COTTLE CREEK FINAL ASSESSMENT 2018

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Executive Summary

A team of three Vancouver Island University (VIU) Students have been involved in the monitoring of Cottle Creek under the supervision of Dr. Eric Demers. Cottle Creek is found in Linley Valley in Nanaimo BC. The stream runs from the western side of Linley Valley down into Cottle Lake, where it flows east through residential neighborhoods before it enters Departure Bay in the Straight of Georgia. Data collected from the monitoring project will be used by various organisations including the Department of Fisheries and Oceans (DFO), the City of Nanaimo, and VIU. The data will help to monitor the health and condition of Cottle Creek.

Two sampling events took place at four sites along Cottle Creek. The first sampling event was completed on October 30th, 2019 and the second sampling event took place on November 20th, 2019. The parameters studied included hydrology measurements, water quality and stream invertebrate sampling, as well as microbiology cultures. Water quality was analyzed in the laboratory at VIU by the team of students for pH, turbidity, hardness, phosphorous, nitrates, alkalinity, and conductivity; samples were also sent to ALS laboratories in Vancouver, BC in order to analyze nutrients and total metals. Temperature and dissolved oxygen were measured in field on both sampling occasions. Most of the parameters tested fell within the BC Water Quality Guidelines for aquatic life. Stream invertebrate samples obtained on October 30th resulted in surprisingly low site assessment ratings.

Due to rains during the week of November 11th the discharge recorded at all four sites on November 20th was higher than those recorded on October 30th. The higher flow of Cottle Creek impacted many water quality parameters as expected. The higher volume of water led to a change in many of the tested parameters.

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1.0 Introduction

1.1 Project Overview

The team of three students worked to collect various water samples and data during the two sampling events, October 30th and November 20th, and to analyze various parameters of water quality. The two separate field sampling events - one in October and one in November – were taken to analyze stream health during both low and high flow conditions. Due to the amount of rain that central Vancouver Island typically receives in November, it is relevant to sample at two different times as stream conditions can change significantly with different discharge rates. Cottle Creek is situated near many residential neighborhoods and private properties, centered in the middle of Nanaimo. Due to the location of the Creek, there are many potential sites for contamination, and monitoring of stream health is important in order to ensure the environment remains suitable for aquatic life. Water samples were analyzed in lab, and in this report the results will be compared to the BC water quality guidelines. The date compiled is used by VIU, DFO, and the City of Nanaimo.

1.2 Historical Review

Since 2012, natural resource protection students from Vancouver Island University (VIU) have been working on annual monitoring projects involving Cottle Creek in Nanaimo. This has resulted in the creation of valuable baseline data to be used for comparison over the years. Cottle Creek is situated in Linley Valley (Cottle Lake) Park in north Nanaimo, British Columbia (Figure 1). Linley Valley is part of a large area of land that has not been developed for commercial or residential properties. in May of 2019, the City of Nanaimo purchased more land in Linley Valley bringing the total area of the park to 428 acres. The City of Nanaimo has been working to acquire land and protect the park since 2004 (City of Nanaimo 2019).

FIGURE 1: LINLEY VALLEY (COTTLE LAKE) PARK, NANAIMO BC

Cottle Creek has two main sources: the first comes from North Cottle Creek which flows from Lost Lake - roughly one kilometer north of Cottle Lake - the second, from Upper Cottle Creek which flows into the western tip of Cottle lake. Cottle Creek flows out of the eastern tip of Cottle lake and down through Linley Valley and empties into the Straight of Georgia (Figure 2) in Departure Bay near the Pacific Biological Station.

FIGURE 2: COTTLE CREEK, NANAIMO BC

Linley Valley is home to a variety of wildlife and plants. Many animals such as black-tailed deer (*Odocoileus hemionus*), beavers (*Castor canadensis*), red legged frogs (*Rana aurora*), and other amphibians reside in this area. Most of Linley Valley is mature forest which houses a multitude of songbird species and larger birds of prey such as hawks, eagles and vultures (NALT 2017). Cottle Lake itself is home to many waterfowl which rely on the lake for food and shelter. Theses species require clean and unpolluted water in order to survive.

Linley Valley is a popular recreation area for hikers, dog walkers, and cyclists. The trails are used by locals and visitors year-round. It is important to ensure that steps are taken to protect the sensitive ecosystem, and to minimize the impact of visitors.

1.3 Potential Environmental Concerns

Although large sections of Cottle Creek flow through a protected area, there are many factors that could have a negative impact on the stream. The city of Nanaimo and many residential neighborhoods surround the park. There are many new developments in construction around

Linley Valley that pose a threat to Cottle creek. Run-off from streets and construction sites could leech into the watershed and contaminate Cottle Creek. There are many rural properties and hobby farms situated around Cottle Lake that may produce harmful runoff. These properties have steep and sloping topography allowing potential fecal matter, chemicals and bacteria to flow down and contaminate the aquatic habitat that surrounds Cottle Lake and Cottle Creek. Linley Valley (Cottle Lake) Park is a popular dog walking spot and many owners do not pick up dog feces which eventually make their way into the water as well. Cottle Lake contains many aquatic plants and other vegetation that create favourable habitat for waterfowl, beavers, and other organisms that thrive in nutrient rich aquatic environments. Below the lake, Cottle Creek it exits the park and makes it way through many residential neighborhoods and road crossings. Roads and urban areas may collect oil, grease, and other toxic chemicals and metals that come from vehicles and other anthropogenic practices. Pesticides from lawns and other excessive nutrients may find their way into the creek as well (EPA 2019). All these added nutrients and chemicals could be detrimental to the health of the ecosystem and the organisms that depend on it. Cottle Creek may also be susceptible to blockages and debris falling into the stream.

1.4 Project Objectives

The Cottle Creek environmental monitoring project aims to monitor the creek and evaluate its health. Since 2012 groups of undergraduate students have been conducting theses evaluations in order to collect data to monitor the long-term health of Cottle Creek. This data is used by VIU, DFO and the City of Nanaimo to monitor and ensure that Cottle Creek is a healthy ecosystem. The evaluation took place at four different sites along Cottle Creek's course. With multiple sampling sites we will be able to monitor and record any changes in water quality as we progress down Cottle Creek's course. Multiple sampling sites help to show the "whole picture" of the stream, and sampling along the its entirety aids in identifying sources of contaminants (if any). Comparing the data collected this year with the results from studies completed on Cottle Creek in years past allows for trends to be identified and potential discrepancies to be examined. Any significant changes from one year to another could indicate a new stressor to the environment.

2.0 Environmental Sampling & Analytical Procedures

2.1 Sampling Program

As part of the Cottle Creek environmental monitoring project completed by Resource Management and Protection students, four sites along Cottle Creek were sampled (Figure 3). All work was completed by the three-student group under the guidance of Dr. Eric Demers. Two sampling events were carried out during the fall semester of 2019, with the first event taking place on October 30th, 2019 and the second event occurring on November 20th, 2019. Many parameters including water quality, stream invertebrates, microbiology and basic hydrology were sampled at each of the four sites.

FIGURE 3: FOUR SAMPLING SITES ALONG COTTLE CREEK

As referenced in the historical review portion of this report, water quality testing has been carried out at site specific locations on Cottle Creek since 2012. It was therefore concluded that the four sampling sites on the creek that were used in the past be used again for this study. This effectively maintained the continuity of the Cottle Creek water quality assessment (repeatability of the study). As these sites have been carefully chosen in the past, re-visiting and assessing the same sites again continued the legacy established in 2012, helping to ensure ease of access for sampling, and minimizing any additional potential stream impacts. Similarly, it was concluded that all previous methods and protocols (such as sample frequencies and invertebrate sampling procedures) be adhered to, to ensure that all results compiled were appropriate and valid. This ensured that any changes to the water quality of Cottle Creek would be recorded and observed.

The four sample locations on Cottle Creek (numbered 1-4 from upstream to downstream) were visited once by the team as part of the initial site visit procedure on October 17th, 2019, and twice more during the two sampling events as stated above. At the time of the initial visit, specific sampling locations were chosen as the result of much careful thought and consideration. It was ensured that invertebrate samples could be taken, that the sample site was representative of the entire stream reach, and that each site had similar characteristics so that comparisons could later be made (substrate, habitat type, canopy, etc.). Site photos are visible in Appendix A.

2.1.1 Sampling Site Locations & Specific Habitat Characteristics

Site #1 was accessed via Landalt Road off Rock City Road. Specifically, the site is located down the embankment west (upstream) of Landalt Rd and south of Arrowsmith Rd (UTM 10 U 427938mE 5452173mN, +108m elevation). Defining the downstream border of Site #1 was a large culvert that directs water under Landalt Road east towards Cottle Lake. Further upstream, there was a man-made metal grate that acts as a dam, creating a small pool, collecting debris and slowing the flow of the creek. The substrate consists of approximately 20% cobble, 20% gravel and 60% fines. The banks were low and there was approximately 30-40% canopy cover. The canopy was comprised largely of red alder (*Alnus rubra*), with ferns, small bushes and other woody debris creating shade along the low banks. The gradient of the stream at Site #1 would be considered gradual or low, estimated at less that 2%.

Site #2 was located downstream of the foot bridge across the outflow at the eastern end of Cottle Lake (UTM 10 U 428897mE 5452249mN, +101m elevation). It was accessed via a short (roughly 0.5 km) hike off Rock City Road around Cottle Lake through Linley Valley (Cottle Lake) Park. Site #2 was estimated to have roughly 25% canopy cover, generated almost entirely by a large western red cedar (*Thuja plicata*). The riparian zone of Site #2 was comprised mostly of western sword ferns (*Polystichum munitum*), salmonberry bushes (*Rubus spectabilis*) and long grasses. Much like Site #1, the gradient of Cottle Creek at this point was very gradual, estimated at 2%. The substrate consisted roughly of 40% cobble, 50% gravel and 10% fines.

Site #3 was accessed off Nottingham Drive where the creek crosses the road under a large concrete bridge. The sampling site was on the downstream side of the bridge and required scaling down large boulders (UTM 10U 430201mE 5452003mN, +62m elevation). Cottle Creek was notably shallow under the bridge during all site visits. Once out from under the bridge, the creek widened out and deepened into a marshy area characterized by red alder trees and long swamp grasses. The in-stream substrate at site #3 was soft and somewhat swampy with about 50% of the substrate being fines, 40% being gravel and 10% consisting of cobble. The canopy cover was sparse, with less than 10% coverage being generated by the red alders spaced intermittently throughout the site.

Site #4 was the lowest sample site on Cottle Creek, located less than 100 m from the ocean (UTM 10 U 430583mE 5451370mN, +32m elevation). It was accessed off the east side of the busy Stephenson Point Road. There was a culvert directing Cottle Creek under the road and a storm drain emptying water collected from the pavement above. The substrate was comprised of roughly 10% boulders, 60% cobble, 10% gravel and 20% fines. There was approximately 90% cover, provided by several large Douglas fir trees (*Pseudotsuga menziesii*). The stream gradient was relatively shallow as the water came through the culvert; however, it increased and cascaded around the corner towards the ocean.

2.1.2 Sampling Frequency

For this project, two sampling events were completed, one during the low flow season and one during the high flow season. The first sampling event took place on October 30th, 2019, while the second sampling event took place on November 20th, 2019. With respect to the specific samples taken (Table 1), water quality samples, microbiology samples, basic hydrological measurements and stream invertebrate samples were taken at the sites along Cottle Creek. During the first sampling event, VIU water quality samples were taken at all 4 sites, hydrological measurements were taken at all 4 sites and ALS water quality samples were taken at sites 1, 2 and 4. Microbiology samples were taken at all sites during the first sampling event, and stream invertebrate samples were collected at sites 1, 2 and 4. For the second sampling event, only VIU water quality samples and hydrological measurements were collected at all 4 sites; microbiological samples were not completed. ALS water quality samples were taken at sites 1,2 and 4, while stream invertebrate samples were not taken. Stream invertebrate analyses were not completed during the second sampling event, as high-water levels made sampling dangerous. The decision to not complete invertebrate samples or ALS samples at site 3 was made in order to conserve resources; these parameters had not been sampled at site 3 during any past studies. It was hypothesized that past studies excluded site 3 from ALS and invertebrate sampling due to its unrepresentative habitat characteristics (marsh, swamp, still water).

