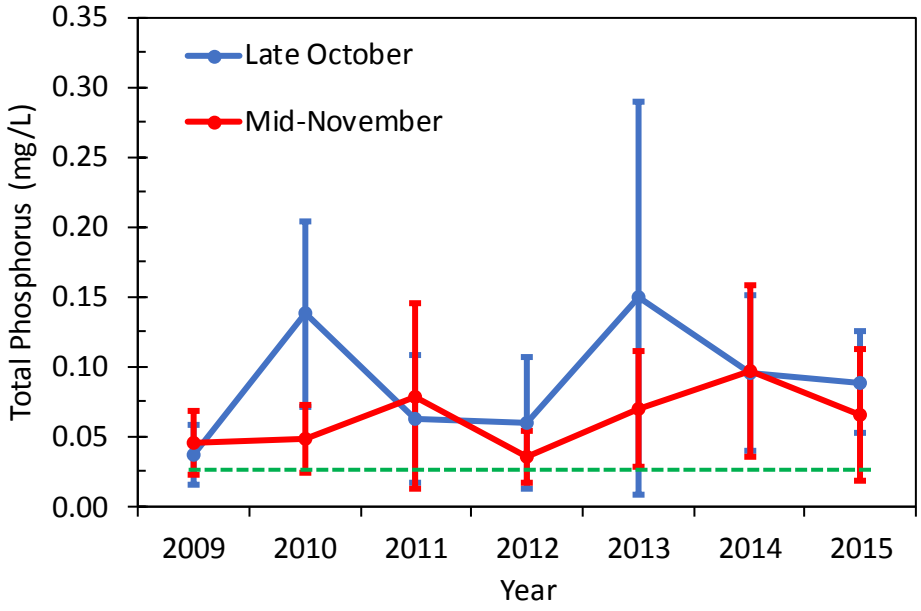

Figure 15. Total phosphorus concentrations (mg/L) measured during two sampling events in 2009-2015 in Richards Creek. Points show average concentrations from 3-4 sampling stations. Sampling events were conducted in late October (blue) and mid-November (red) each year. The green dashed line represents the division between "mesotrophic" water (<0.025 mg/L) and "eutrophic" water (>0.025 mg/L). Error bars represent ±1 standard error. No results are available for 2008.

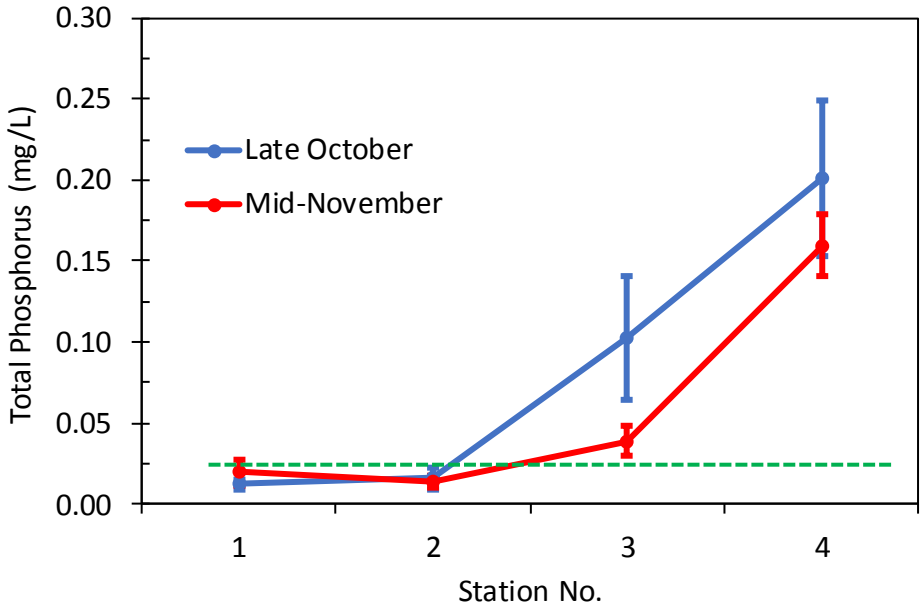

Figure 16. Total phosphorus concentrations (mg/L) measured at four stations during two sampling events in Richards Creek. Points show average levels between 2009 and 2015. Sampling events were conducted in late October (blue) and mid-November (red) each year. The green dashed line represents the division between "mesotrophic" water (<0.025 mg/L) and "eutrophic" water (>0.025 mg/L). Error bars represent ±1 standard error.

Overall, nitrate levels were always well below the water quality guideline for aquatic life (maximum concentration: 32.8 mg/L). However, the ranges of concentrations observed in Richards Creek (0.008-3.28 mg/L) were higher than those observed at other watersheds during similar studies (nitrate concentration ranges for 2008-2015 – Englishman River, Parksville: 0.005-0.287 mg/L; Millstone River, Nanaimo: 0.005-1.080 mg/L) (Demers, 2016a, b). Nitrate is the main form of combined nitrogen found in natural waters and it is the primary form of nitrogen used by plants as a nutrient to stimulate growth. Excessive amounts of nitrogen may result in excessive aquatic plant growth. Continued monitoring of nitrate levels is warranted to determine long-term conditions within the watershed.

4.1.9. Total phosphorus

Total phosphorus concentrations were highly variable between years (Figure 15), and generally decreased between the late October (average: 0.090 mg/L) and mid-November (average: 0.061 mg/L) sampling events. Overall, average total phosphorus levels ranged from 0.037 to 0.149 mg/L during late October and from 0.035 to 0.097 mg/L during mid-November.

Total phosphorus concentrations increased sharply with distance downstream (Figure 16). Total phosphorus levels were similar at stations 1 and 2 (average: 0.016 mg/L), and were within the range for "mesotrophic" water (0.010-0.025 mg/L) (RISC 1998). However, total phosphorus concentrations at station 3 (average: 0.070 mg/L) and station 4 (average: 0.180 mg/L) were consistently within the range for "eutrophic" water (>0.025 mg/L). The high phosphorus levels observed at stations 3 and 4 likely caused eutrophication of the watercourse at these locations and further downstream in Somenos Lake.

The ratio of the total nitrogen and total phosphorus concentrations (also called the N to P ratio, or N:P) can provide a further indication of eutrophication when it is near or below a value of 16. Total nitrogen was measured in Richards Creek during 2013-2015 (see Tables A.6 to A.8 in Appendix A). For those years, average N:P ratios were 92.5 at station 1, 31.8 at station 3 and 13.0 at station 4. These values further suggest that eutrophication conditions existed at station 4.

Phosphorus is often a limiting nutrient in freshwater habitats, and elevated levels may result in excessive aquatic plant growth and ecosystem metabolism. In turn, enhanced ecosystem metabolism likely caused the hypoxic conditions (i.e., low dissolved oxygen) observed at station 4 (Figure 5).

Potential sources of phosphorus to Richards Creek near stations 3 and 4 may include runoff from the surrounding agricultural lands, especially since there is little or no riparian buffer zone along much of the creek at these locations. Continued monitoring of total phosphorus levels is warranted to determine long-term conditions within the watershed.

4.1.10. Total metals

With the exception of aluminum and iron, most metals were below applicable water quality guidelines or below minimum detection limits. Total aluminum concentrations exceeded the applicable guideline for aquatic life (maximum concentration: 0.1 mg/L) in at least one sampling

event during each year of this study (Table 4). The highest aluminum concentrations were most often recorded at station 4. It is important to note that the aluminum levels measured were only slightly above the water quality guideline, and aluminum is not considered a serious threat to aquatic life, except in areas of acidic inputs.

Table 4. Maximum concentrations of aluminum (mg/L) measured during two sampling events in 2008-2015 in Richards Creek. The water quality guideline of aluminum for aquatic life is 0.10 mg/L. Note that measured levels below method detection limit (<0.20 mg/L) cannot be assumed to be below the guideline.

Year	Late October	Mid-November
2008	<0.20	0.21
2009	0.28	0.49
2010	0.89	0.27
2011	<0.20	0.28
2012	<0.20	0.55
2013	<0.20	0.27
2014	0.38	<0.20
2015	0.40	0.85

Total iron concentration exceeded the applicable guideline for aquatic life (maximum concentration: 1 mg/L) during late October 2010 (1.03 mg/L) and 2013 (1.07 mg/L).

Total metal analyses measure the combined amount of metals dissolved in water and bound to particles. In general, dissolved metals are more bio-available (hence toxicologically available) than metals that are bound to particles. It is unclear whether the observed elevated aluminum and iron levels represented dissolved metals or metals bound to suspended particles.

1.1. Microbiology

Total coliform levels fluctuated between years, with levels ranging from 32 CFU / 100 ml (in 2009) to 1,324 CFU / 100 ml (in 2010) (Figure 17). Fecal coliforms were always present and levels ranged from 9 to 815 CFU / 100 ml. The proportion of total coliform made up of fecal coliform ranged from 1 to 75%. There was no apparent temporal trend in coliform levels.

Total and fecal coliform levels generally increased with distance downstream (Figure 18). Total coliform levels increased by 112% between station 1 (570 CFU / 100 ml) and station 4 (1,208 CFU / 100 ml). The proportion of total coliform made up of fecal coliform was generally similar between stations and ranged from 13 to 36%. Potential sources of fecal coliforms may come from warm-blooded animals (e.g., waterfowl, beavers, dogs).