TABLE 1: ENVIRONMENTAL MONITORING SAMPLING PROGRAM

	Sample Site Number			
	#1	#2	#3	#4
Samples to be taken during event 1 (Oct. 30th, 2019):	• VIU Water quality • ALS Water Quality • Microbiology • Hydrology • Invertebrates	• VIU Water quality • ALS Water Quality • Microbiology • Hydrology • Invertebrates	• VIU Water quality • Microbiology • Hydrology	• VIU Water quality • ALS Water Quality • Microbiology • Hydrology • Invertebrates
Samples to be taken during event 2 (November 20th, 2019):	• VIU Water Quality • ALS Water Quality • Hydrology	• VIU Water Quality • ALS Water Quality • Hydrology	• VIU Water Quality • Hydrology	• VIU Water Quality • ALS Water Quality • Hydrology

2.2 Basic Hydrology

Basic hydrological measurements were collected and calculated at all 4 sites during each sampling event in order to provide some hydrological contexts to the other test results. These hydrological measurements included the average wetted width (m), average cross-sectional water depth (m) as well as flow (m/s) for a 5 m representative section of stream in each site. A measuring tape was used to obtain the wetted width and cross-sectional water depth measurements. To measure flow, a ping pong ball was timed with a stopwatch as it flowed down the chosen 5 m of stream. From these measurements, it was possible to calculate discharge (m^3/s) by multiplying the cross-sectional area by the mean water velocity (flow). These discharge results helped provide contextual information regarding the changes between low flow samples and high flow samples, aiding in the interpretation of the data and explaining some of the trends.

2.3 Water Quality

2.3.1 Field Measurements & Collection of Water Samples

Most of the studied parameters were analysed in the laboratory at Vancouver Island University and by ALS Labs in Vancouver, British Columbia. With respect to measurements taken and analysed in situ, temperature (°C), dissolved oxygen (mg/L) and discharge (m^3/s) were collected, recorded and calculated in the field at all 4 sites during both sampling events. Water temperature was measured to the nearest 0.1°C, while dissolved oxygen was measured to the nearest 0.1 mg/L and discharge was calculated to the nearest 0.01 m^3/s. Samples collected/filled to be analysed in a lab setting at a later time included VIU water quality bottles (1 per site, a replicate at site 1, both sampling events), ALS water quality bottles (3 per site at sites 1, 2 and 4, first sampling event only, no replicates), microbiological Whirl-Pak samples (1 per site, a replicate a site 1, first sampling event only) and stream invertebrates (3 replicates each at sites 1, 2 and 4, first sampling event only).

2.3.2 VIU Laboratory Analyses

Upon collecting water samples in the field, the VIU water quality analyses took place in a lab after each sampling event. The first analyses took place on October 30th, 2019, while the second laboratory analyses took place on November 20th, 2019. All analyses were conducted under the guidance of Dr. Eric Demers. Phosphate (mg/L PO_4^{3-}), nitrate (mg/L NO_3^-), hardness (mg/L $CaCO_3$), Turbidity (NTU), pH and Alkalinity ($CaCO_3$) were measured from the water collected. In the VIU lab, 10 of the 12 samples (4 sites plus 1 replicate for each sampling event) were tested for all the parameters listed above. The 2 additional trip blanks (1 per sampling event) were tested for nitrate and phosphate. All equipment/test kits used for analysing the water samples belong to Vancouver Island University. The same equipment was used to test the samples from both sampling events.

2.3.3 ALS Laboratory Analyses

During each sampling event, 3 different water samples were collected at sites 1, 2 and 4 and sent to ALS Labs in Vancouver, BC. It was imperative to add the correct chemical preservatives to the corresponding samples, as incorrectly doing so would alter the results. ALS was able to repeat physical parameters tested by the students in the lab at VIU (conductivity, hardness, pH) as well as test for anions and nutrients as well as total metals. Submitting samples to ALS during both sampling events allowed students to make comparisons between the two sampling events and continued the legacy of the monitoring program, banking valuable data.

2.3.4 Water Quality: Quality Assurance/Quality Control

Throughout the environmental monitoring project that was carried out on Cottle Creek, it was ensured that certain quality assurance (QA) and quality control (QC) measures were taken. QA measures focused on preventing poor results, while QC measures focused on identifying any potential poor results. Many QA/QC measures were adopted in order to ensure and maintain the integrity of the water quality sampling program. All samples were taken from the same location at each site during both sampling events. All samples were taken below the water surface to ensure that no surface contaminants were gathered. All samples were gathered in order of downstream to upstream (4, 3, 2, 1) to avoid unnecessary site or sample contamination. All sample containers that had not been previously sterilized were rinsed 3 times in situ (ALS sample bottles were pre-sterilized). All personnel collecting samples wore latex gloves and clean and appropriate containers were used to collect all samples. The collected samples were kept in a cooler on ice or in a refrigerator until further analyses were conducted. In the VIU lab setting, all personnel wore latex gloves and official VIU lab coats. All beakers, graduated cylinders and test jars were also rinsed 3 times prior to use. One trip blank containing distilled water (also known as a field blank) was always carried during sampling occasions to identify any potential contamination (bias or imprecision) introduced or picked up during sampling, transportation or storage. One field duplicate/replicate was taken at site 1 to help establish sampling, environmental and analytical precision. It should also be noted that in addition to testing for anions, nutrients and total metals, ALS Labs also measured the same basic water quality parameters that students measured in the VIU lab. These “lab replicates” were an additional QA/QC measure that allowed students to compare their results to the more precise ALS results to detect any discrepancies and improve analytical precision.

2.3.5 Data Analyses, Comparison to Guidelines

Upon collecting and analysing the VIU water quality samples, these results were compared to the ALS Lab results as previously stated. Further analysis was completed by comparing both the VIU lab results and the ALS Lab results to the Guidelines for Interpreting Water Quality Data (Ministry of Environment and Climate Change Strategy 2019). This allowed students to determine whether Cottle Creek may be suitable for aquatic life, and to determine if there were any parameters that were above the allowable limits as stated in the guideline. Upon analysing the VIU and ALS water quality results, students discussed discrepancies and parameters that were over/under the guidelines, attempting to identify possible reasons for the discrepancies and inadequate water quality parameters. To conclude these findings, students included recommendations as to how further testing on Cottle Creek could be improved, thus potentially improving the water quality data of the creek.

2.4 Microbiology

2.4.1 Water Sample Collection

Microbiology samples were collected from all 4 sites on Cottle Creek during the first sampling event only. All sampling was completed using sterile 100 ml Whirl-Pak bags that had been previously labeled and organized.

2.4.2 VIU Laboratory Analyses

Microbiological samples were analysed through coliform incubation and counts. 20 ml water samples, petri dishes and m-ColiBlue24 broth were used to incubate coliforms over a 24-hour period at 35°C. The number of Colony Forming Units (CFU/100 ml) were noted for each sample, where attention was paid to the number of fecal coliforms (blue) as compared to the number of non-fecal coliforms (red). The numbers of each were totaled and presented in CFU/100 ml (to the nearest 1 CFU/ 100 ml), and the fecal coliforms were expressed as a percentage (%) of the total coliform count.

2.4.2 Microbiology Quality Assurance/Quality Control

As previously discussed, it was ensured that certain QA/QC measures were taken throughout the entire Cottle Creek environmental monitoring project. QA measures focused on preventing poor results, while QC measures focused on identifying any potential poor results. Many QA/QC measures were adopted in order to ensure and maintain the integrity of the microbiology sampling and analysis program. As with water quality samples, microbiology samples were conducted from downstream to upstream (sites 4, 3, 2, 1) to ensure that downstream water samples were not contaminated by upstream testing disturbances. The pre-sterilized Whirl-Pak bags were filled with water from below the surface to ensure that no surface contaminants entered the bags. One field duplicate/replicate was taken at site 1. Once collected, all samples were stored in a cooler on ice until analysis could be completed. All personnel collecting the samples wore latex gloves. In the lab setting, students wore VIU lab coats and latex gloves, and used sterilized tweezers to handle all pre-sterilized incubation pads to avoid sample contamination. All beakers, graduated cylinders and test jars were also rinsed 3 times prior to use. It should also be noted that a filtration blank was run with distilled water and no bacterial colonies were observed.

2.5 Stream Invertebrate Communities

2.5.1 Invertebrate Sample Collection

Stream invertebrates were sampled at sites 1, 2 and 4 during the first sampling event only. Three field duplicates/replicates (triplicate samples) were collected at each sample site (0.09 m^2 each for a total of 0.27m^2 sampled per site) in the hopes that this would provide an accurate reflection of the stream invertebrate population in Cottle Creek. All samples were collected using a Hess sampler and transported in plastic containers to the VIU laboratory where they were analysed. No preservatives were added to keep the invertebrates alive and make analyses of samples easier for the students.

2.5.2 VIU Laboratory Analyses & Data Analysis

Upon collecting the invertebrate samples and transporting them to the VIU laboratory, the invertebrates were organized into taxonomic groups and counted. To make this process easier, the invertebrates were removed from the transport containers and emptied onto large trays. A microscope was used to aid in spotting and organizing the invertebrates. As directed by *The*

Streamkeepers Handbook (1995), each taxonomic group was placed in one of three categories. This data was used to determine the predominant taxon, abundance, density, diversity and overall invertebrate counts. This was then used to create an overall site assessment rating. This data was also analysed by use of the Shannon-Weiner Index to assess the species diversity in Cottle Creek. All these results were used to determine a representation of water quality in terms of the streams ability to support life.

2.5.3 Invertebrate Quality Assurance/Quality Control

As previously discussed, it was ensured that certain QA/QC measures were taken throughout the entire Cottle Creek environmental monitoring project. QA measures focused on preventing poor results, while QC measures focused on identifying any potential poor results. Many QA/QC measures were adopted in order to ensure and maintain the integrity of the invertebrate sampling and analysis program. As with water quality samples and microbiology samples, invertebrate samples were conducted from downstream to upstream (sites 4, 3, 2, 1) to ensure that downstream water samples were not contaminated by upstream testing disturbances. All samples were kept in a cooler and handled carefully, in order to keep the invertebrates alive.

3.0 Results & Discussion

Field measurements and samples from each of the four sites along Cottle Creek were collected during two events according to the methods discussed. The samples were then transported to VIU for examination of water quality, microbiology, and invertebrate communities. Samples were also sent to the ALS laboratory in Vancouver, BC for more in-depth water quality analyses. In this section, field conditions, hydrological measurements, field measurements, and results from sample analyses will be discussed and compared to water quality guidelines for aquatic life.

3.1 General Field Conditions

3.1.1 Hydrology

Hydrological measurements occurred at all four sites during both sampling events. The weather immediately prior to each event impacted the creek's discharge rates significantly. This in turn, influenced many of the other parameters that were sampled and caused discrepancies between sampling event 1 and sampling event 2.

Prior to the first sampling event, the city of Nanaimo had seen little rainfall in the past 8 days (Figure 4). As demonstrated in Figure 5 and summarized in Table 2, significant rain fell between sampling events 1 and 2. All discharge rates for sampling event 1 were measured to be quite low when compared to the data from previous years. Discharge was measured at 0.01m^3/s at the first site, 0.04 m^3/s at the second, 0.05 m^3/s at the third, and 0.04 m^3/s at the fourth site. The lowest discharge rate was seen at site 1. This is most likely due to its geographical location above Cottle Lake, where it can be argued that the sites below the lake are benefiting from the lake's buffering effects.

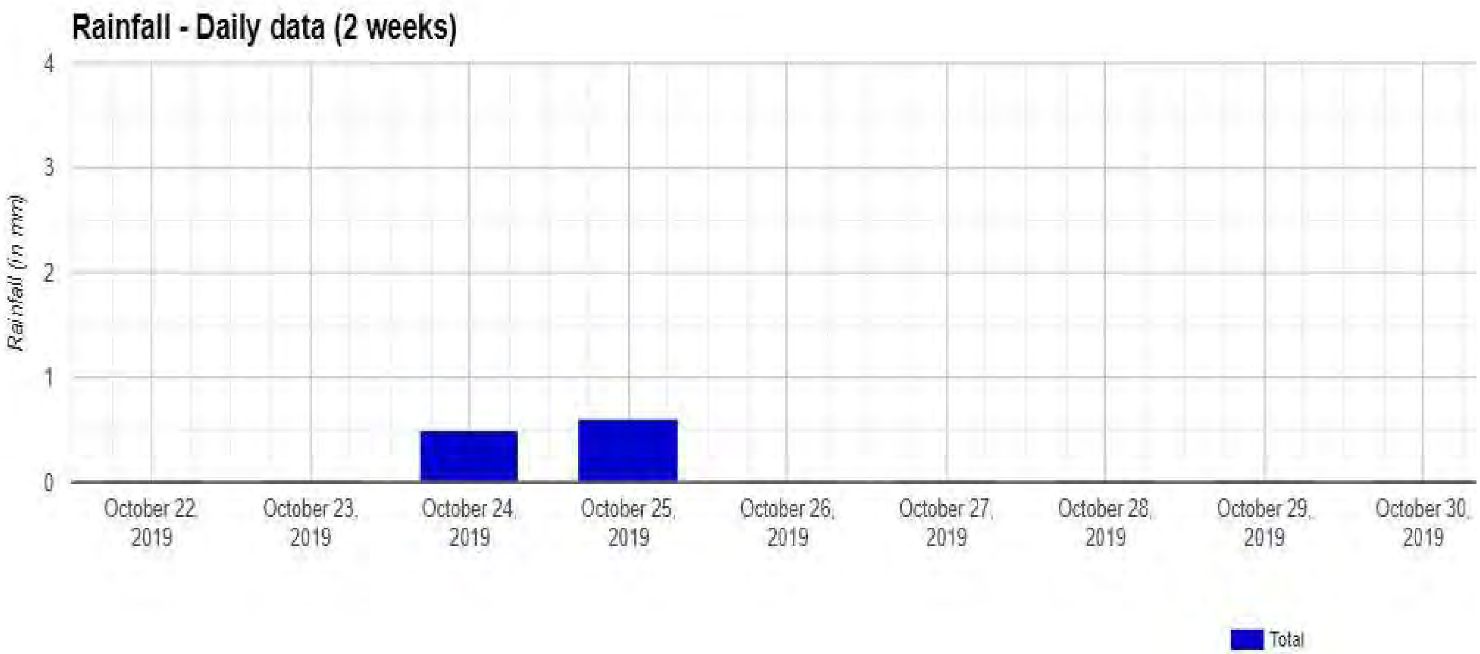

FIGURE 4: NANAIMO RAINFALL (OCTOBER 22-30, 2019)

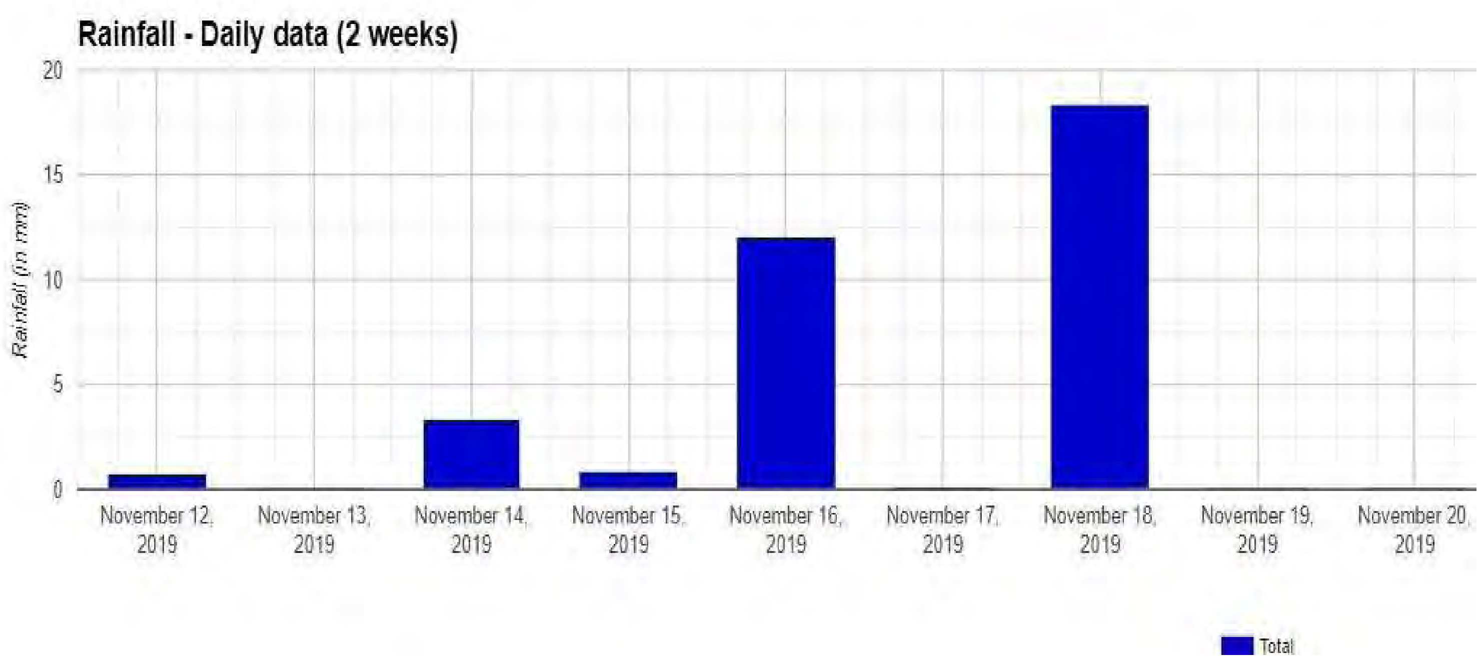

FIGURE 5: NANAIMO RAINFALL (NOVEMBER 12-20, 2019)

TABLE 2: NANAIMO RAINFALL TOTALS (OCTOBER 22 - NOVEMBER 20, 2019)

Date	Total
Nov 20 2019	0.0 mm
Nov 19 2019	0.0 mm
Nov 18 2019	18.4 mm
Nov 17 2019	0.1 mm
Nov 16 2019	12.1 mm
Nov 15 2019	0.9 mm
Nov 14 2019	3.4 mm
Nov 13 2019	0.0 mm
Nov 12 2019	0.8 mm
Nov 11 2019	18.1 mm
Nov 10 2019	0.0 mm
Nov 9 2019	0.5 mm
Nov 8 2019	3.0 mm
Nov 7 2019	0.0 mm
Nov 6 2019	0.0 mm
Nov 5 2019	0.0 mm
Nov 4 2019	0.1 mm
Nov 3 2019	0.0 mm
Nov 2 2019	0.0 mm
Nov 1 2019	0.0 mm
Oct 31 2019	0.0 mm
Oct 30 2019	0.0 mm
Oct 29 2019	0.0 mm
Oct 28 2019	0.0 mm
Oct 27 2019	0.0 mm
Oct 26 2019	0.0 mm
Oct 25 2019	0.6 mm
Oct 24 2019	0.5 mm
Oct 23 2019	0.0 mm
Oct 22 2019	0.0 mm

As was summarised in the above figures and table, significant rain fell prior to the second sampling event. This resulted in higher discharge rates for Cottle Creek. Site 1 had the lowest discharge for sampling event 2 at 0.03 m^3/s likely because excess water had flushed into the lake during the one day without rainfall before sampling. Sites 2, 3, and 4 had significantly higher discharge rates than the first sampling event at 0.20 m^3/s, 0.23 m^3/s, and 0.21 m^3/s respectively. The high rainfall rates earlier in the week clearly raised the water levels in Cottle Lake, and as a result the sites below the lake were experiencing higher flow rates. Table 3 below summarizes the discharge measurements for both sampling events. Full calculations can be seen in Appendix H.

TABLE 3: COTTLE CREEK DISCHARGE LEVELS DURING BOTH SAMPLING EVENTS

	Sampling Event 1 – low flow				Sampling Event 2 – high flow			
Site	1	2	3	4	1	2	3	4
Discharge (m^3/s)	0.01	0.04	0.05	0.04	0.03	0.20	0.23	0.21

3.2 Water Quality

3.2.1 Field Measurements

Temperature and dissolved oxygen were measured at all four sites during both sampling events. On October 30th, 2019 atmospheric temperature was lower, and so stream temperature was colder which increased dissolved oxygen. On November 20th, 2019, the atmospheric temperature was slightly higher, which impacted the stream temperature and dissolved oxygen during that sampling time.

Temperature:

Water temperatures were recorded as slightly colder during the first event than the second (Table 4), likely due to the air temperatures at the time of sampling: 10.1°C during the first event, and 11.5°C during the second. Average water temperature between all four sites during the first sampling event was 5.7°C, and during the second was 8.1°C. The rise in temperature had an expected effect on levels of dissolved oxygen.

TABLE 4: WATER TEMPERATURE AND DISSOLVED OXYGEN MEASUREMENTS FOR BOTH SAMPLING EVENTS

	October 30th, 2019				November 20th, 2019			
Site	1	2	3	4	1	2	3	4
Temperature (°C)	5.9	5.3	5.6	5.9	8.4	7.2	8.0	8.4
Dissolved Oxygen (mg/L)	11.5	10.0	11.6	12.4	11.1	8.9	11.2	11.5

Dissolved Oxygen:

Due to the rise in water temperature between sampling events, dissolved oxygen showed a slight decrease at each site. The mean loss of dissolved oxygen through all sites between sampling events was recorded to be 0.7mg/L. Site one's dissolved oxygen decreased from 11.5mg/L to 11.1mg/L, site two from 10.0mg/L to 8.9mg/L, site three from 11.6mg/L to 11.2mg/L, and site four from 12.4 mg/L to 11.5mg/L.

Site 2 (at the outflow of Cottle Lake) was recorded to have had the lowest DO levels during both sampling events. Reduced levels of oxygen may likely be caused by increased biochemical oxygen demand in the lake water, as well as the stagnancy of the water entering the creek. On the other end of the spectrum, site 4 likely exhibited the highest DO levels due to the perched culvert stirring oxygen into the water as it fell back into the natural creek.

Although there are notable differences in DO between sites and sampling times, all levels fall above the BC Water Quality Guideline for buried embryo and alevin stages of aquatic life ($\geq$9mg/L).

3.2.2 VIU Laboratory Analyses

In the VIU lab, students measured conductivity, hardness, turbidity, nitrates, phosphate, pH, and alkalinity of samples taken from the four stations along Cottle Creek during both sampling occasions. Those parameters measured at the VIU laboratory showed expected trends regarding an increase in discharge. See table 5 for all VIU lab results.