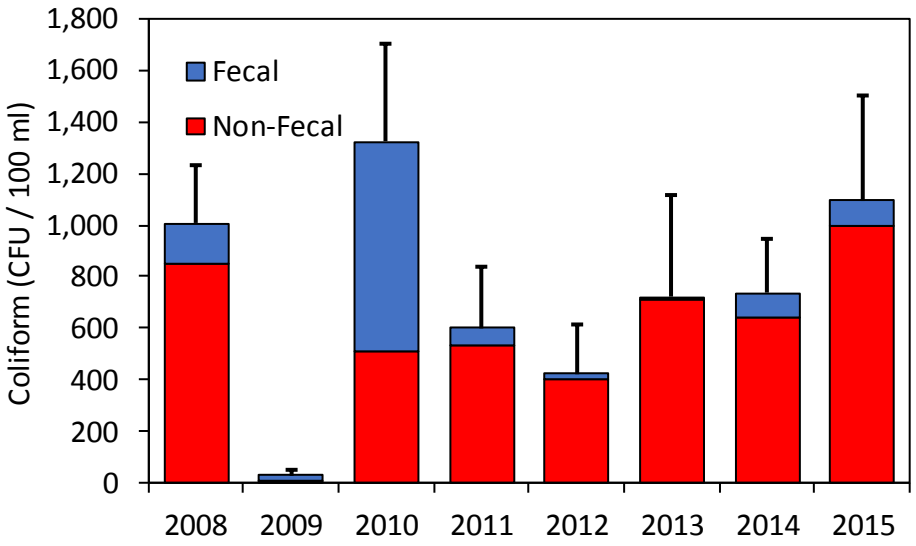

Figure 17. Fecal (blue) and non-fecal (red) coliform levels (colony forming unit; CFU / 100 ml) measured during late October in 2008-2015 in Richards Creek. Bars show average coliform levels from 3-4 sampling stations. Error bars represent ±1 standard error of total coliform (the sum of fecal and non-fecal coliforms).

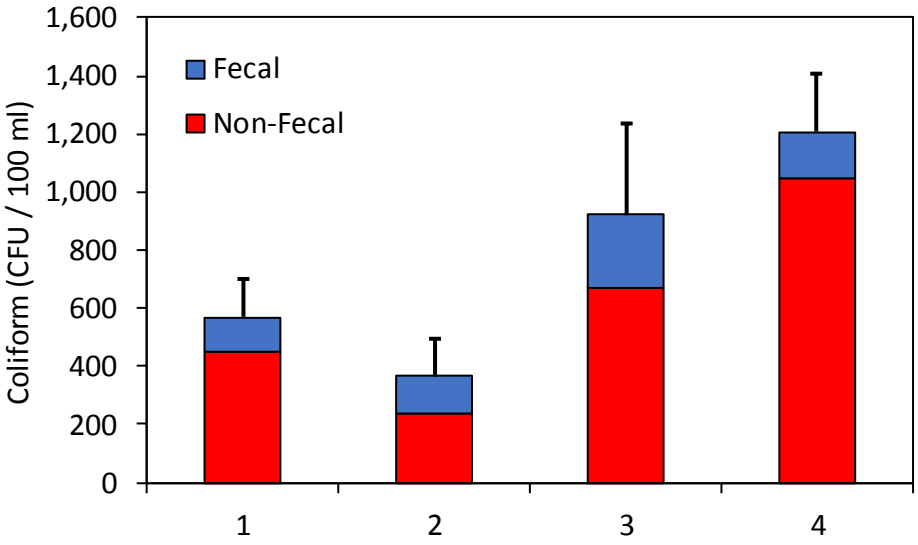

Figure 18. Fecal (blue) and non-fecal (red) coliforms (colony forming unit; CFU / 100 ml) measured at four stations during two sampling events in Richards Creek. Bars show average coliform levels between 2008 and 2015. Error bars represent ±1 standard error of total coliform (the sum of fecal and non-fecal coliforms).

4.2. Stream Invertebrates

Stream invertebrate densities showed a gradual decreasing trend between years (Figure 19). This trend was mainly due to decreasing densities of pollution-sensitive (category 1) and pollution-tolerant (category 3) taxa. Overall, the proportion of stream invertebrates made up of pollution-sensitive taxa (category 1) ranged from 12 to 65%. Pollution-sensitive taxa include mayflies, caddisflies and stoneflies, which are indicators of good water quality. Stream invertebrate densities were highest at station 3 (576 animals / m^2) compared to stations 1 and 2 (299-327 animals / m^2) (Figure 20). Reasons for these temporal and spatial trends are unknown. It is important to note that measurements of stream invertebrate densities can be highly variable, and subject to fluctuations in environmental variables, substrate types, flow regime and sampling efficiency.

Average site assessment ratings ranged from 2.1 to 3.6 (out of 4.0), with an overall average of 3.0 from 2008 to 2015 (Figure 21). This average rating suggests that "acceptable" conditions existed for community abundance and diversity of stream invertebrates during most years. The highest average site assessment rating (3.3) was recorded at station 3. There was no apparent temporal or spatial trend in animal density or site assessment rating, or correlation with water quality parameters. All Invertebrate Survey Field Data Sheets are included in Appendix C (Tables C.1 to C.8).

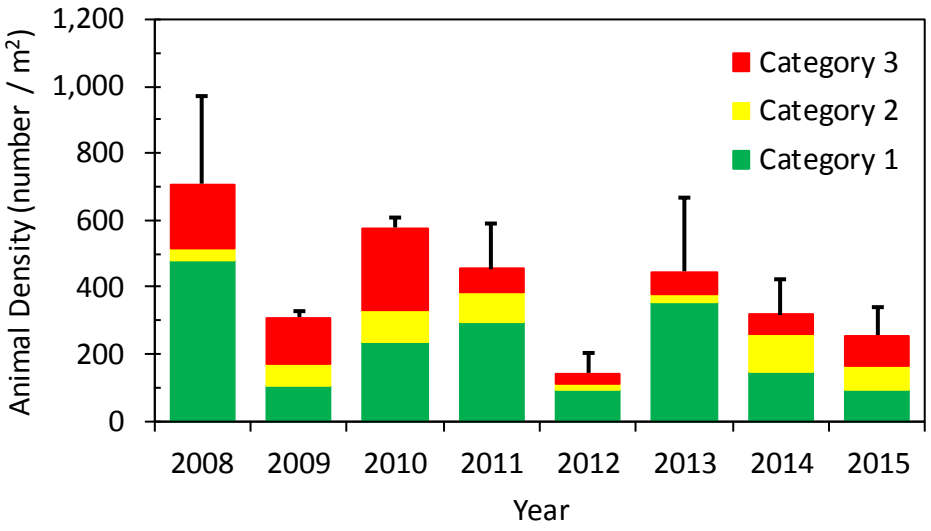

Figure 19. Density of stream invertebrates (number of animals / m^2) measured during late October in 2008-2015 in Richards Creek. Bars represent average densities from three sampling stations. Colours represent "pollution sensitive" taxa (green; category 1), "somewhat pollution tolerant" taxa (yellow; category 2), and "pollution tolerant" taxa (red; category 3). Error bars represent ±1 standard error of total animal density.

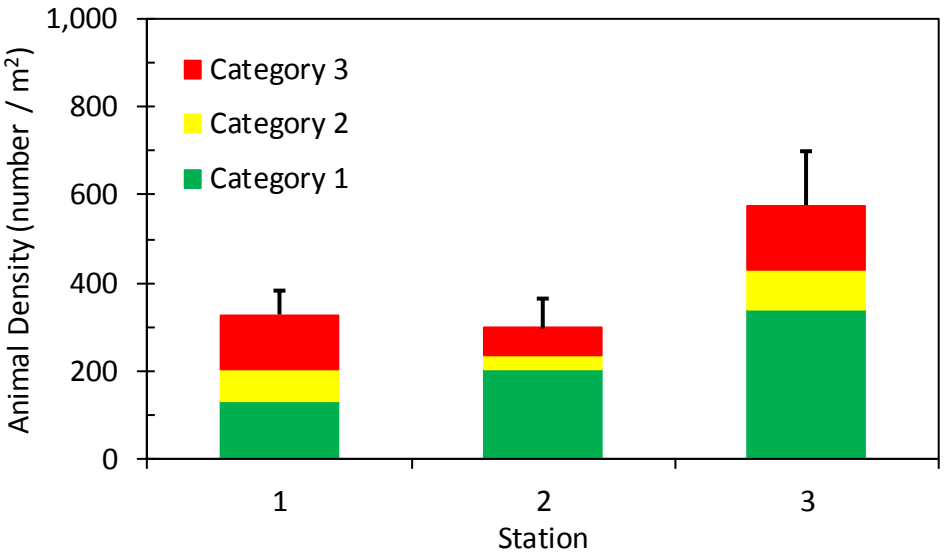

Figure 20. Density of stream invertebrates (number of animals / m^2) measured at three stations during late October in Richards Creek. Bars represent average densities between 2008 and 2015. Colours represent "pollution sensitive" taxa (green; category 1), "somewhat pollution tolerant" taxa (yellow; category 2), and "pollution tolerant" taxa (red; category 3). Error bars represent ±1 standard error of total animal density.

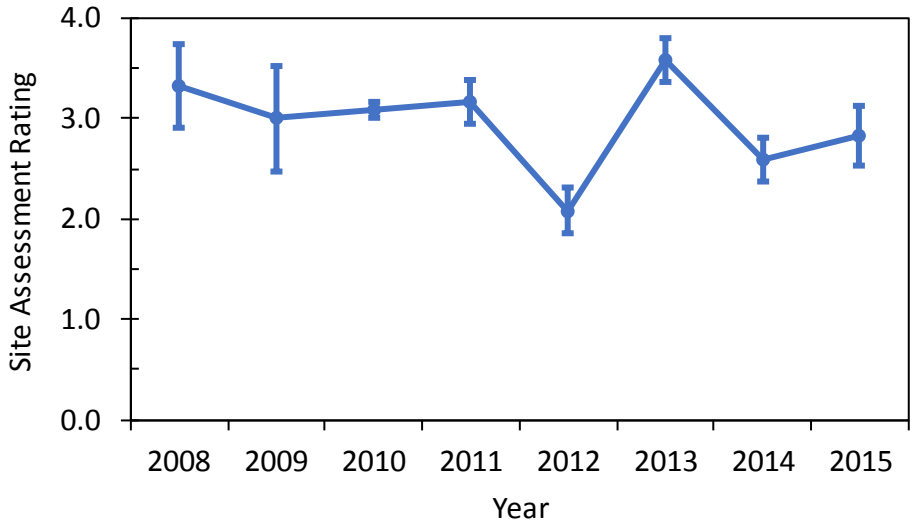

Figure 21. Site assessment ratings (range: 1 = "poor", 2 = "marginal", 3 = "acceptable", 4 = "Good") for the stream invertebrates communities assessed during late October in 2008-2015 in Richards Creek. Points show average ratings from three sampling stations. Error bars represent ±1 standard error of site assessment ratings.