TABLE 5: FULL VIU WATER QUALITY ANALYSIS RESULTS

	Sample Event 1						Sample Event 2						Guidelines
Parameter	**Site 1**		**Site 2**	**Site 3**	**Site 4**	**Blank**	**Site 1**		**Site 2**	**Site 3**	**Site 4**	**Blank**	
	S	**R**					**S**	**R**					
Phosphate (mg/L PO_4^{3-})	0.08	0.05	0.11	0.04	0.02	0.02	0.04	0.03	0.02	0.02	0.04	0.02	Mesotrophic 0.010-0.025
Nitrates (mg/L NO_3^-)	0.63	0.18	0.12	1.00	0.44	0.02	1.31	1.47	0.42	1.08	0.92	0.03	32.8
Hardness (mg/L $CaCO_3$)	72	68	64	64	76	/	60	72	56	64	56	/	Soft <60 Hard >120
Conductivity (µS/cm)	161	168	194	172	189	/	151	153	166	151	180	/	Variable
Turbidity (NTU)	1.47	1.49	2.99	1.17	2.53	/	3.06	3.05	3.58	2.43	2.53	/	Variable
pH	6.0	5.9	6.1	6.1	6.1	/	7.8	7.9	7.8	7.8	7.8	/	6.5-9
Alkalinity (mg/L $CaCO_3$)	50.0	51.2	51.2	55.2	60.0	/	49.2	52.0	50.8	48.0	54.8	/	>20
DO (mg/L)	11.5	11.5	10.0	11.6	12.4	/	11.1	11.1	8.9	11.2	11.5	/	>5
Temp. ('C)	5.9	5.9	5.3	5.6	5.9	/	8.4	8.4	7.2	8.0	8.4	/	Variable
Discharge (m^3/s)	0.01	/	0.04	0.05	0.04	/	0.03	/	0.20	0.23	0.21	/	Variable

Conductivity:

Conductivity is a measure of charged ions in the water column, analyzed by placing a probe with two anodes in the water and passing electricity through one anode to the other. Average conductivity of streams on the western coast of Canada typically stays below 100µS/cm. Conductivity levels measured at the VIU lab showed a trend of decrease through the two sampling events at all four stations. Site 2 showed the largest decrease from the first sampling event, dropping from 194µS/cm to 166µS/cm. On average, sites showed a mean decrease of 16.6µS/cm from the first sampling occasion to the second. The decrease in conductivity is likely due to the dilution of ions with the increased discharge levels of the stream.

Higher than normal conductivity may be due to anthropogenic sources such as salt from roads, or effluent runoff. Sites 3 and 4 likely had higher conductivity levels than upstream sites 1 and 2 due to the increase of storm drains and infrastructure surrounding the creek further down.

Hardness:

Hardness equates to the amount of calcium, magnesium, and other present metallic ions in a stream, measured by calcium carbonate in the water. Softer water can breakdown metals into the water column, and raise toxicity, while hard water causes metals to precipitate – effectively buffering any toxic heavy metals which may be present.

The hardness levels in Cottle Creek were overall quite neutral, falling mainly between the BC water quality guideline parameters of hard (>120mg $CaCO_3$/L) and soft (<60mg/L), but notably on the softer side. Sites 2 and 4 fell into the soft category during the second sampling occasion, both measuring at 56mg $CaCO_3$/L. Hardness likely dropped due to dilution in the stream, with a mean decrease of 7.2mg/L. As the Creek water is on the softer side of the hardness spectrum, the stream may be slightly more susceptible to toxicity from heavy metals.

Turbidity:

Turbidity is a measure of particles in water which affect the clarity – if levels are too high, turbid water can block light, clog gills, and support excess bacterial growth.

Turbidity in the stream remained low (1.17-3.58 NTU's) throughout sampling, however it did increase by an average of 1.00 NTU's from the first event to the second. The increase is likely due to the rise in flow sweeping in particles from the banks, as well as sediments on the stream floor being stirred up into the water column.

Nitrates:

Nitrate and phosphate are the two major nutrients required by plants and algae to photosynthesize and grow. When overly abundant, these nutrients can cause harmful algal blooms and can quickly deplete dissolved oxygen levels in water. Nitrate is mainly added to water sources from anthropogenic inputs such as fertilizer runoff, effluents, or recreational activities; without human nitrogen input, nitrate levels are normally <0.3mg/L. Nitrogen occurs naturally in streams due to inputs from nitrogen fixation, atmospheric deposition and watershed runoff.

Nitrate results in Cottle Creek ranged from 0.12-1.47mg/L (well below the BC water quality guideline maximum 32.8 mg/L). Nitrates increased at an average of 0.56 mg NO3-/L from the first event to the second, most likely due to the first major 'flush' of runoff in the season.

Phosphate:

As the freshwater on Vancouver Island is typically P-limited, the amount of phosphate in a water column determines the rate at which plant and algae growth occurs. High phosphate levels can cause excessive growth and resulting eutrophication, and low levels can create oligotrophic waters.

In the VIU lab, phosphate levels were measured as higher than the BC water quality guideline (0.010-0.025mg/L) in Cottle Creek at site 1, 2, and 3 during the first event, and sites 1 and 4 during the second. Site 2 had the highest recorded measurement of phosphate (0.11mg/L) during the first sampling event, likely due to the outflow of Cottle Lake during the low flow season. During the second event, phosphate levels dropped in sites 1, 2, and 3 – site 1 remaining above the guideline – however site 4 which was within the guidelines the first event rose above the guidelines at the second event. The decrease in sites 1 through 3 can most likely be explained by dilution but leaves site 4 as an outlier.

The ALS study of orthophosphate revealed much lower values than VIU. Levels were below the minimum detection limit except for site 2 during the second sampling event, which even then was detected below the BC water quality guideline for total phosphorus.

pH:

The first time pH was measured, the creek results were slightly more acidic than guidelines had outlined as acceptable for fish habitat (acceptable pH: 6.5-9). Results from the first sampling event ranged from 5.9 to 6.1. The low pH could be due to a variety of factors including pollution and eutrophication, however the main contributors to the slight acidity of the stream are most likely low rainfall rates during the summer and low hardness in the stream. Decreased discharge results in less acid dilution, and low hardness values limit the water's ability to maintain a neutral pH.

After the increase of discharge, the pH rose into the acceptable levels laid out in the BC water quality guidelines, the higher water levels likely flushed out any present acid sources and significantly diluted the stream.

Alkalinity:

Alkalinity is the measurement of water's ability to neutralize acid. Higher alkalinity levels allow a stream to effectively buffer added acids for longer. Levels were within the range of low acid sensitivity even after a slight decrease with the higher discharge during the second event.

3.2.3 ALS Laboratory Analyses

Results from the ALS lab revealed minute changes (mainly below 1mg/L) throughout the two sampling events, likely due to dilution from increased flow, and the introduction of runoff. Although less significant than the VIU lab results, trends reflecting the dilution are still present.

Conductivity decreased slightly at each site from the first to the second analysis, as did hardness and calcium levels, sodium also fell by 1mg/L.

Heavy Metals tested for in the ALS laboratory were all within the BC water quality guidelines. All parameters measured at ALS which were present above the minimal detection limit are reflected in Tables 6-9.

TABLE 6: COTTLE CREEK SITE 1 ALS LAB ANALYSIS RESULTS

Parameter*	Event 1	Event 2
Conductivity µS/cm	168	165
Hardness mg $CaCO_3$/L	62.3	58.0
pH	7.72	7.77
Ammonia mg/L	0.0067	0.0095
Nitrate (N) mg/L	0.278	0.564
Nitrite (N) mg/L	0.0018	0.0020
Total Nitrogen mg/L	0.525	0.824
Orthophosphate (P) mg/L	<0.0010	0.0022
Phosphorus (P) mg/L	0.0089	0.0127
Calcium mg/L	16.8	15.7
Iron mg/L	0.421	0.722
Magnesium mg/L	4.96	4.57
Manganese mg/L	0.0306	0.0883
Silicon mg/L	6.58	6.57
Sodium mg/L	11.0	10.2
Strontium mg/L	0.0693	0.0649
*Results in table do not include analyzed parameters which fell below the minimum detectable quantity, see Appendix B for further results.		

TABLE 7: COTTLE CREEK SITE 2 ALS LAB ANALYSIS RESULTS

Parameter*	Event 1	Event 2
Conductivity µS/cm	168	165
Hardness mg $CaCO_3$/L	62.3	58.0
pH	7.72	7.77
Ammonia mg/L	0.0067	0.0095
Nitrate (N) mg/L	0.278	0.564
Nitrite (N) mg/L	0.0018	0.0020
Total Nitrogen mg/L	0.525	0.824
Orthophosphate (P) mg/L	<0.0010	0.0022
Phosphorus (P) mg/L	0.0089	0.0127
Calcium mg/L	16.8	15.7
Iron mg/L	0.421	0.722
Magnesium mg/L	4.96	4.57
Manganese mg/L	0.0306	0.0883
Silicon mg/L	6.58	6.57
Sodium mg/L	11.0	10.2
Strontium mg/L	0.0693	0.0649
*Results in table do not include analyzed parameters which fell below the minimum detectable quantity, see Appendix B for further results.		

Table 8: Cottle Creek Site 3 ALS Lab Analysis Results

Parameter*	Event 1	Event 2
Conductivity µS/cm	170	161
Hardness mg $CaCO_3$/L	59.4	54.1
pH	7.50	7.52
Ammonia mg/L	0.0189	0.0133
Nitrate (N) mg/L	0.0765	0.202
Nitrite (N) mg/L	0.0025	0.0013
Total Nitrogen mg/L	0.433	0.477
Phosphorus (P) mg/L	0.0122	0.0122
Calcium mg/L	16.2	14.8
Iron mg/L	0.631	0.686
Magnesium mg/L	4.61	4.18
Manganese mg/L	0.0280	0.102
Silicon mg/L	5.07	5.83
Sodium mg/L	11.3	10.8
Strontium mg/L	0.0671	0.0604
*Results in table do not include analyzed parameters which fell below the minimum detectable quantity, see Appendix B for further results.		

TABLE 9: COTTLE CREEK SITE 4 ALS LAB ANALYSIS RESULTS

Parameter*	Event 1	Event 2
Conductivity µS/cm	185	171
Hardness mg $CaCO_3$/L	67.8	58.4
pH	7.87	7.84
Ammonia mg/L	<0.0050	0.0070
Nitrate (N) mg/L	0.440	0.448
Nitrite (N) mg/L	0.0014	0.0013
Total Nitrogen mg/L	0.685	0.703
Phosphorus (P) mg/L	0.0065	0.0106
Calcium mg/L	18.6	16.0
Iron mg/L	0.422	0.504
Magnesium mg/L	5.19	4.50
Manganese mg/L	0.0473	0.0254
Silicon mg/L	6.05	6.12
Sodium mg/L	12.2	11.6
Strontium mg/L	0.0690	0.0626
*Results in table do not include analyzed parameters which fell below the minimum detectable quantity, see Appendix B for further results.		

Due to the relative softness of Cottle Creek, metals are more likely to dissolve into the water column and cause toxicity. Monitoring heavy metals yearly ensures a close eye is kept on the health of this stream for years to come.

3.2.4 Quality Assurance/Quality Control

All afore mentioned quality assurance and control methods were conducted appropriately during water quality sampling analysis, and due to strict adherence, confidence in the water quality data is high, however there were some noted concerns. Replicate data measured at site 1 differed significantly for some parameters, this may be due to the low number of replicates (1), results may have been more consistent if multiple replicates were taken at each site.

The ALS results also differed from the VIU results – phosphate levels were measured to be significantly lower at ALS, and pH was measured to be higher and consistent throughout both events compared to the VIU results. Other parameters (conductivity and hardness) seemed to have less of a discrepancy between the two labs' analyses.

3.3 Microbiology

Coliform culturing is a way of viewing the total number of bacteria in a sample as well as those bacteria introduced from fecal sources. The microbiology of a water source is often analyzed to monitor the potential for pathogens to be present in that stream; pathogens like giardia and E. coli can be difficult to test for as they can occur in such small amounts. Generally, the more fecal coliforms present in a sample, the more likely there are harmful pathogens present in the water.

The 2019 results (Figure 1) showed relatively low counts of CFU's in Cottle Creek compared to the 2018 data. However, an obvious spike was present at site 3 – rising from just over 300

CFU/100ml to 600 CFU/100ml - site 4 also had higher results than the first two sites. These results were unexpected at site 2, as Cottle Lake is home to many waterfowl, amphibians, and possibly beavers – coliforms were expected to spike at the lake outflow. The jump in sites 3 and 4 may simply be explained by their locations further down the watershed and deeper into the Nanaimo infrastructure. As well, site 3 was very marshy, stagnant and was characterized by lots of vegetation and animal sign. This may explain the high coliform counts at site 3.

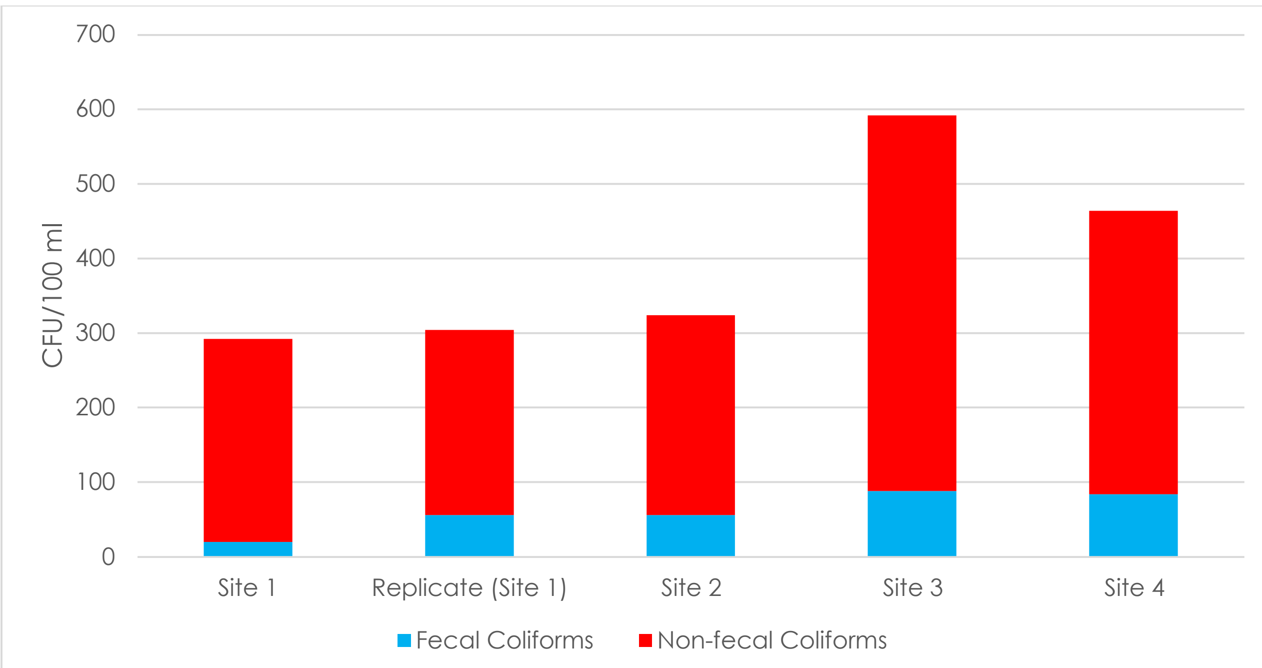

FIGURE 6: COTTLE CREEK COLIFORMS PER SAMPLING SITE

It is worth noting that the fecal coliform percentages were relatively low in all four sites, lower than previous years. In 2018 for example, fecal coliforms outnumbered non-fecal coliforms at many of the sampling sites. All 2019 microbiological plates are visible in Appendix D.

3.4 Stream Invertebrate Communities

3.4.1 Pollution Sensitivity/Distribution

The stream invertebrate results from Cottle Creek seemed to contradict the water quality results obtained from the same sampling sites. As seen in Figure 7 and Table 10, most of the invertebrates sampled belonged to category 2 and category 3. This is interesting, as category 1 invertebrates are the most pollution sensitive, while category 2 invertebrates are only somewhat pollution sensitive and invertebrates belonging to category 3 are considered pollution tolerant. Of note is the fact that category 1 invertebrates were completely absent from sampling site 2 at the outflow of Cottle Lake.

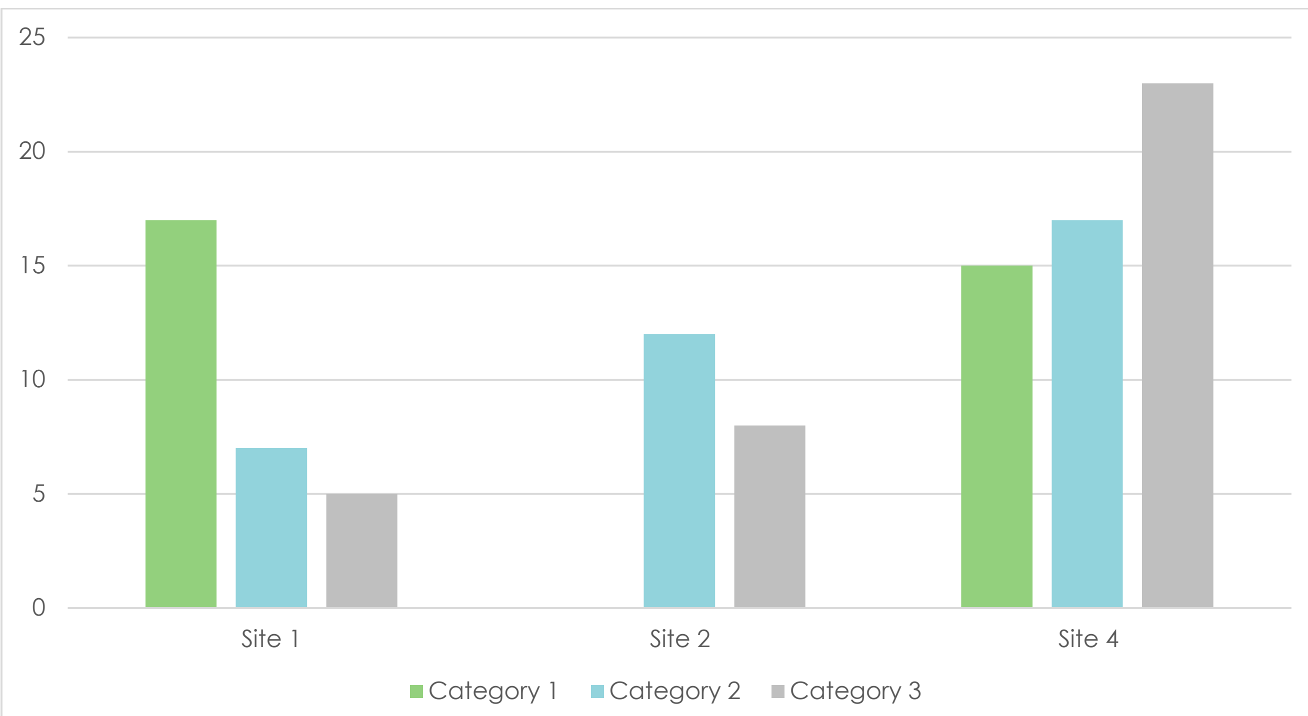

FIGURE 7: COTTLE CREEK INVERTEBRATE CATEGORY COUNTS PER SAMPLING SITE

TABLE 10: COTTLE CREEK INVERTEBRATE CATEGORY COUNTS WITH SPECIES PER SAMPLING SITE

Site 1			Site 2			Site 4		
Common Name	**#**	**Category**	**Common Name**	**#**	**Category**	**Common Name**	**#**	**Category**
Mayfly Nymph	3	1	Clam Mussel	8	2	Mayfly Nymph	15	1
Stonefly Nymph	14	1	Cranefly Larva	1	2	Amphipod	17	2
Cranefly Larva	7	2	Dragonfly Larva	1	2	Aquatic Worm	20	3
Aquatic Worm	4	3	Amphipod	2	2	Midge Larva	3	3
Midge Larva	1	3	Aquatic Worm	8	3			

To explain these results, many things should be considered. All sampling sites consisted of similar substrate material makeup, water temperatures, water flows as well as in-stream and canopy cover. The water quality results for site 2 provided no clues with respect to the low category 1 (EPT) invertebrate counts, and there was nothing to explain the dominance by category 2 and 3 invertebrates at all sampling sites. After much discussion, it was discovered that geography and anthropogenic factors may be playing a role. Being that site 1 is the farthest away from development (roads, houses and other infrastructure) and given that it is the most upstream site, it was understandable as to why this site may be characterized by the lowest pollution levels.

Looking back to previous studies, it should be noted that similar trends were discovered with respect to low (or no) EPT invertebrates at site 2. In 2018, invertebrate sampling results yielded no category 1 invertebrates at site 2. In 2017 only one category 1 invertebrate was collected, and in 2016 only two category 1 invertebrates were identified at site 2 (VIU 2018, VIU 2017, VIU 2016). When discussing factors that may contribute to pollution levels and decrease the ability of EPT invertebrates to survive at site 2, Cottle Lake, the surrounding geography and the anthropogenic uses of the area must be considered. Although no official tests were completed, Cottle Lake is seen to be relatively eutrophic as indicated by murky water, underwater and surface vegetation, an abundance of waterfowl, and rather stagnant sections of water. Cottle lake acts as a basin, collecting water from the surrounding area. This area is characterized by hobby farms and popular dog walking trails. As site 2 is located directly downstream from Cottle Lake, water quality may be impacted in a way not picked up in the VIU or ALS water quality parameters.

3.4.2 Abundance/Density

The abundance of invertebrates at each site is summarized as follows: 29 invertebrates were collected from site 1, 20 invertebrates were collected from site 2 and 55 invertebrates were collected from site 4. Ignoring which invertebrates were categorized as pollution sensitive, somewhat pollution tolerant and pollution tolerant, site 4 is the healthiest site, followed by site 1 and then site 2. It is interesting to note that even when considering abundance only, site 2 had the poorest results.

The density of invertebrates for the four sampling sites on Cottle Creek was calculated using the Invertebrate Survey Field Data Sheets (Appendix E). The total number of organisms collected from each site was divided by the sampling area of 0.27 m^2. This provided an invertebrate diversity calculation indicating the number of invertebrates per 1 m^2. Sampling site 1 had a density of 107.4 invertebrates/m^2, site 2 had a density of 74.1 invertebrates/m^2 and site 4 had a density of 203.7 invertebrates/m^2. Again, ignoring the sensitivity of each invertebrate to pollutants, site 4 would seem to be the healthiest site based on density, followed by sites 1 and 2. Site 2 again received the poorest rating.

3.4.3 Diversity/Site Ratings

Invertebrate diversity was calculated using the number of invertebrate taxa collected at each site. These results were recorded on the provided Invertebrate Survey Field Data Sheets (Appendix E). As seen in Table 11, there were a total of 10 different taxa, 4 from category 1, 3 from category 2 and 3 from category 3. At site 2, a total of 5 invertebrate taxa were collected; 4 from category 2 and 1 from category 3. At site 4, there were a total of 8 different taxa; 3 from category 1, 1 from category 2 and 4 from category 3.

TABLE 11: COTTLE CREEK INVERTEBRATE TAXA COUNTS

Site 1			Site 2			Site 4		
Species	**#**	**# of Taxa**	**Species**	**#**	**# of Taxa**	**Species**	**#**	**# of Taxa**
Mayfly Nymph	3	1	Clam Mussel	8	1	Mayfly Nymph	15	3
Stonefly Nymph	14	3	Cranefly Larva	1	1	Amphipod	17	1
Cranefly Larva	7	3	Dragonfly Larva	1	1	Aquatic Worm	20	3
Aquatic Worm	4	2	Amphipod	2	1	Midge Larva	3	1
Midge Larva	1	1	Aquatic Worm	8	1			

Just as the categorized results showed, these taxon count results indicate that site 1 was the healthiest, followed by site 4 and then site 2. The overall Site Assessment Ratings as calculated on the Invertebrate Survey Interpretations Sheet (Appendix E) followed the same trend. Site 1 had the highest site assessment rating at 2.75. Site 4 followed closely behind at 2.25, and site 2 showed the poorest site assessment rating at 1.50. For context, the ratings are interpreted as follows: 1 is poor, 2 is marginal, 3 is acceptable and 4 is good. The highest site assessment rating of the three sites sampled was still only marginal.

Students also calculated the Shannon-Weiner diversity index. The results are shown below in tables 12-14.