5. Conclusions

Results from this 8-year environmental monitoring program suggest that water quality has remained consistently "acceptable" for Richards Creek. However, there was a general decline in water quality with distance downstream, especially at station 4 (Herd Road crossing). Consistently low dissolved oxygen concentrations in this area were especially of concern, suggesting that hypoxic conditions and poor habitat quality prevailed. The high nutrient concentrations at station 4 (especially total phosphorus) suggest that nutrient enrichment was likely the cause of the reduced environmental quality.

Some results warrant continued monitoring of Richards Creek. These include: (1) low dissolved oxygen levels, (2) a recent rising trend in nitrate levels, (3) elevated total phosphorus concentrations, (4) aluminum concentrations above BC water quality guidelines, (5) consistently elevated coliform levels, and (6) declining trend in stream invertebrate densities. Continued monitoring at the same time of year and location, and using consistent methodologies will provide a long-term time series, which will be helpful to detect changes in environmental quality.

6. Acknowledgements

This long-term monitoring project would not have been possible without continued interest and support from Fisheries and Oceans Canada. We would like to acknowledge Margaret Wright (Fisheries and Oceans Canada) for continued support in facilitating this and other monitoring projects.

Long-term monitoring was conducted by students attending the Environmental Monitoring (RMOT 306) course at Vancouver Island University. Students conducted all tasks related to site visits, project proposal, field sampling, laboratory analyses, and oral and written presentations. The following students conducted the yearly monitoring projects:

- 2008: L. Brown, T. McDonald, and M. Rochetta
- 2009: M. Anderson, M. Corbett, B. Isbister, and K. Reaume
- 2010: B. Brooks, A. Godkin, and J. McNish
- 2011: M. Dorey, G. Haider, H. McCabe, and H. McCubbin
- 2012: H. Coopsie, and S. Senkiw
- 2013: M. Demkiw, S. Gregory, L. Parker, and C. Seibert
- 2014: T. Aikman, C. Brophy, and F. Linza
- 2015: T. Der, S. Govier, H. Quist, and H. Richardson

The Resource Management and Protection (RMAP) 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. We would also like to acknowledge Amber Springer (ALS Laboratory) for continued support of these monitoring projects.

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Vancouver Island University (VIU: M. Anderson, M. Corbett, B. Isbister, K. Reaume, and E. Demers). 2010. Water Quality and Stream Invertebrate Assessment for Richards Creek, BC (Fall 2009). Data Report.

Vancouver Island University (VIU: B. Brooks, A. Godkin, J. McNish, and E. Demers). 2011. Water Quality and Stream Invertebrate Assessment for Richards Creek, BC (Fall 2010). Data Report.

Vancouver Island University (VIU: M. Dorey, G. Haider, H. McCabe, H. McCubbin, and E. Demers). 2012. Water Quality and Stream Invertebrate Assessment for Richards Creek, BC (Fall 2011). Data Report.

2. Appendix A

Table A.1. Water quality results for water samples taken from 4 stations at Richards Creek during fall 2008. All values are expressed in mg/L unless specified otherwise.

Parameters	27 October 2008				17 November 2008			
	1	2	3	4	1	2	3	4
General / Physical								
Water Temperature (°C)	6.0	7.0	7.0	7.0	8.5	8.5	8.5	8.8
Dissolved Oxygen					9.8	10.6	9.2	1.9
Conductivity (µS/cm)	76.9	90.0	107	145	150	170	177	201
pH (pH units)	7.24	7.30	7.39	6.95	7.76	7.84	7.86	7.43
Alkalinity	20.2	26.4	33.2	40.0	31.4	37.6	34.8	41.6
Hardness, Total	28.0	33.1	39.6	53.7	52.9	62.6	68.9	76.2
Nutrients								
Bromide (Br)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	5.12	6.32	7.63	12.7	14.5	14.1	14.5	14.5
Fluoride (F)	0.023	0.026	0.030	0.047	0.021	0.024	0.028	0.041
Nitrate (as N)	0.0139	0.0548	0.0573	0.332	0.57	0.617	0.615	0.607
Nitrite (as N)	<0.0010	<0.0010	<0.0010	0.0052	<0.0010	0.001	0.0011	0.0235
Sulfate (SO_4)	7.81	8.41	9.03	10.8	13.4	19.7	18.7	25.4
Coliforms								
Non-fecal (CFU/100 ml)	400	400	1130	1480				
Fecal (CFU/100 ml)	560	10	40	10				
% fecal	58.3	2.4	3.4	0.7				

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Table A.1. (Continued)

Parameters	27 October 2008				17 November 2008			
	1	2	3	4	1	2	3	4
Total Metals								
Aluminum (Al)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.21
Antimony (Sb)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Arsenic (As)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Barium (Ba)	<0.010	<0.010	<0.010	<0.010	0.012	0.013	0.013	0.018
Berylium (Be)	<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)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cadmium (Cd)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Calcium (Ca)	8.73	10	11.5	16	16.4	19.6	20.7	22
Chromium (Cr)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cobalt (Co)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Copper (Cu)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron (Fe)	0.152	0.133	0.179	0.339	0.176	0.197	0.203	0.328
Lead (Pb)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lithium (Li)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Magnesium (Mg)	1.51	1.96	2.67	3.32	2.88	3.35	4.22	5.17
Manganese (Mn)	0.0229	0.0154	0.0124	0.0287	0.0561	0.0299	0.0126	0.117
Molybdenum (Mo)	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Nickel (Ni)	<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	0.4
Potassium (K)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	3.1
Selenium (Se)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Silicon (Si)	1.97	2.86	3.64	4.25	5.01	5.84	6.44	5.63
Silver (Ag)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Sodium (Na)	3.5	4.1	4.8	6.4	7.6	7.9	8.7	8.6
Strontium (Sr)	0.0257	0.0316	0.0401	0.0624	0.0539	0.0629	0.0792	0.105
Thallium (Tl)	<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)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.012
Vanadium (V)	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zinc (Zn)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0088

Table A.2. Water quality results for water samples taken from 4 stations at Richards Creek during fall 2009. All values are expressed in mg/L unless specified otherwise.

Parameters	3 November 2009				23 November 2009			
	1	2	3	4	1	2	3	4
General / Physical								
Water Temperature (ºC)	8.2	8.0	7.8	7.3	7.1	7.4	7.4	6.7
Dissolved Oxygen	10.2	11.3	11.1	2.5	11.2	11.4	11.4	8.8
Conductivity (µS/cm)	138	177	185	212	75.4	83.5	88.0	112
pH (pH units)	7.39	7.56	7.61	7.03	7.28	7.31	7.34	7.22
Alkalinity	43.6	34.8	39.2	29.6	10.4	27.6	15.6	28.8
Hardness, Total	47.6	61.1	65.9	73.6	26.4	30.3	31.7	39.5
Turbidity (NTU)	4.0	4.0	2.0	5.0	2.0	6.0	1.0	1.0
Nutrients								
Ammonia	<0.020	<0.020	<0.020	0.049	0.023	0.060	0.071	0.115
Nitrate	1.07	1.01	0.958	0.867	0.268	0.259	0.397	0.749
Nitrite	<0.0010	<0.0010	<0.0010	0.0111	<0.0010	<0.0010	<0.0010	0.0051
Orthophosphate	<0.0010	<0.0010	0.0195	0.0587	<0.0010	<0.0010	0.0153	0.0714
Total Phosphorus	0.0057	0.0072	0.0363	0.097	0.0161	0.0170	0.0340	0.113
Coliforms								
Non-fecal (CFU/100 ml)	4	6	13	9				
Fecal (CFU/100 ml)	4	4	6	81				
% fecal	50.0	40.0	31.6	90.0				

(Continued on next page)

Table A.2. (Continued)

Parameters	3 November 2009				23 November 2009			
	1	2	3	4	1	2	3	4
Total Metals								
Aluminum (Al)	<0.20	<0.20	<0.60	0.28	0.33	0.32	0.46	0.49
Antimony (Sb)	<0.20	<0.20	<0.60	<0.20	<0.20	<0.20	<0.20	<0.20
Arsenic (As)	<0.20	<0.20	<0.60	<0.20	<0.20	<0.20	<0.20	<0.20
Barium (Ba)	0.011	0.012	<0.030	0.018	0.012	0.012	0.013	0.014
Berylium (Be)	<0.0050	<0.0050	<0.015	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bismuth (Bi)	<0.20	<0.20	<0.60	<0.20	<0.20	<0.20	<0.20	<0.20
Boron (B)	<0.10	<0.10	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10
Cadmium (Cd)	<0.010	<0.010	<0.030	<0.010	<0.010	<0.010	<0.010	<0.010
Calcium (Ca)	14.6	18.5	19.2	21.3	8.29	9.68	9.90	11.8
Chromium (Cr)	<0.010	<0.010	<0.030	<0.010	<0.010	<0.010	<0.010	<0.010
Cobalt (Co)	<0.010	<0.010	<0.030	<0.010	<0.010	<0.010	<0.010	<0.010
Copper (Cu)	<0.010	<0.010	<0.030	<0.010	<0.010	<0.010	<0.010	<0.010
Iron (Fe)	0.177	0.140	0.276	0.391	0.378	0.370	0.440	0.451
Lead (Pb)	<0.050	<0.050	<0.15	<0.050	<0.050	<0.050	<0.050	<0.050
Lithium (Li)	<0.010	<0.010	<0.030	<0.010	<0.010	<0.010	<0.010	<0.010
Magnesium (Mg)	2.68	3.63	4.36	4.94	1.38	1.48	1.69	2.41
Manganese (Mn)	0.0326	0.0173	0.019	0.0311	0.0423	0.0323	0.0313	0.0192
Molybdenum (Mo)	<0.030	<0.030	<0.090	<0.030	<0.030	<0.030	<0.030	<0.030
Nickel (Ni)	<0.050	<0.050	<0.15	<0.050	<0.050	<0.050	<0.050	<0.050
Phosphorus (P)	<0.30	<0.30	<0.90	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	<2.0	<2.0	<6.0	<2.0	<2.0	<2.0	<2.0	<2.0
Selenium (Se)	<0.20	<0.20	<0.60	<0.20	<0.20	<0.20	<0.20	<0.20
Silicon (Si)	4.02	5.23	5.78	5.24	3.80	4.23	4.47	4.50
Silver (Ag)	<0.010	<0.010	<0.030	<0.010	<0.010	<0.010	<0.010	<0.010
Sodium (Na)	7.3	8.7	9.8	11.1	4.3	4.6	4.8	5.9
Strontium (Sr)	0.0485	0.0637	0.077	0.114	0.0265	0.0293	0.0341	0.0566
Thallium (Tl)	<0.20	<0.20	<0.60	<0.20	<0.20	<0.20	<0.20	<0.20
Tin (Sn)	<0.030	<0.030	<0.090	<0.030	<0.030	<0.030	<0.030	<0.030
Titanium (Ti)	<0.010	<0.010	<0.030	0.014	0.017	0.016	0.021	0.023
Vanadium (V)	<0.030	<0.030	<0.090	<0.030	<0.030	<0.030	<0.030	<0.030
Zinc (Zn)	<0.0050	<0.0050	<0.015	<0.0050	<0.0050	<0.0050	<0.0050	0.0124

Table A.3. Water quality results for water samples taken from 5 stations at Richards Creek during fall 2010. All values are expressed in mg/L unless specified otherwise.