Table 12: Shannon-Weiner Index Calculations for Site 1

Common Name:	Column C	pi (C/T)	ln (pi)	pi*ln(pi)
Mayfly Nymph	3	0.103448276	-2.268683541	-0.23469140
Stonefly Nymph	14	0.482758621	-0.728238500	-0.35156341
Cranefly Larvae	7	0.241379310	-1.421385681	-0.34309310
Aquatic Worm	4	0.137931034	-1.981001469	-0.27324158
Midge Larva	1	0.034482759	-3.367295830	-0.11611365
TOTAL	**29**	**1**		**-1.319**
Shannon-Weiner Diversity Index:			**H =**	**0.819**

Table 13: Shannon-Weiner Index Calculations for Site 2

Common Name:	Column C	pi (C/T)	ln (pi)	pi*ln(pi)
Clam, Mussel	8	0.4	-0.916290732	-0.36651629
Cranefly Larva	1	0.05	-2.995732274	-0.14978661
Dragonfly Larva	1	0.05	-2.995732274	-0.14978661
Amphipod	2	0.1	-2.302585093	-0.23025851
Aquatic Worm	8	0.4	-0.916290732	-0.36651629
TOTAL	**20**	**1**		**-1.263**
Shannon-Weiner Diversity Index:			**H =**	**0.785**

TABLE 14: SHANNON-WEINER INDEX CALCULATIONS FOR SITE 4

Common Name:	Column C	pi (C/T)	ln (pi)	pi*ln(pi)
Mayfly Nymph	15	0.272727273	-1.299282984	-0.35434990
Amphipod	17	0.309090909	-1.174119841	-0.36290977
Aquatic Worm	20	0.363636364	-1.011600912	-0.36785488
Midge Larva	3	0.054545455	-2.908720897	-0.15865750
TOTAL	**55**	**1**		**-1.244**
Shannon-Weiner Diversity Index:			**H =**	**0.897**

For the indices calculated above, higher values of H represent more diverse communities of invertebrates. Sites 1 and 4 show similar diversity, however site 2 is once again characterized by lower diversity results.

3.4.4 Quality Assurance/Quality Control

All quality control and quality assurance methods listed in the methods portion of this report were followed by the students completing the invertebrate sampling. No unexpected errors occurred and even though invertebrate counts may seem low when compared to previous years, the students responsible are confident in their results.

4.0 Conclusions and Recommendations

Cottle Creek has been monitored for the last seven years by RMOT students and the database for water quality, hydrology, invertebrate samples, coliforms, and ALS lab results has been steadily growing. The water quality parameters analyzed in lab were mainly within the BC water quality guidelines (Appendix G). The ALS Laboratory results were also mostly within the BC water quality guidelines. This was interesting given the low invertebrate counts and low site assessment ratings. Overall Cottle Creek seems to be in a healthy state; however, it can be argued that there is room for improvement.

We recommend that water quality, hydrology, invertebrate, coliforms, and ALS laboratory samples continue to be taken yearly as part of the RMOT 306 program. The continuous monitoring of Cottle Creek is important and helps preserve the sensitive ecosystem. We also recommend that the low invertebrate counts be investigated and that new monitoring efforts be conducted along North Cottle Creek downstream from Lost Lake. This system drains into Cottle Lake and into Cottle creek at site #2. Previous monitoring projects have done assessments there in the past and we believe that it would be beneficial to know what quality of water is coming into Cottle Lake.

We had very poor invertebrate counts, especially at the outflow of Cottle Lake. We recommend adding a fish component to this study as well. Fish play a significant role in stream classification and how streams are managed. There are sites that could be tested for the presence of fish, and we believe that it could be vital in how we manage Cottle Creek. We recommend that the City of Nanaimo increase the riparian buffer along Cottle Creek, especially in the lower reaches where it is surrounded by residential neighborhoods. Water quality indicated that Cottle Creek was quite healthy, however invertebrate analyses determined that Cottle Creek's health was between acceptable and poor at all four sites. We would like to see an improvement in the health status of Cottle Creek.

5.0 Acknowledgements

The students responsible for completing the 2019 environmental monitoring project on Cottle Creek would like to acknowledge those who helped with the production of this report. First and foremost, this project and report would not have been possible without the immense contribution and dedicated guidance of Dr. Erick Demers, Resource Management and Protection professor and chair of the VIU Biology Department. His wealth of knowledge in the classroom, his guidance during lab analyses and his preparatory work in the field were instrumental in the successful completion of this final report. VIU Resource Management and Protection technician Mike Lester was responsible for much of the behind the scenes work, helping to set up and take down the laboratory equipment and rushing the ALS samples to the post office.

6.0 References

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7.0 Appendix

Appendix A – Sampling Site Photos

Site #1 on Upper Cottle Creek West of Landalt Road looking upstream at metal grate.

Site #1 on Upper Cottle Creek West of Landalt Road facing downstream at culvert.

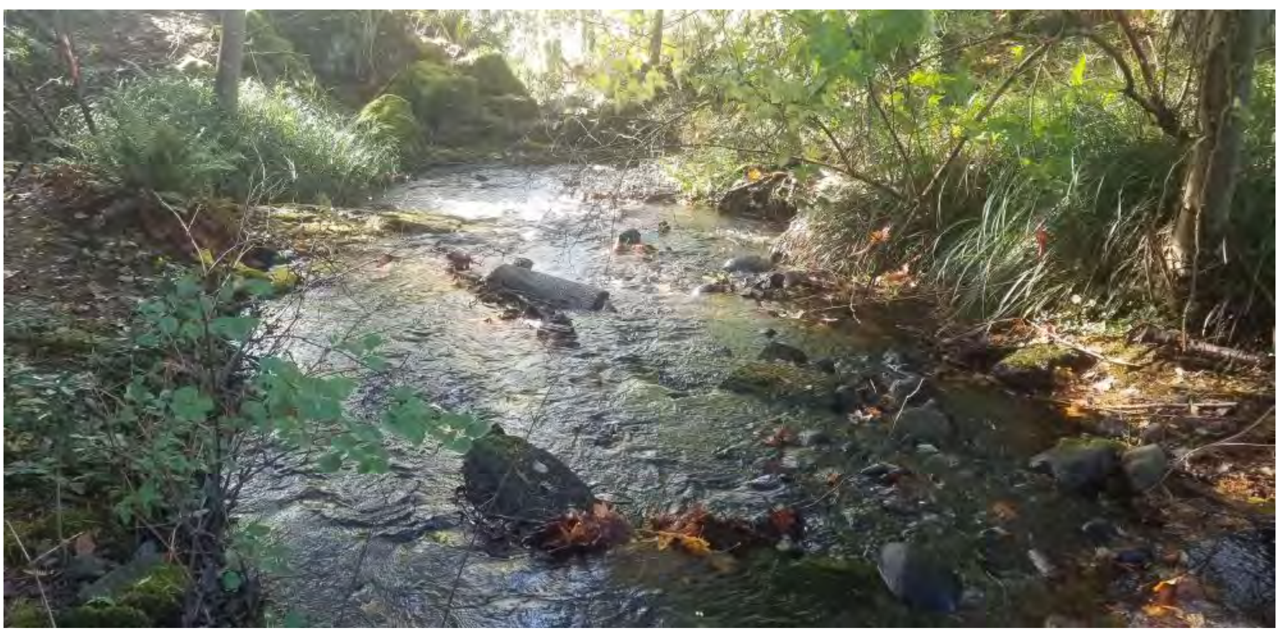
Site #2 at the outflow of Cottle Lake facing upstream towards foot bridge.

Site #2 at the outflow of Cottle Lake facing downstream from sampling site.

Site #3 facing downstream from the bridge over Nottingham Road.

Site #3 facing upstream under the bridge over Nottingham Road.

Site #4 facing upstream towards culvert under Stephenson Pint Road.



Site #4 facing downstream from the sampling sight towards Departure Bay.

Appendix B – ALS Lab Results & Methods

Sampling Event 1 Results:

ALS Environmental

Report To	Eric Demers, Vancouver Island University Nanaimo Campus 900 Fifth Street Nanaimo, BC V9R 5S5	**Date Received** **Report Date** **Report Revision** **Version**	31-Oct-2019 08:30 7-Nov-2019 12:49 1 FINAL
Client Phone	250-753-3245		

Certificate of Analysis

Lab Work Order #	L2374864
Project P.O. #	
Job Reference	ENVIRONMENTAL MONITORING COURSE
Legal Site Description	
C of C Numbers	

Case Narrative/Comments

Amber Springer

Amber Springer, B.Sc
Account Manager

Results Summary L2374854

Job Reference ENVIRONMENTAL MONITORING COUI
Report To Eric Demers, Vancouver Island Universit
Date Received 31-Oct-2019 8:30
Report Date 7-Nov-2019 12:49
Report Version 1

Client Sample ID			COTTLE CREEK-STATION 1	COTTLE CREEK-STATION 2	COTTLE CREEK-STATION 4
Date Sampled			30-Oct-2019	30-Oct-2019	30-Oct-2019
Time Sampled			13:00	13:00	13:00
ALS Sample ID			L2374854-4	L2374854-5	L2374854-6
Parameter	Lowest Detection Limit	Units	Water	Water	Water
Physical Tests (Water)					
Conductivity	2.0	uS/cm	168	170	185
Hardness (as CaCO3)	0.50	mg/L	62.3	59.4	67.8
pH	0.10	pH	7.72	7.50	7.87
Anions and Nutrients (Water)					
Ammonia, Total (as N)	0.0050	mg/L	0.0067	0.0189	<0.0050
Nitrate (as N)	0.0050	mg/L	0.278	0.0765	0.440
Nitrite (as N)	0.0010	mg/L	0.0018	0.0025	0.0014
Total Nitrogen	0.030	mg/L	0.525	0.433	0.685
Orthophosphate-Dissolved (as P)	0.0010	mg/L	<0.0010	<0.0010	<0.0010
Phosphorus (P)-Total	0.0020	mg/L	0.0089	0.0122	0.0065
N:P	N/A	N/A	59.0	35.5	105.4
Total Metals (Water)					
Aluminum (Al)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Antimony (Sb)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Arsenic (As)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Barium (Ba)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Beryllium (Be)-Total	0.0050	mg/L	<0.0050	<0.0050	<0.0050
Bismuth (Bi)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Boron (B)-Total	0.10	mg/L	<0.10	<0.10	<0.10
Cadmium (Cd)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Calcium (Ca)-Total	0.050	mg/L	16.8	16.2	18.6
Chromium (Cr)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Cobalt (Co)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Copper (Cu)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Iron (Fe)-Total	0.030	mg/L	0.421	0.631	0.422
Lead (Pb)-Total	0.050	mg/L	<0.050	<0.050	<0.050
Lithium (Li)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Magnesium (Mg)-Total	0.10	mg/L	4.96	4.61	5.19
Manganese (Mn)-Total	0.0050	mg/L	0.0306	0.0280	0.0473
Molybdenum (Mo)-Total	0.030	mg/L	<0.030	<0.030	<0.030
Nickel (Ni)-Total	0.050	mg/L	<0.050	<0.050	<0.050
Phosphorus (P)-Total	0.30	mg/L	<0.30	<0.30	<0.30
Potassium (K)-Total	2.0	mg/L	<2.0	<2.0	<2.0
Selenium (Se)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Silicon (Si)-Total	0.10	mg/L	6.58	5.07	6.05
Silver (Ag)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Sodium (Na)-Total	2.0	mg/L	11.0	11.3	12.2
Strontium (Sr)-Total	0.0050	mg/L	0.0693	0.0671	0.0690
Thallium (Tl)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Tin (Sn)-Total	0.030	mg/L	<0.030	<0.030	<0.030
Titanium (Ti)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Vanadium (V)-Total	0.030	mg/L	<0.030	<0.030	<0.030
Zinc (Zn)-Total	0.0050	mg/L	<0.0050	<0.0050	<0.0050

Results of Analysis   L2374854

Job Reference ENVIRONMENTAL MONITORING COURSE
Report To Eric Demers, Vancouver Island University
Date Received 31-Oct-2019 8:30
Report Date 7-Nov-2019 12:49
Report Version 1