Parameters	1 November 2010				22 November 2010			
	1	2	3	4	1	2	3	4
General / Physical								
Water Temperature (ºC)	10.9	10.3	10.4	9.9	2.6	2.4	2.2	1.7
Dissolved Oxygen	9.5	10.8	10.7	2.5	13.1	13.7	13.6	8.8
Conductivity (µS/cm)	118	138	158	148	135	146	160	182
pH (pH units)	7.25	7.48	7.48	6.98	7.54	7.75	7.53	7.38
Alkalinity	45.0	54.0	59.0	55.0	41.0	46.0	52.0	58.0
Hardness, Total	43.2	51.6	59.4	58.4	48.1	53.9	60.2	68.9
Turbidity (NTU)	10.0	11.0	17.0	6.0	4.0	2.0	5.0	5.0
Nutrients								
Ammonia	0.0065	<0.0050	0.0748	0.0374	0.0068	0.0054	0.0088	0.0638
Nitrate	0.756	0.634	0.776	0.0079	0.447	0.434	0.621	0.767
Nitrite	0.0011	<0.0010	0.0112	0.0017	<0.0010	<0.0010	0.0015	0.0093
Orthophosphate	<0.0010	<0.0010	0.226	0.117	<0.0010	<0.0010	0.0527	0.0674
Total Phosphorus	0.0303	0.0296	0.299	0.191	0.0065	0.0075	0.0713	0.107
Coliforms								
Non-fecal (CFU/100 ml)	292	332	646	767				
Fecal (CFU/100 ml)	216	824	1695	525				
% fecal	42.5	71.3	72.4	40.6				

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Table A.3. (Continued)

	1 November 2010				22 November 2010			
Parameters	1	2	3	4	1	2	3	4
Total Metals								
Aluminum (Al)	0.62	0.60	0.89	<0.20	<0.20	<0.20	0.24	0.27
Antimony (Sb)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Arsenic (As)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Barium (Ba)	0.016	0.016	0.019	0.013	0.011	0.012	0.012	0.014
Berylium (Be)	<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)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cadmium (Cd)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Calcium (Ca)	13.3	15.9	17.1	16.3	15.2	17.0	18.1	20.7
Chromium (Cr)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cobalt (Co)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Copper (Cu)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron (Fe)	0.803	0.775	1.03	0.545	0.233	0.225	0.316	0.472
Lead (Pb)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lithium (Li)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Magnesium (Mg)	2.42	2.92	4.05	4.26	2.49	2.80	3.65	4.21
Manganese (Mn)	0.108	0.0681	0.0580	0.157	0.0557	0.0330	0.0341	0.0199
Molybdenum (Mo)	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Nickel (Ni)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Phosphorus (P)	<0.30	<0.30	0.31	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	<2.0	<2.0	2.3	<2.0	<2.0	<2.0	<2.0	<2.0
Selenium (Se)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Silicon (Si)	4.98	5.65	6.27	2.50	5.29	5.61	5.92	5.12
Silver (Ag)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Sodium (Na)	6.7	7.0	7.8	8.9	7.4	6.9	7.5	7.9
Strontium (Sr)	0.0452	0.0538	0.0727	0.0898	0.0461	0.0509	0.0691	0.0941
Thallium (Tl)	<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)	0.032	0.029	0.039	<0.010	<0.010	<0.010	0.013	0.013
Vanadium (V)	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zinc (Zn)	<0.0050	0.0056	0.0057	0.0064	<0.0050	<0.0050	<0.0050	<0.0050

Table A.4. Water quality results for water samples taken from 5 stations at Richards Creek during fall 2011. All values are expressed in mg/L unless specified otherwise.

Parameters	29 October 2011				20 November 2011			
	1	2	3	4	1	2	3	4
General / Physical								
Water Temperature (ºC)	7.5	7.9	7.0	6.0	2.0	2.5	1.7	3.3
Dissolved Oxygen	12.9	12.7	16.1	8.1				
Conductivity (µS/cm)	89.7		131	165	129		196	279
pH (pH units)	7.90		8.00	7.90	7.87		8.04	7.86
Alkalinity	21.2	31.6	27.8	28.8	25.5	32.6	34.5	50.1
Hardness, Total	33.7		49.1	55.2	48.9		77.1	98.7
Turbidity (NTU)	1.1	1.2	1.9	2.4	0.8	0.9	1.3	3.9
Nutrients								
Ammonia	0.0071		0.0067	0.236	0.0246		0.0054	0.317
Nitrate	0.0650		0.271	0.292	0.130		0.407	0.865
Nitrite	<0.0010		0.0066	0.0131	<0.0010		<0.0010	0.0180
Orthophosphate	<0.0010		0.0103	0.109	<0.0010		0.0093	0.144
Total Phosphorus	0.0087		0.0240	0.154	0.0054		0.0190	0.212
Coliforms								
Non-fecal (CFU/100 ml)	152	240	612	1136				
Fecal (CFU/100 ml)	32	76	60	100				
% fecal	17.4	24.1	8.9	8.1				

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Table A.4. (Continued)

	29 October 2011				20 November 2011			
Parameters	1	2	3	4	1	2	3	4
Total Metals								
Aluminum (Al)	<0.20		<0.20	<0.20	<0.20		<0.20	0.28
Antimony (Sb)	<0.20		<0.20	<0.20	<0.20		<0.20	<0.20
Arsenic (As)	<0.20		<0.20	<0.20	<0.20		<0.20	<0.20
Barium (Ba)	<0.010		<0.010	<0.010	<0.010		0.011	0.014
Berylium (Be)	<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
Boron (B)	<0.10		<0.10	<0.10	<0.10		<0.10	<0.10
Cadmium (Cd)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Calcium (Ca)	10.5		14.3	16.0	14.9		21.8	28.7
Chromium (Cr)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Cobalt (Co)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Copper (Cu)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Iron (Fe)	0.288		0.303	0.493	0.311		0.200	0.650
Lead (Pb)	<0.050		<0.050	<0.050	<0.050		<0.050	<0.050
Lithium (Li)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Magnesium (Mg)	1.82		3.26	3.68	2.84		5.49	6.58
Manganese (Mn)	0.0261		0.0157	0.105	0.0773		0.0109	0.117
Molybdenum (Mo)	<0.030		<0.030	<0.030	<0.030		<0.030	<0.030
Nickel (Ni)	<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
Potassium (K)	<2.0		<2.0	<2.0	<2.0		<2.0	3.9
Selenium (Se)	<0.20		<0.20	<0.20	<0.20		<0.20	<0.20
Silicon (Si)	3.12		5.19	5.07	4.62		7.82	7.78
Silver (Ag)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Sodium (Na)	3.9		5.8	8.7	6.2		9.1	16.5
Strontium (Sr)	0.0311		0.0495	0.0631	0.0473		0.0840	0.130
Thallium (Tl)	<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
Titanium (Ti)	<0.010		<0.010	<0.010	<0.010		<0.010	0.017
Vanadium (V)	<0.030		<0.030	<0.030	<0.030		<0.030	<0.030
Zinc (Zn)	<0.0050		<0.0050	<0.0050	<0.0050		<0.0050	0.0091

Table A.5. Water quality results for water samples taken from 5 stations at Richards Creek during fall 2012. All values are expressed in mg/L unless specified otherwise.

Parameters	28 October 2012				17 November 2012			
	1	2	3	4	1	2	3	4
General / Physical								
Water Temperature (ºC)	9.6	9.5	9.4	8.5	7.7	7.8	7.8	7.2
Dissolved Oxygen	11.1	11.5	11.4	5.3	9.4	10.1	10.0	4.9
Conductivity (µS/cm)	97.7	123	153		118	138	148	
pH (pH units)	7.60	7.59	7.72		7.56	7.67	7.58	
Alkalinity	20.0	16.0	19.6	21.6	20.8	24.2	31.6	36.4
Hardness, Total	37.9	46.3	57.8		41.8	50.4	55.1	
Turbidity (NTU)	1.3	1.4	2.3	3.1	3.6	5.3	2.9	1.8
Nutrients								
Ammonia	<0.0050	<0.0050	0.0261		0.0065	0.0062	0.0067	
Nitrate	0.217	0.333	0.467		0.299	0.299	0.357	
Nitrite	0.0016	0.0018	0.0058		<0.0010	<0.0010	<0.0010	
Orthophosphate	<0.0010	<0.0010	0.132		<0.0010	<0.0010	0.0437	
Total Phosphorus	0.0120	0.0126	0.154		0.0144	0.0190	0.0728	
Coliforms								
Non-fecal (CFU/100 ml)	767	302	132					
Fecal (CFU/100 ml)	30	10	34					
% fecal	3.8	3.2	20.5					

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Table A.5. (Continued)

	28 October 2012				17 November 2012			
Parameters	1	2	3	4	1	2	3	4
Total Metals								
Aluminum (Al)	<0.20	<0.20	<0.20		0.42	0.55	0.39	
Antimony (Sb)	<0.20	<0.20	<0.20		<0.20	<0.20	<0.20	
Arsenic (As)	<0.20	<0.20	<0.20		<0.20	<0.20	<0.20	
Barium (Ba)	<0.010	<0.010	0.011		0.013	0.016	0.014	
Berylium (Be)	<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	
Boron (B)	<0.10	<0.10	<0.10		<0.10	<0.10	<0.10	
Cadmium (Cd)	<0.010	<0.010	<0.010		<0.010	<0.010	<0.010	
Calcium (Ca)	11.6	13.9	16.5		13.1	16.0	16.7	
Chromium (Cr)	<0.010	<0.010	<0.010		<0.010	<0.010	<0.010	
Cobalt (Co)	<0.010	<0.010	<0.010		<0.010	<0.010	<0.010	
Copper (Cu)	<0.010	<0.010	<0.010		0.022	<0.010	<0.010	
Iron (Fe)	0.262	0.267	0.336		0.433	0.638	0.476	
Lead (Pb)	<0.050	<0.050	<0.050		<0.050	<0.050	<0.050	
Lithium (Li)	<0.010	<0.010	<0.010		<0.010	<0.010	<0.010	
Magnesium (Mg)	2.13	2.81	4.01		2.17	2.56	3.24	
Manganese (Mn)	0.0372	0.0314	0.0188		0.0495	0.0521	0.0412	
Molybdenum (Mo)	<0.030	<0.030	<0.030		<0.030	<0.030	<0.030	
Nickel (Ni)	<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	
Potassium (K)	<2.0	<2.0	<2.0		<2.0	<2.0	<2.0	
Selenium (Se)	<0.20	<0.20	<0.20		<0.20	<0.20	<0.20	
Silicon (Si)	3.32	4.62	5.42		5.06	5.53	5.59	
Silver (Ag)	<0.010	<0.010	<0.010		<0.010	<0.010	<0.010	
Sodium (Na)	5.3	6.7	8.4		6.9	7.0	6.9	
Strontium (Sr)	0.0383	0.0487	0.0696		0.0422	0.0490	0.0612	
Thallium (Tl)	<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	
Titanium (Ti)	<0.010	<0.010	0.010		0.022	0.025	0.019	
Vanadium (V)	<0.030	<0.030	<0.030		<0.030	<0.030	<0.030	
Zinc (Zn)	<0.0050	<0.0050	<0.0050		<0.0050	<0.0050	<0.0050	

Table A.6. Water quality results for water samples taken from 5 stations at Richards Creek during fall 2013. All values are expressed in mg/L unless specified otherwise.

	28 October 2013				18 November 2013			
Parameters	1	2	3	4	1	2	3	4
General / Physical								
Water Temperature (ºC)		10.1	9.4	9.4	7.5	7.3	8.3	6.6
Dissolved Oxygen					11.6	12.8	12.4	5.4
Conductivity (µS/cm)	86.5		120	335	149		183	245
pH (pH units)	7.62		7.72	7.19	7.85		7.83	7.49
Alkalinity	30.0	35.6	39.8	54.0	52.0	37.6	50.8	60.8
Hardness, Total	34.1		47.2	104	54.0		68.6	96.2
Turbidity (NTU)	1.2	0.8	1.0	3.6	1.6	3.2	1.9	4.1
Nutrients								
Ammonia	0.0068		0.0058	0.299	0.0108		0.0073	0.252
Nitrate	0.0151		0.0989	0.129	0.338		0.543	0.785
Nitrite	<0.0010		<0.0010	0.0094	<0.0010		0.0023	0.0218
Total Nitrogen	0.227		0.315	1.62	0.471		0.798	1.56
Orthophosphate	<0.0010		0.0021	0.184	<0.0010		0.0251	0.108
Total Phosphorus	0.0072		0.0101	0.430	0.0203		0.0374	0.152
Coliforms								
Non-fecal (CFU/100 ml)	827	64	176	1776				
Fecal (CFU/100 ml)	2	2	5	26				
% fecal	0.2	3.0	2.8	1.4				

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Table A.6. (Continued)

	28 October 2013				18 November 2013			
Parameters	1	2	3	4	1	2	3	4
Total Metals								
Aluminum (Al)	<0.20		<0.20	<0.20	<0.20		<0.20	0.27
Antimony (Sb)	<0.20		<0.20	<0.20	<0.20		<0.20	<0.20
Arsenic (As)	<0.20		<0.20	<0.20	<0.20		<0.20	<0.20
Barium (Ba)	<0.010		<0.010	0.022	0.011		0.012	0.017
Berylium (Be)	<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
Boron (B)	<0.10		<0.10	<0.10	<0.10		<0.10	<0.10
Cadmium (Cd)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Calcium (Ca)	10.7		14.0	31.5	16.9		20.3	29.8
Chromium (Cr)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Cobalt (Co)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Copper (Cu)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Iron (Fe)	0.316		0.148	1.07	0.252		0.221	0.615
Lead (Pb)	<0.050		<0.050	<0.050	<0.050		<0.050	<0.050
Lithium (Li)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Magnesium (Mg)	1.81		2.97	6.16	2.89		4.33	5.28
Manganese (Mn)	0.0536		0.0103	0.372	0.0756		0.0170	0.123
Molybdenum (Mo)	<0.030		<0.030	<0.030	<0.030		<0.030	<0.030
Nickel (Ni)	<0.050		<0.050	<0.050	<0.050		<0.050	<0.050
Phosphorus (P)	<0.30		<0.30	0.37	<0.30		<0.30	<0.30
Potassium (K)	<2.0		<2.0	4.8	<2.0		<2.0	<2.0
Selenium (Se)	<0.20		<0.20	<0.20	<0.20		<0.20	<0.20
Silicon (Si)	3.56		5.22	7.44	5.77		6.61	6.74
Silver (Ag)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Sodium (Na)	4.0		5.5	25.1	7.8		8.7	12.7
Strontium (Sr)	0.0320		0.0473	0.133	0.0542		0.0776	0.124
Thallium (Tl)	<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
Titanium (Ti)	0.012		<0.010	0.016	<0.010		<0.010	0.013
Vanadium (V)	<0.030		<0.030	<0.030	<0.030		<0.030	<0.030
Zinc (Zn)	<0.0050		<0.0050	<0.0050	<0.0050		<0.0050	0.0092

Table A.7. Water quality results for water samples taken from 5 stations at Richards Creek during fall 2014. All values are expressed in mg/L unless specified otherwise.

	27 October 2014				17 November 2014			
Parameters	1	2	3	4	1	2	3	4
General / Physical								
Water Temperature (ºC)	9.4	9.4	9.5	10.3	4.5	4.2	3.6	3.0
Dissolved Oxygen	9.1	10.0	9.8	1.9	12.9	13.1	13.3	5.6
Conductivity (µS/cm)	164		204	241	102		129	191
pH (pH units)	7.51		7.73	7.10	7.55		7.67	7.20
Alkalinity	34.0	32.0	40.0	32.0				
Hardness, Total	57.2		77.2	84.1	37.4		50.2	77.1
Turbidity (NTU)	1.5	1.8	3.2	3.3	0.8	0.7	1.1	3.0
Nutrients								
Ammonia	0.0120		0.0096	0.106	0.0184		<0.0050	0.162
Nitrate	1.65		1.58	1.40	0.216		0.327	0.334
Nitrite	0.0035		0.0034	0.0551	<0.0010		<0.0010	0.0112
Total Nitrogen	1.83		2.06	2.40	0.685		0.542	1.52
Orthophosphate	<0.0010		0.0526	0.109	<0.0010		0.0047	0.166
Total Phosphorus	0.0062		0.0828	0.197	0.0661		0.0102	0.214
Coliforms								
Non-fecal (CFU/100 ml)	316	452	632	1168				
Fecal (CFU/100 ml)	38	80	92	160				
% fecal	10.7	15.0	12.7	12.0				

(Continued on next page)

Table A.7. (Continued)

	27 October 2014				17 November 2014			
Parameters	1	2	3	4	1	2	3	4
Total Metals								
Aluminum (Al)	<0.20		0.25	0.38	<0.20		<0.20	<0.20
Antimony (Sb)	<0.20		<0.20	<0.20	<0.20		<0.20	<0.20
Arsenic (As)	<0.20		<0.20	<0.20	<0.20		<0.20	<0.20
Barium (Ba)	0.014		0.016	0.020	<0.010		0.011	0.018
Berylium (Be)	<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
Boron (B)	<0.10		<0.10	<0.10	<0.10		<0.10	<0.10
Cadmium (Cd)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Calcium (Ca)	17.6		22.5	24.8	11.8		15.5	23.7
Chromium (Cr)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Cobalt (Co)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Copper (Cu)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Iron (Fe)	0.260		0.339	0.568	0.148		0.176	0.490
Lead (Pb)	<0.050		<0.050	<0.050	<0.050		<0.050	<0.050
Lithium (Li)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Magnesium (Mg)	3.19		5.08	5.41	1.92		2.78	4.37
Manganese (Mn)	0.0653		0.0198	0.0612	0.0359		0.0158	0.213
Molybdenum (Mo)	<0.030		<0.030	<0.030	<0.030		<0.030	<0.030
Nickel (Ni)	<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
Potassium (K)	<2.0		<2.0	<2.0	<2.0		<2.0	<2.0
Selenium (Se)	<0.20		<0.20	<0.20	<0.20		<0.20	<0.20
Silicon (Si)	5.66		7.33	6.71	3.74		4.93	5.23
Silver (Ag)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Sodium (Na)	8.6		10.6	12.7	5.0		6.1	8.7
Strontium (Sr)	0.0605		0.0991	0.132	0.0354		0.0508	0.0951
Thallium (Tl)	<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
Titanium (Ti)	<0.010		0.015	0.020	<0.010		<0.010	0.012
Vanadium (V)	<0.030		<0.030	<0.030	<0.030		<0.030	<0.030
Zinc (Zn)	<0.0050		<0.0050	0.0063	<0.0050		<0.0050	0.0075

Table A.8. Water quality results for water samples taken from 5 stations at Richards Creek during fall 2015. All values are expressed in mg/L unless specified otherwise.

	2 November 2015				24 November 2015			
Parameters	1	2	3	4	1	2	3	4
General / Physical								
Water Temperature (ºC)	10.1	9.4	9.4	11.3	6.9	5.6	5.6	4.2
Dissolved Oxygen	12.5	12.1	11.8	3.7	11.2	13.1	13.5	8.1
Conductivity (µS/cm)	199		217	274	108		139	177
pH (pH units)	7.20		7.56	6.81	7.37		7.52	7.09
Alkalinity	31.0	26.0	30.0	27.0	8.0	13.0	16.0	20.0
Hardness, Total	69.3		76.9	99.6	35.7		48.5	61.6
Turbidity (NTU)	2.4	2.7	5.5	7.6	2.2	1.7	2.6	3.9
Nutrients								
Ammonia	0.0233		0.0106	0.0828	0.0131		0.0053	0.0889
Nitrate	1.72		1.44	3.28	0.533		0.811	1.09
Nitrite	0.0057		0.0032	0.0302	0.0011		0.0011	0.0166
Total Nitrogen	2.14		2.16	4.35	0.792		1.08	2.10
Orthophosphate	0.0032		0.0871	0.0958	0.0044		0.0222	0.0796
Total Phosphorus	0.0172		0.109	0.139	0.0112		0.0267	0.159
Coliforms								
Non-fecal (CFU/100 ml)	844	84	2040	1016				
Fecal (CFU/100 ml)	76	52	76	200				
% fecal	8.3	38.2	3.6	16.4				

(Continued on next page)

Table A.8. (Continued)

	2 November 2015				24 November 2015			
Parameters	1	2	3	4	1	2	3	4
Total Metals								
Aluminum (Al)	<0.20		0.37	0.40	<0.20		0.25	0.85
Antimony (Sb)	<0.20		<0.20	<0.20	<0.20		<0.20	<0.20
Arsenic (As)	<0.20		<0.20	<0.20	<0.20		<0.20	<0.20
Barium (Ba)	0.018		0.017	0.023	0.010		0.013	0.018
Berylium (Be)	<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
Boron (B)	<0.10		<0.10	<0.10	<0.10		<0.10	<0.10
Cadmium (Cd)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Calcium (Ca)	21.3		21.9	30.0	11.3		15.0	18.4
Chromium (Cr)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Cobalt (Co)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Copper (Cu)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Iron (Fe)	0.435		0.461	0.673	0.212		0.259	0.926
Lead (Pb)	<0.050		<0.050	<0.050	<0.050		<0.050	<0.050
Lithium (Li)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Magnesium (Mg)	3.92		5.36	5.97	1.84		2.70	3.79
Manganese (Mn)	0.0968		0.0273	0.0627	0.0277		0.0245	0.0527
Molybdenum (Mo)	<0.030		<0.030	<0.030	<0.030		<0.030	<0.030
Nickel (Ni)	<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
Potassium (K)	<2.0		<2.0	2.3	<2.0		<2.0	<2.0
Selenium (Se)	<0.20		<0.20	<0.20	<0.20		<0.20	<0.20
Silicon (Si)	6.46		7.57	7.03	4.10		4.94	5.79
Silver (Ag)	<0.010		<0.010	<0.010	<0.010		<0.010	<0.010
Sodium (Na)	10.7		10.6	11.8	5.2		5.9	8.3
Strontium (Sr)	0.0734		0.0955	0.125	0.0349		0.0529	0.0826
Thallium (Tl)	<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
Titanium (Ti)	0.012		0.020	0.021	0.011		0.013	0.038
Vanadium (V)	<0.030		<0.030	<0.030	<0.030		<0.030	<0.030
Zinc (Zn)	<0.0050		<0.0050	<0.0050	<0.0050		<0.0050	0.0089

3. Appendix B

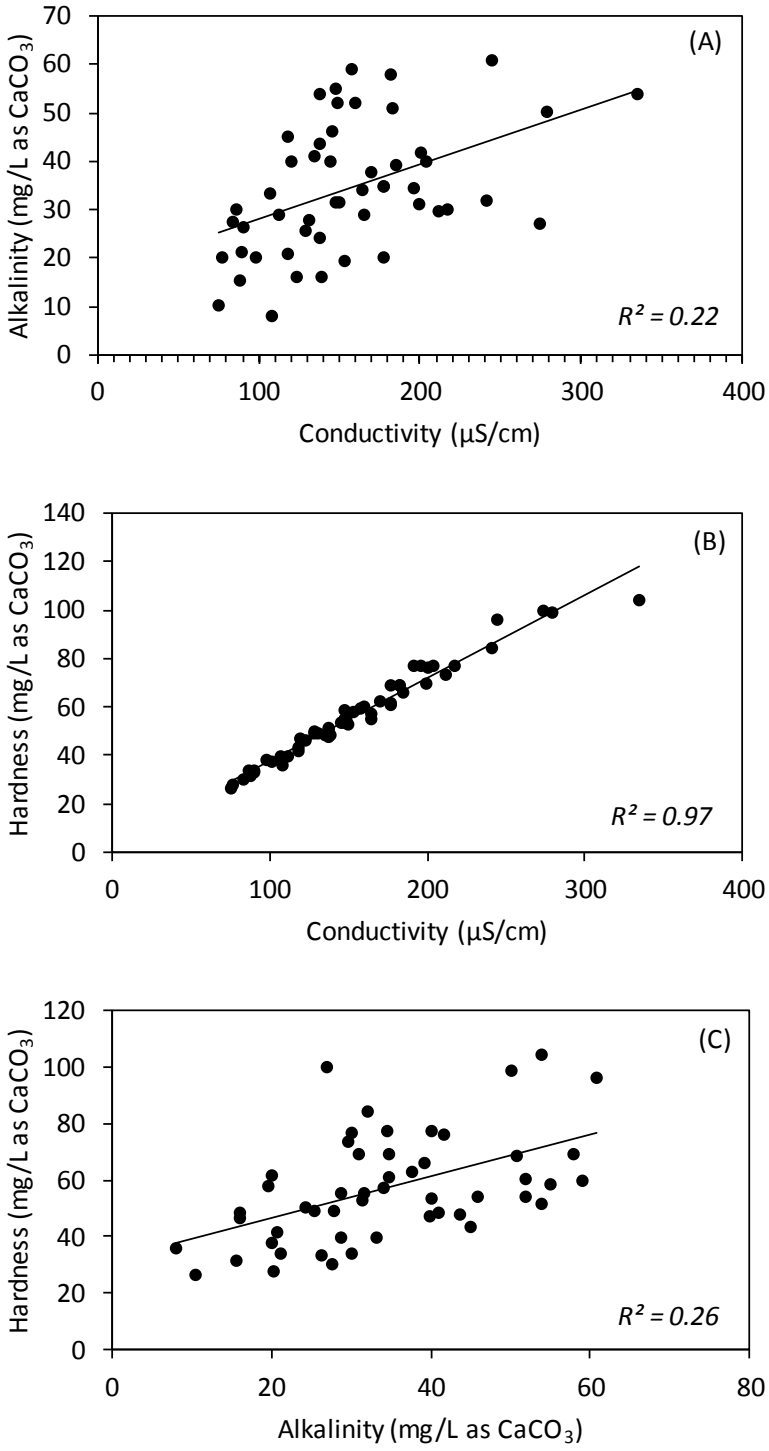

Figure B.1. Linear relationships between (A) alkalinity and conductivity, (B) hardness and conductivity, and (C) harness and alkalinity measured at four stations in Richards Creek during two sampling events in 2008-2015.

4. Appendix C

Table C.1. Invertebrate Survey Field Data Sheet completed for triplicate stream invertebrate samples collected at Stations 1-3 on Richards Creek during 2008.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Richards Creek		Date: 27 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)	4	1
	Mayfly Nymph (EPT)	7	1
	Stonefly Nymph (EPT)	12	2
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		23	4
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	6	2
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)		
	Watersnipe Larva		
Sub-Total		6	2
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	46	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	2	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite	8	1
Sub-Total		56	3
TOTAL		85	9

Table C.1. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 85

DENSITY: Invertebrate density per square metre:

85 ÷ 0.27 = 315

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 4 + 2 x 2 + 3 = 19

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1 + 1 + 2 = 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

(4 + 7 + 12) / 85 = 0.27

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

46 / 85 = 0.54

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	2
EPT To Total Ratio	2
Predominant Taxon Ratio	3

Average Rating
2.50

Table C.1. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards Creek		Date: 27 October 2008
Station Name:	**Station 2**		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)	2	1
	Mayfly Nymph (EPT)	33	5
	Stonefly Nymph (EPT)	93	3
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		128	9
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva	1	1
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	7	2
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)		
	Watersnipe Larva		
Sub-Total		8	3
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	23	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	2	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite	2	1
Sub-Total		27	3
TOTAL		163	15

Table C.1. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 163

DENSITY: Invertebrate density per square metre:

163 ÷ 0.27 = 604

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C): Stonefly 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 x D2 + D3

3 x 9 + 2 x 3 + 3 = 36

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1 + 5 + 3 = 9

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

(2 + 33 + 93) / 163 = 0.79

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 15

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

93 / 163 = 0.57

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	4
EPT To Total Ratio	4
Predominant Taxon Ratio	3

Average Rating
3.75

Table C.1. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards Creek		Date: 27 October 2008
Station Name:	**Station 3**		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)	117	4
	Mayfly Nymph (EPT)	54	4
	Stonefly Nymph (EPT)	67	5
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		238	13
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva	3	1
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	5	1
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	7	1
	Watersnipe Larva		
Sub-Total		15	3
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	68	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	5	2
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		73	3
TOTAL		326	19

Table C.1. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 326

DENSITY: Invertebrate density per square metre:

326 ÷ 0.27 = 1207

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C): Caddisfly Larva (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 x D2 + D3

3 x 13 + 2 x 3 + 3 = 48

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

4 + 4 + 5 = 13

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

(117 + 54 + 67) / 326 = 0.73

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 19

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

117 / 326 = 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	4
EPT To Total Ratio	3
Predominant Taxon Ratio	4

Average Rating
3.75

Table C.2. Invertebrate Survey Field Data Sheet completed for triplicate stream invertebrate samples collected at Stations 1-3 on Richards Creek during 2009.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards Creek		Date:	3 November 2009
Station Name:	**Station 1**		Flow status:	Moderate
Sampler Used:	Number of replicates	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates		
Hess	4	0.09 x 4 =	0.36	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)	3	2
	Stonefly Nymph (EPT)		
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		4	3
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	38	2
	Watersnipe Larva		
Sub-Total		38	2
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	75	6
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		75	6
TOTAL		117	11

Table C.2. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 117

DENSITY: Invertebrate density per square metre:

117 ÷ 0.36 = 325

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C): 75

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 3 + 2 x 2 + 6 = 19

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1 + 2 + 0 = 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

(1 + 3 + 0) / 117 = 0.03

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 11

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

75 / 117 = 0.64

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	2
EPT To Total Ratio	1
Predominant Taxon Ratio	2

Average Rating
2.00

Table C.2. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards Creek		Date: 3 November 2009
Station Name:	**Station 2**		Flow status: Moderate
Sampler Used: Hess	Number of replicates 4	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.09 x 4 = 0.36 m^2	

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	1	1
	Mayfly Nymph (EPT)	32	8
	Stonefly Nymph (EPT)	25	6
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		58	15
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	6	3
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva	4	2
	Fishfly Larva		
	Scud (amphipod)	3	1
	Watersnipe Larva	1	1
Sub-Total		14	7
Category 3	Aquatic Worm (oligochaete)	22	4
	Blackfly Larva		
	Leech	1	1
	Midge Larva (chironomid)	2	1
	Planarian (flatworm)		
Pollution Tolerant	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite	1	1
Sub-Total		26	7
TOTAL		98	29

Table C.2. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 98

DENSITY: Invertebrate density per square metre:

98 ÷ 0.36 = 272

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C): 32

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 15 + 2 x 7 + 7 = 66

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1 + 8 + 6 = 15

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 + 32 + 25) / 98 = 0.59

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 29

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

32 / 98 = 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	4
EPT Index	4
EPT To Total Ratio	3
Predominant Taxon Ratio	4

Average Rating
3.75

Table C.2. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards Creek		Date: 3 November 2009
Station Name:	**Station 3**		Flow status: Moderate
Sampler Used: Hess	Number of replicates 4	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.09 x 4 = 0.36 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	3
	Mayfly Nymph (EPT)	22	3
	Stonefly Nymph (EPT)	10	2
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle	1	1
	Water Penny		
Sub-Total		51	9
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle	1	1
	Aquatic Sowbug		
	Clam, Mussel	8	2
	Cranefly Larva		
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	11	2
	Watersnipe Larva		
Sub-Total		20	5
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	46	3
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	2	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		48	4
TOTAL		119	18

Table C.2. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 119

DENSITY: Invertebrate density per square metre:

119 ÷ 0.36 = 331

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C): 46

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 9 + 2 x 5 + 4 = 41

EPT INDEX: Total number of EPT taxa.

Good	Accpetable	Marginal	Poor
>8	5-8	2-4	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	0.50-0.74	0.25-0.49	<0.25

(EPT1 + EPT2 + EPT3) / CT

(18 + 22 + 10) / 119 = 0.42

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 18

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

46 / 119 = 0.39

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	2
Predominant Taxon Ratio	4

Average Rating
3.25

Table C.3. Invertebrate Survey Field Data Sheet completed for triplicate stream invertebrate samples collected at Stations 1-3 on Richards Creek during 2010.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards Creek		Date:	1 November 2010
Station Name:	**Station 1**		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)	13	2
	Mayfly Nymph (EPT)	27	1
	Stonefly Nymph (EPT)	21	1
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		61	4
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel	5	1
	Cranefly Larva	10	2
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	16	1
	Watersnipe Larva		
Sub-Total		31	4
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	49	2
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite	3	1
Sub-Total		52	3
TOTAL		144	11

Table C.3. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 144

DENSITY: Invertebrate density per square metre:

144 ÷ 0.27 = 533

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 4 + 2 x 4 + 3 = 23

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

2 + 1 + 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	0.50-0.74	0.25-0.49	<0.25

(EPT1 + EPT2 + EPT3) / CT

(13 + 27 + 21) / 144 = 0.42

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 11

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

49 / 144 = 0.34

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

Table C.3. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards Creek		Date:	1 November 2010
Station Name:	**Station 2**		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)	19	2
	Mayfly Nymph (EPT)	28	3
	Stonefly Nymph (EPT)	16	2
	Dobsonfly (hellgrammite)	1	1
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		64	8
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	19	1
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)		
	Watersnipe Larva	2	1
Sub-Total		21	2
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	63	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite	3	1
Sub-Total		66	2
TOTAL		151	12

Table C.3. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 151

DENSITY: Invertebrate density per square metre:

151 ÷ 0.27 = 559

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 + 2 = 30

EPT INDEX: Total number of EPT taxa.

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

(19 + 28 + 16) / 151 = 0.42

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 12

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

63 / 151 = 0.42

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	2
Predominant Taxon Ratio	3

Average Rating
3.00

Table C.3. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards Creek		Date:	1 November 2010
Station Name:	**Station 3**		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)	24	5
	Mayfly Nymph (EPT)	11	2
	Stonefly Nymph (EPT)	29	2
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		64	9
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel	6	1
	Cranefly Larva	19	2
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	1	1
	Watersnipe Larva		
Sub-Total		26	4
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	71	2
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	6	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite	5	1
Sub-Total		82	4
TOTAL		172	17

Table C.3. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 172

DENSITY: Invertebrate density per square metre:

172 ÷ 0.27 = 637

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 9 + 2 x 4 + 4 = 39

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

5 + 2 + 2 = 9

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

(24 + 11 + 29) / 172 = 0.37

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 17

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

71 / 172 = 0.41

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S4, S5, S6, S8), then calculate the average.

Assessment Rating	
Good	4
Accpetable	3
Marginal	2
Poor	1

Assessment	Rating
Pollution Tolerance Index	4
EPT Index	4
EPT To Total Ratio	2
Predominant Taxon Ratio	3

Average Rating
3.25

Table C.4. Invertebrate Survey Field Data Sheet completed for triplicate stream invertebrate samples collected at Stations 1-3 on Richards Creek during 2011.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Richards Creek		Date: 29 October 2011
Station Name: **Station 1**		Flow status: Moderate
Sampler Used: Surber	Number of replicates 4	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.09 x 4 = 0.36 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	2	2
	Mayfly Nymph (EPT)	103	2
	Stonefly Nymph (EPT)	15	2
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		120	6
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	2	2
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	29	1
	Watersnipe Larva		
Sub-Total		31	3
Category 3	Aquatic Worm (oligochaete)	16	1
	Blackfly Larva	18	1
	Leech		
	Midge Larva (chironomid)	16	1
Pollution Tolerant	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		50	3
TOTAL		201	12

Table C.4. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 201

DENSITY: Invertebrate density per square metre:

201 ÷ 0.36 = 558

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 6 + 2 x 3 + 3 = 27

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

2 + 2 + 2 = 6

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

(2 + 103 + 15) / 201 = 0.60

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 12

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

103 / 201 = 0.51

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	3

Average Rating
3.25

Table C.4. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards Creek		Date:	29 October 2011
Station Name:	**Station 2**		Flow status:	Moderate
Sampler Used:	Number of replicates	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates		
Surber	4	0.09 x 4 =	0.36	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)	41	2
	Stonefly Nymph (EPT)	15	1
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		56	3
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva	2	1
	Fishfly Larva		
	Scud (amphipod)	3	1
	Watersnipe Larva		
Sub-Total		5	2
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	3	1
	Blackfly Larva	5	1
	Leech		
	Midge Larva (chironomid)	1	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		9	3
TOTAL		70	8

Table C.4. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 70

DENSITY: Invertebrate density per square metre:

70 ÷ 0.36 = 194

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 3 + 2 x 2 + 3 = 16

EPT INDEX: Total number of EPT taxa.

Good	Accpetable	Marginal	Poor
>8	5-8	2-4	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 + 41 + 15) / 70 = 0.80

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 8

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

41 / 70 = 0.59

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	4
Predominant Taxon Ratio	3

Average Rating
2.75

Table C.4. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards Creek		Date:	29 October 2011
Station Name:	**Station 3**		Flow status:	Moderate
Sampler Used:	Number of replicates	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates		
Surber	4	0.09 x 4 =	0.36	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)	44	3
	Mayfly Nymph (EPT)	85	3
	Stonefly Nymph (EPT)	11	2
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		140	8
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	56	2
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	8	1
	Watersnipe Larva		
Sub-Total		64	3
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	16	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	1	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		17	2
TOTAL		221	13

Table C.4. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 221

DENSITY: Invertebrate density per square metre:

221 ÷ 0.36 = 614

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 8 + 2 x 3 + 2 = 32

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	0.50-0.74	0.25-0.49	<0.25

(EPT1 + EPT2 + EPT3) / CT

(44 + 85 + 11) / 221 = 0.63

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

85 / 221 = 0.38

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

Table C.5. Invertebrate Survey Field Data Sheet completed for triplicate stream invertebrate samples collected at Stations 1-3 on Richards Creek during 2012.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards	Date:	31 October 2012
Station Name:	**Station 1**	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)	6	1
	Mayfly Nymph (EPT)		
	Stonefly Nymph (EPT)		
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		6	1
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel	5	1
	Cranefly Larva		
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	9	1
	Watersnipe Larva		
Sub-Total		14	2
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	6	1
	Blackfly Larva	1	1
	Leech		
	Midge Larva (chironomid)	1	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		8	3
TOTAL		28	6

Table C.5. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 28

DENSITY: Invertebrate density per square metre:

28 ÷ 0.27 = 104

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	17-22	11-16	<11

3 x D1 + 2 x D2 + D3

3 x 1 + 2 x 2 + 3 = 10

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1 + 0 + 0 = 1

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

(6 + 0 + 0) / 28 = 0.21

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 6

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

9 / 28 = 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	1
EPT Index	1
EPT To Total Ratio	1
Predominant Taxon Ratio	4

Average Rating
1.75

Table C.5. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards		Date:	31 October 2012
Station Name:	**Station 2**		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)	14	1
	Mayfly Nymph (EPT)	17	1
	Stonefly Nymph (EPT)	35	1
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		66	3
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)		
	Watersnipe Larva		
Sub-Total		0	0
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	4	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		4	1
TOTAL		70	4

Table C.5. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 70

DENSITY: Invertebrate density per square metre:

70 ÷ 0.27 = 259

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C): Stonefly 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 3 + 2 x 0 + 1 = 10

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1 + 1 + 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

(14 + 17 + 35) / 70 = 0.94

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 4

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

35 / 70 = 0.50

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	4
Predominant Taxon Ratio	3

Average Rating
2.50

Table C.5. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards		Date:	31 October 2012
Station Name:	**Station 3**		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)	1	1
	Mayfly Nymph (EPT)		
	Stonefly Nymph (EPT)	4	1
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		5	2
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)		
	Watersnipe Larva		
Sub-Total		0	0
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	4	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	7	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		11	2
TOTAL		16	4

Table C.5. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 16

DENSITY: Invertebrate density per square metre:

16 ÷ 0.27 = 59

PREDOMINANT TAXON:

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

3 x D1 + 2 x D2 + D3

3 x 2 + 2 x 0 + 2 = 8

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 + 4) / 16 = 0.31

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 4

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

7 / 16 = 0.44

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	2
Predominant Taxon Ratio	3

Average Rating
2.00

Table C.6. Invertebrate Survey Field Data Sheet completed for triplicate stream invertebrate samples collected at Stations 1-3 on Richards Creek during 2013.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards	Date:	30 October 2013
Station Name:	**Station 1**	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)	4	1
	Mayfly Nymph (EPT)	31	3
	Stonefly Nymph (EPT)	4	1
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		39	5
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	5	5
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	4	1
	Watersnipe Larva		
Sub-Total		9	6
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	13	3
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	4	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		17	4
TOTAL		65	15

Table C.6. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 65

DENSITY: Invertebrate density per square metre:

65 ÷ 0.27 = 241

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 6 + 4 = 31

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

(4 + 31 + 4) / 65 = 0.60

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 15

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

31 / 65 = 0.48

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	3

Average Rating
3.25

Table C.6. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards		Date:	30 October 2013
Station Name:	**Station 2**		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)	1	1
	Mayfly Nymph (EPT)	25	2
	Stonefly Nymph (EPT)	16	3
	Dobsonfly (hellgrammite)	6	3
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		48	9
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	1	1
	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)	1	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite	1	1
Sub-Total		5	3
TOTAL		54	13

Table C.6. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 54

DENSITY: Invertebrate density per square metre:

54 ÷ 0.27 = 200

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 9 + 2 x 1 + 3 = 32

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1 + 2 + 3 = 6

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 + 25 + 16) / 54 = 0.78

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

25 / 54 = 0.46

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	4
Predominant Taxon Ratio	3

Average Rating
3.50

Table C.6. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards		Date:	30 October 2013
Station Name:	**Station 3**		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)	77	2
	Mayfly Nymph (EPT)	53	5
	Stonefly Nymph (EPT)	62	3
	Dobsonfly (hellgrammite)	6	3
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		198	13
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	2	1
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	9	1
	Watersnipe Larva		
Sub-Total		11	2
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	27	2
	Blackfly Larva		
	Leech	2	1
	Midge Larva (chironomid)	1	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite	2	1
Sub-Total		32	5
TOTAL		241	20

Table C.6. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 241

DENSITY: Invertebrate density per square metre:

241 ÷ 0.27 = 893

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C): Caddisfly Larva (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 13 + 2 x 2 + 5 = 48

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

2 + 5 + 3 = 10

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

(77 + 53 + 62) / 241 = 0.80

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 20

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

77 / 241 = 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	4
EPT To Total Ratio	4
Predominant Taxon Ratio	4

Average Rating
4.00

Table C.7. Invertebrate Survey Field Data Sheet completed for triplicate stream invertebrate samples collected at Stations 1-3 on Richards Creek during 2014.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards	Date:	27 October 2014
Station Name:	**Station 1**	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)	55	1
	Stonefly Nymph (EPT)	3	1
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		58	2
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	8	3
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	23	1
	Watersnipe Larva		
Sub-Total		31	4
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	10	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	5	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		15	2
TOTAL		104	8

Table C.7. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 104

DENSITY: Invertebrate density per square metre:

104 ÷ 0.27 = 385

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 2 + 2 x 4 + 2 = 16

EPT INDEX: Total number of EPT taxa.

Good	Accpetable	Marginal	Poor
>8	5-8	2-4	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 + 55 + 3) / 104 = 0.56

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 8

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

55 / 104 = 0.53

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	3
Predominant Taxon Ratio	3

Average Rating
2.50

Table C.7. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards		Date:	27 October 2014
Station Name:	**Station 2**		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)		
	Stonefly Nymph (EPT)	20	2
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		20	2
Category 2 Somewhat Pollution Tolerant	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	2	1
	Crayfish	2	1
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	2	1
	Watersnipe Larva		
Sub-Total		6	3
Category 3 Pollution Tolerant	Aquatic Worm (oligochaete)	4	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		4	1
TOTAL		30	6

Table C.7. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 30

DENSITY: Invertebrate density per square metre:

30 ÷ 0.27 = 111

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C): Stonefly 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 2 + 2 x 3 + 1 = 13

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

0 + 0 + 2 = 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 + 0 + 20) / 30 = 0.67

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 6

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

20 / 30 = 0.67

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	3
Predominant Taxon Ratio	2

Average Rating
2.25

Table C.7. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards		Date:	27 October 2014
Station Name:	**Station 3**		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)	2	1
	Mayfly Nymph (EPT)		
	Stonefly Nymph (EPT)	32	2
	Dobsonfly (hellgrammite)	5	1
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		39	4
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	14	3
	Crayfish		
	Damselfly Larva	4	1
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	39	2
	Watersnipe Larva		
Sub-Total		57	6
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	22	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	3	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite	1	1
Sub-Total		26	3
TOTAL		122	13

Table C.7. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 122

DENSITY: Invertebrate density per square metre:

122 ÷ 0.27 = 452

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	17-22	11-16	<11

3 x D1 + 2 x D2 + D3

3 x 4 + 2 x 6 + 3 = 27

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1 + 0 + 2 = 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

(2 + 0 + 32) / 122 = 0.28

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

39 / 122 = 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

Table C.8. Invertebrate Survey Field Data Sheet completed for triplicate stream invertebrate samples collected at Stations 1-3 on Richards Creek during 2015.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards	Date:	4 November 2015
Station Name:	**Station 1**	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)	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		
	Clam, Mussel		
	Cranefly Larva	3	1
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	15	2
	Watersnipe Larva		
Sub-Total		18	3
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	18	2
	Blackfly Larva	1	1
	Leech		
	Midge Larva (chironomid)	3	2
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		22	5
TOTAL		42	10

Table C.8. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 42

DENSITY: Invertebrate density per square metre:

42 ÷ 0.27 = 156

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 2 + 2 x 3 + 5 = 17

EPT INDEX: Total number of EPT taxa.

Good	Accpetable	Marginal	Poor
>8	5-8	2-4	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) / 42 = 0.05

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 10

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

18 / 42 = 0.43

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S4, S5, S6, S8), then calculate the average.

Assessment Rating	
Good	4
Accpetable	3
Marginal	2
Poor	1

Assessment	Rating
Pollution Tolerance Index	3
EPT Index	2
EPT To Total Ratio	1
Predominant Taxon Ratio	3

Average Rating
2.25

Table C.8. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards		Date:	4 November 2015
Station Name:	**Station 2**		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
	Caddisfly Larva (EPT)		
Category 1	Mayfly Nymph (EPT)	15	1
	Stonefly Nymph (EPT)	10	2
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		25	3
	Alderfly Larva		
Category 2	Aquatic Beetle	3	1
	Aquatic Sowbug		
	Clam, Mussel	1	1
	Cranefly Larva	13	2
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	3	1
	Watersnipe Larva		
Sub-Total		20	5
	Aquatic Worm (oligochaete)	1	1
Category 3	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	5	3
	Planarian (flatworm)		
Pollution Tolerant	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		6	4
TOTAL		51	12

Table C.8. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 51

DENSITY: Invertebrate density per square metre:

51 ÷ 0.27 = 189

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 3 + 2 x 5 + 4 = 23

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

0 + 1 + 2 = 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 + 15 + 10) / 51 = 0.49

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 12

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

15 / 51 = 0.29

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

Table C.8. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards		Date:	4 November 2015
Station Name:	**Station 3**		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)	2	2
	Mayfly Nymph (EPT)	28	2
	Stonefly Nymph (EPT)	20	3
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		50	7
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle	1	1
	Aquatic Sowbug	1	1
	Clam, Mussel		
	Cranefly Larva	4	1
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	10	2
	Watersnipe Larva		
Sub-Total		16	5
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	40	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	6	2
	Planarian (flatworm)		
	Pouch and Pond Snails	1	1
	True Bug Adult		
	Water Mite		
Sub-Total		47	4
TOTAL		113	16

Table C.8. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 113

DENSITY: Invertebrate density per square metre:

113 ÷ 0.27 = 419

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 5 + 4 = 35

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

2 + 2 + 3 = 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

(2 + 28 + 20) / 113 = 0.44

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 16

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

40 / 113 = 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	4
EPT Index	3
EPT To Total Ratio	2
Predominant Taxon Ratio	4

Average Rating
3.25