Parameter	ALS ID	Client Sample ID	ALS Test Code	Results	Detection Limit	Units	Qual	Date Sampled	Time Sampled	Prep Date	Analysis Date	QC Lot	QC Eval	Hold Time Eval	Matrix	Class
Physical Tests (Water)																
Conductivity	L2374854-4	COTTLE CREEK-STATION 1	EC-PCT-VA	168	2.0	uS/cm		30-Oct-19	13:00		31-Oct-19	1216853	✓	✓	Water	Physical Tests
Hardness (as CaCO3)	L2374854-4	COTTLE CREEK-STATION 1	HARDNESS-CALC-VA	62.3	0.50	mg/L	HTC	30-Oct-19	13:00		04-Nov-19		✓	✓	Water	Physical Tests
pH	L2374854-4	COTTLE CREEK-STATION 1	PH-PCT-VA	7.72	0.10	pH		30-Oct-19	13:00		31-Oct-19	1216853	✓	✗	Water	Physical Tests
Anions and Nutrients (Water)																
Ammonia, Total (as N)	L2374854-4	COTTLE CREEK-STATION 1	NH3-F-VA	0.0067	0.0050	mg/L		30-Oct-19	13:00		01-Nov-19	1217030	✓	✓	Water	Anions and Nutrients
Nitrate (as N)	L2374854-4	COTTLE CREEK-STATION 1	NO3-L-IC-N-VA	0.278	0.0050	mg/L		30-Oct-19	13:00		31-Oct-19	1216860	✓	✓	Water	Anions and Nutrients
Nitrite (as N)	L2374854-4	COTTLE CREEK-STATION 1	NO2-L-IC-N-VA	0.0018	0.0010	mg/L		30-Oct-19	13:00		31-Oct-19	1216860	✓	✓	Water	Anions and Nutrients
Total Nitrogen	L2374854-4	COTTLE CREEK-STATION 1	N-T-COL-VA	0.525	0.030	mg/L		30-Oct-19	13:00	31-Oct-19	01-Nov-19	1217058	✓	✓	Water	Anions and Nutrients
Orthophosphate-Dissolved (as P)	L2374854-4	COTTLE CREEK-STATION 1	PO4-DO-COL-VA	<0.0010	0.0010	mg/L		30-Oct-19	13:00		31-Oct-19	1216870	✓	✓	Water	Anions and Nutrients
Phosphorus (P)-Total	L2374854-4	COTTLE CREEK-STATION 1	P-T-PRES-COL-VA	0.0089	0.0020	mg/L		30-Oct-19	13:00		01-Nov-19	1217031	✓	✓	Water	Anions and Nutrients
Total Metals (Water)																
Aluminum (Al)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Antimony (Sb)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Arsenic (As)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Barium (Ba)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Beryllium (Be)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.0050	0.0050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Bismuth (Bi)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Boron (B)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.10	0.10	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Cadmium (Cd)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Calcium (Ca)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	16.8	0.050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Chromium (Cr)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Cobalt (Co)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Copper (Cu)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Iron (Fe)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	0.421	0.030	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Lead (Pb)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.050	0.050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Lithium (Li)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Magnesium (Mg)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	4.96	0.10	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Manganese (Mn)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	0.0306	0.0050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Molybdenum (Mo)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.030	0.030	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Nickel (Ni)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.050	0.050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Phosphorus (P)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.30	0.30	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Potassium (K)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<2.0	2.0	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Selenium (Se)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Silicon (Si)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	6.58	0.10	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Silver (Ag)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Sodium (Na)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	11.0	2.0	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Strontium (Sr)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	0.0693	0.0050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Thallium (Tl)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Tin (Sn)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.030	0.030	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Titanium (Ti)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Vanadium (V)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.030	0.030	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Zinc (Zn)-Total	L2374854-4	COTTLE CREEK-STATION 1	MET-TOT-ICP-VA	<0.0050	0.0050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Physical Tests (Water)																
Conductivity	L2374854-5	COTTLE CREEK-STATION 2	EC-PCT-VA	170	2.0	uS/cm		30-Oct-19	13:00		31-Oct-19	1216853	✓	✓	Water	Physical Tests
Hardness (as CaCO3)	L2374854-5	COTTLE CREEK-STATION 2	HARDNESS-CALC-VA	59.4	0.50	mg/L	HTC	30-Oct-19	13:00		04-Nov-19		✓	✓	Water	Physical Tests
pH	L2374854-5	COTTLE CREEK-STATION 2	PH-PCT-VA	7.50	0.10	pH		30-Oct-19	13:00		31-Oct-19	1216853	✓	✗	Water	Physical Tests
Anions and Nutrients (Water)																
Ammonia, Total (as N)	L2374854-5	COTTLE CREEK-STATION 2	NH3-F-VA	0.0189	0.0050	mg/L		30-Oct-19	13:00		01-Nov-19	1217030	✓	✓	Water	Anions and Nutrients
Nitrate (as N)	L2374854-5	COTTLE CREEK-STATION 2	NO3-L-IC-N-VA	0.0765	0.0050	mg/L		30-Oct-19	13:00		31-Oct-19	1216860	✓	✓	Water	Anions and Nutrients
Nitrite (as N)	L2374854-5	COTTLE CREEK-STATION 2	NO2-L-IC-N-VA	0.0025	0.0010	mg/L		30-Oct-19	13:00		31-Oct-19	1216860	✓	✓	Water	Anions and Nutrients
Total Nitrogen	L2374854-5	COTTLE CREEK-STATION 2	N-T-COL-VA	0.433	0.030	mg/L		30-Oct-19	13:00	31-Oct-19	01-Nov-19	1217058	✓	✓	Water	Anions and Nutrients
Orthophosphate-Dissolved (as P)	L2374854-5	COTTLE CREEK-STATION 2	PO4-DO-COL-VA	<0.0010	0.0010	mg/L		30-Oct-19	13:00		31-Oct-19	1216870	✓	✓	Water	Anions and Nutrients

Results of Analysis L2374854

Job Reference ENVIRONMENTAL MONITORING COURSE
Report To Eric Demers, Vancouver Island University
Date Received 31-Oct-2019 8:30
Report Date 7-Nov-2019 12:49
Report Version 1

Parameter	ALS ID	Client Sample ID	ALS Test Code	Results	Detection Limit	Units	Qual	Date Sampled	Time Sampled	Prep Date	Analysis Date	QC Lot	QC Eval	Hold Time Eval	Matrix	Class
Phosphorus (P)-Total	L2374854-5	COTTLE CREEK-STATION 2	P-T-PRES-COL-VA	0.0122	0.0020	mg/L		30-Oct-19	13:00		01-Nov-19	1217031	✓	✓	Water	Anions and Nutrients
Total Metals (Water)																
Aluminum (Al)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Antimony (Sb)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Arsenic (As)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Barium (Ba)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Beryllium (Be)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.0050	0.0050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Bismuth (Bi)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Boron (B)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.10	0.10	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Cadmium (Cd)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Calcium (Ca)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	16.2	0.050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Chromium (Cr)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Cobalt (Co)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Copper (Cu)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Iron (Fe)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	0.631	0.030	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Lead (Pb)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.050	0.050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Lithium (Li)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Magnesium (Mg)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	4.61	0.10	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Manganese (Mn)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	0.0280	0.0050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Molybdenum (Mo)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.030	0.030	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Nickel (Ni)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.050	0.050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Phosphorus (P)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.30	0.30	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Potassium (K)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<2.0	2.0	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Selenium (Se)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Silicon (Si)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	5.07	0.10	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Silver (Ag)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Sodium (Na)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	11.3	2.0	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Strontium (Sr)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	0.0671	0.0050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Thallium (Tl)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Tin (Sn)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.030	0.030	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Titanium (Ti)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Vanadium (V)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.030	0.030	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Zinc (Zn)-Total	L2374854-5	COTTLE CREEK-STATION 2	MET-TOT-ICP-VA	<0.0050	0.0050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Physical Tests (Water)																
Conductivity	L2374854-6	COTTLE CREEK-STATION 4	EC-PCT-VA	185	2.0	uS/cm		30-Oct-19	13:00		31-Oct-19	1216853	✓	✓	Water	Physical Tests
Hardness (as CaCO3)	L2374854-6	COTTLE CREEK-STATION 4	HARDNESS-CALC-VA	67.8	0.50	mg/L	HTC	30-Oct-19	13:00		04-Nov-19		✓	✓	Water	Physical Tests
pH	L2374854-6	COTTLE CREEK-STATION 4	PH-PCT-VA	7.87	0.10	pH		30-Oct-19	13:00		31-Oct-19	1216853	✓	✗	Water	Physical Tests
Anions and Nutrients (Water)																
Ammonia, Total (as N)	L2374854-6	COTTLE CREEK-STATION 4	NH3-F-VA	<0.0050	0.0050	mg/L		30-Oct-19	13:00		01-Nov-19	1217030	✓	✓	Water	Anions and Nutrients
Nitrate (as N)	L2374854-6	COTTLE CREEK-STATION 4	NO3-L-IC-N-VA	0.440	0.0050	mg/L		30-Oct-19	13:00		31-Oct-19	1216860	✓	✓	Water	Anions and Nutrients
Nitrite (as N)	L2374854-6	COTTLE CREEK-STATION 4	NO2-L-IC-N-VA	0.0014	0.0010	mg/L		30-Oct-19	13:00		31-Oct-19	1216860	✓	✓	Water	Anions and Nutrients
Total Nitrogen	L2374854-6	COTTLE CREEK-STATION 4	N-T-COL-VA	0.685	0.030	mg/L		30-Oct-19	13:00	31-Oct-19	01-Nov-19	1217058	✓	✓	Water	Anions and Nutrients
Orthophosphate-Dissolved (as P)	L2374854-6	COTTLE CREEK-STATION 4	PO4-DO-COL-VA	<0.0010	0.0010	mg/L		30-Oct-19	13:00		31-Oct-19	1216870	✓	✓	Water	Anions and Nutrients
Phosphorus (P)-Total	L2374854-6	COTTLE CREEK-STATION 4	P-T-PRES-COL-VA	0.0065	0.0020	mg/L		30-Oct-19	13:00		01-Nov-19	1217031	✓	✓	Water	Anions and Nutrients
Total Metals (Water)																
Aluminum (Al)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Antimony (Sb)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Arsenic (As)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Barium (Ba)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Beryllium (Be)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.0050	0.0050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Bismuth (Bi)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Boron (B)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.10	0.10	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Cadmium (Cd)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals

Results of Analysis L2374854

Job Reference ENVIRONMENTAL MONITORING COURSE
Report To Eric Demers, Vancouver Island University
Date Received 31-Oct-2019 8:30
Report Date 7-Nov-2019 12:49
Report Version 1

Parameter	ALS ID	Client Sample ID	ALS Test Code	Results	Detection Limit	Units	Qual	Date Sampled	Time Sampled	Prep Date	Analysis Date	QC Lot	QC Eval	Hold Time Eval	Matrix	Class
Calcium (Ca)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	18.6	0.050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Chromium (Cr)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Cobalt (Co)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Copper (Cu)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Iron (Fe)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	0.422	0.030	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Lead (Pb)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.050	0.050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Lithium (Li)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Magnesium (Mg)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	5.19	0.10	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Manganese (Mn)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	0.0473	0.0050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Molybdenum (Mo)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.030	0.030	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Nickel (Ni)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.050	0.050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Phosphorus (P)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.30	0.30	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Potassium (K)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<2.0	2.0	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Selenium (Se)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Silicon (Si)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	6.05	0.10	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Silver (Ag)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Sodium (Na)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	12.2	2.0	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Strontium (Sr)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	0.0690	0.0050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Thallium (Tl)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.20	0.20	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Tin (Sn)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.030	0.030	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Titanium (Ti)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.010	0.010	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Vanadium (V)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.030	0.030	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals
Zinc (Zn)-Total	L2374854-6	COTTLE CREEK-STATION 4	MET-TOT-ICP-VA	<0.0050	0.0050	mg/L		30-Oct-19	13:00		04-Nov-19	1217156	✓	✓	Water	Total Metals

ALS Methods for Sampling Event 1:

Methodology L2374854

Job Reference	ENVIRONMENTAL MONITORING COURSE
Report To	Eric Demers, Vancouver Island University
Date Received	31-Oct-2019 8:30
Report Date	7-Nov-2019 12:49
Report Version	1

ALS Test Code	ALS Test Description	Lab Location	Matrix	Method Reference	Methodology Description
Physical Tests (Water)					
EC-PCT-VA	Conductivity (Automated)	Vancouver	Water	APHA 2510 Auto. Conduc.	This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.
HARDNESS-CALC-VA	Hardness	Vancouver	Water	APHA 2340B	Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.
PH-PCT-VA	pH by Meter (Automated)	Vancouver	Water	APHA 4500-H pH Value	This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode It is recommended that this analysis be conducted in the field.
Anions and Nutrients (Water)					
N-T-COL-VA	Total Nitrogen in water by Colour	Vancouver	Water	APHA4500-P(J)/NEMI9171/USGS03-4174	This analysis is carried out using procedures adapted from APHA Method 4500-P (J) "Persulphate Method for Simultaneous Determination of Total Nitrogen and Total Phosphorus" and National Environmental Methods Index - Nemi method 5735.
NH3-F-VA	Ammonia in Water by Fluorescence	Vancouver	Water	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC	This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.
NO2-L-IC-N-VA	Nitrite in Water by IC (Low Level)	Vancouver	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
NO3-L-IC-N-VA	Nitrate in Water by IC (Low Level)	Vancouver	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
P-T-PRES-COL-VA	Total P in Water by Colour	Vancouver	Water	APHA 4500-P Phosphorus	This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample. Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples. Arsenic (5+), at elevated levels, is a positive interference on colourimetric phosphate analysis.
PO4-DO-COL-VA	Diss. Orthophosphate in Water by Colour	Vancouver	Water	APHA 4500-P Phosphorus	This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter. Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples. Arsenic (5+), at elevated levels, is a positive interference on colourimetric phosphate analysis.
Total Metals (Water)					
MET-TOT-ICP-VA	Total Metals in Water by ICPOES	Vancouver	Water	EPA SW-846 3005A/6010B	This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

ALS Results for Sampling Event 2:

ALS Environmental

Report To	Eric Demers, Vancouver Island University Nanaimo Campus 900 Fifth Street Nanaimo, BC V9R 5S5	**Date Received** **Report Date** **Report Revision** **Version**	21-Nov-2019 12:00 28-Nov-2019 16:40 1 FINAL
Client Phone	250-753-3245		

Certificate of Analysis

Lab Work Order #	L2386179
Project P.O. #	
Job Reference	ENVIRONMENTAL MONITORING COURSE
Legal Site Description	
C of C Numbers	

Case Narrative/Comments

Amber Springer

Amber Springer, B.Sc
Account Manager

Results Summary L2386179

Job Reference	ENVIRONMENTAL MONITORING COUI
Report To	Eric Demers, Vancouver Island Universit
Date Received	21-Nov-2019 12:00
Report Date	28-Nov-2019 16:40
Report Version	1

Client Sample ID			COTTLE CREEK - STATION 1	COTTLE CREEK - STATION 2	COTTLE CREEK - STATION 4
Date Sampled			20-Nov-2019	20-Nov-2019	20-Nov-2019
Time Sampled			13:00	13:00	13:00
ALS Sample ID			L2386179-4	L2386179-5	L2386179-6
Parameter	Lowest Detection Limit	Units	Water	Water	Water
Physical Tests (Water)					
Conductivity	2.0	uS/cm	165	161	171
Hardness (as CaCO3)	0.50	mg/L	58	54.1	58.4
pH	0.10	pH	7.77	7.52	7.84
Anions and Nutrients (Water)					
Ammonia, Total (as N)	0.0050	mg/L	0.0095	0.0133	0.0070
Nitrate (as N)	0.0050	mg/L	0.564	0.202	0.448
Nitrite (as N)	0.0010	mg/L	0.0020	0.0013	0.0013
Total Nitrogen	0.030	mg/L	0.824	0.477	0.703
Orthophosphate-Dissolved (as P)	0.0010	mg/L	0.0022	<0.0010	<0.0010
Phosphorus (P)-Total	0.0020	mg/L	0.0127	0.0122	0.0106
N:P	N/A	N/A	64.9	39.1	66.3
Total Metals (Water)					
Aluminum (Al)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Antimony (Sb)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Arsenic (As)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Barium (Ba)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Beryllium (Be)-Total	0.0050	mg/L	<0.0050	<0.0050	<0.0050
Bismuth (Bi)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Boron (B)-Total	0.10	mg/L	<0.10	<0.10	<0.10
Cadmium (Cd)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Calcium (Ca)-Total	0.050	mg/L	15.7	14.8	16.0
Chromium (Cr)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Cobalt (Co)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Copper (Cu)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Iron (Fe)-Total	0.030	mg/L	0.722	0.686	0.504
Lead (Pb)-Total	0.050	mg/L	<0.050	<0.050	<0.050
Lithium (Li)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Magnesium (Mg)-Total	0.10	mg/L	4.57	4.18	4.50
Manganese (Mn)-Total	0.0050	mg/L	0.0883	0.102	0.0254
Molybdenum (Mo)-Total	0.030	mg/L	<0.030	<0.030	<0.030
Nickel (Ni)-Total	0.050	mg/L	<0.050	<0.050	<0.050
Phosphorus (P)-Total	0.30	mg/L	<0.30	<0.30	<0.30
Potassium (K)-Total	2.0	mg/L	<2.0	<2.0	<2.0
Selenium (Se)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Silicon (Si)-Total	0.10	mg/L	6.57	5.83	6.12
Silver (Ag)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Sodium (Na)-Total	2.0	mg/L	10.2	10.8	11.6
Strontium (Sr)-Total	0.0050	mg/L	0.0649	0.0604	0.0626
Thallium (Tl)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Tin (Sn)-Total	0.030	mg/L	<0.030	<0.030	<0.030
Titanium (Ti)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Vanadium (V)-Total	0.030	mg/L	<0.030	<0.030	<0.030
Zinc (Zn)-Total	0.0050	mg/L	<0.0050	<0.0050	<0.0050

Results of Analysis L2386179

Job Reference ENVIRONMENTAL MONITORING COURSE
Report To Eric Demers, Vancouver Island University
Date Received 21-Nov-2019 12:00
Report Date 28-Nov-2019 16:40
Report Version 1

Parameter	ALS ID	Client Sample ID	ALS Test Code	Results	Detection Limit	Units	Qual	Date Sampled	Time Sampled	Prep Date	Analysis Date	QC Lot	QC Eval	Hold Time Eval	Matrix	Class
Physical Tests (Water)																
Conductivity	L2386179-4	COTTLE CREEK - STATION 1	EC-PCT-VA	165	2.0	uS/cm		20-Nov-19	13:00		23-Nov-19	1231782	✓	✓	Water	Physical Tests
Hardness (as CaCO3)	L2386179-4	COTTLE CREEK - STATION 1	HARDNESS-CALC-VA	58.0	0.50	mg/L	HTC	20-Nov-19	13:00		26-Nov-19		✓	✓	Water	Physical Tests
pH	L2386179-4	COTTLE CREEK - STATION 1	PH-PCT-VA	7.77	0.10	pH		20-Nov-19	13:00		23-Nov-19	1231782	✓	✗	Water	Physical Tests
Anions and Nutrients (Water)																
Ammonia, Total (as N)	L2386179-4	COTTLE CREEK - STATION 1	NH3-F-VA	0.0095	0.0050	mg/L		20-Nov-19	13:00		26-Nov-19	1232940	✓	✓	Water	Anions and Nutrients
Nitrate (as N)	L2386179-4	COTTLE CREEK - STATION 1	NO3-L-IC-N-VA	0.564	0.0050	mg/L		20-Nov-19	13:00		23-Nov-19	1231775	✓	✓	Water	Anions and Nutrients
Nitrite (as N)	L2386179-4	COTTLE CREEK - STATION 1	NO2-L-IC-N-VA	0.0020	0.0010	mg/L	HTD	20-Nov-19	13:00		26-Nov-19	1234856	✓	✗	Water	Anions and Nutrients
Nitrite (as N)	L2386179-4	COTTLE CREEK - STATION 1	NO2-L-IC-N-VA	0.0020	0.0010	mg/L	HTD	20-Nov-19	13:00		26-Nov-19	1231775	✗	✗	Water	Anions and Nutrients
Total Nitrogen	L2386179-4	COTTLE CREEK - STATION 1	N-T-COL-VA	0.824	0.030	mg/L		20-Nov-19	13:00	26-Nov-19	27-Nov-19	1232951	✓	✓	Water	Anions and Nutrients
Orthophosphate-Dissolved (as P)	L2386179-4	COTTLE CREEK - STATION 1	PO4-DO-COL-VA	0.0022	0.0010	mg/L		20-Nov-19	13:00		23-Nov-19	1231786	✓	✓	Water	Anions and Nutrients
Phosphorus (P)-Total	L2386179-4	COTTLE CREEK - STATION 1	P-T-PRES-COL-VA	0.0127	0.0020	mg/L		20-Nov-19	13:00		26-Nov-19	1232942	✓	✓	Water	Anions and Nutrients
Total Metals (Water)																
Aluminum (Al)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Antimony (Sb)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Arsenic (As)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Barium (Ba)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Beryllium (Be)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.0050	0.0050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Bismuth (Bi)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Boron (B)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.10	0.10	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Cadmium (Cd)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Calcium (Ca)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	15.7	0.050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Chromium (Cr)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Cobalt (Co)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Copper (Cu)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Iron (Fe)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	0.722	0.030	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Lead (Pb)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.050	0.050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Lithium (Li)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Magnesium (Mg)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	4.57	0.10	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Manganese (Mn)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	0.0883	0.0050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Molybdenum (Mo)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.030	0.030	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Nickel (Ni)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.050	0.050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Phosphorus (P)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.30	0.30	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Potassium (K)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<2.0	2.0	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Selenium (Se)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Silicon (Si)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	6.57	0.10	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Silver (Ag)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Sodium (Na)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	10.2	2.0	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Strontium (Sr)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	0.0649	0.0050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Thallium (Tl)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Tin (Sn)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.030	0.030	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Titanium (Ti)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Vanadium (V)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.030	0.030	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Zinc (Zn)-Total	L2386179-4	COTTLE CREEK - STATION 1	MET-TOT-ICP-VA	<0.0050	0.0050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Physical Tests (Water)																
Conductivity	L2386179-5	COTTLE CREEK - STATION 2	EC-PCT-VA	161	2.0	uS/cm		20-Nov-19	13:00		23-Nov-19	1231782	✓	✓	Water	Physical Tests
Hardness (as CaCO3)	L2386179-5	COTTLE CREEK - STATION 2	HARDNESS-CALC-VA	54.1	0.50	mg/L	HTC	20-Nov-19	13:00		26-Nov-19		✓	✓	Water	Physical Tests
pH	L2386179-5	COTTLE CREEK - STATION 2	PH-PCT-VA	7.52	0.10	pH		20-Nov-19	13:00		23-Nov-19	1231782	✓	✗	Water	Physical Tests
Anions and Nutrients (Water)																
Ammonia, Total (as N)	L2386179-5	COTTLE CREEK - STATION 2	NH3-F-VA	0.0133	0.0050	mg/L		20-Nov-19	13:00		26-Nov-19	1232940	✓	✓	Water	Anions and Nutrients
Nitrate (as N)	L2386179-5	COTTLE CREEK - STATION 2	NO3-L-IC-N-VA	0.202	0.0050	mg/L		20-Nov-19	13:00		23-Nov-19	1231775	✓	✓	Water	Anions and Nutrients
Nitrite (as N)	L2386179-5	COTTLE CREEK - STATION 2	NO2-L-IC-N-VA	0.0013	0.0010	mg/L	HTD	20-Nov-19	13:00		26-Nov-19	1234856	✓	✗	Water	Anions and Nutrients
Nitrite (as N)	L2386179-5	COTTLE CREEK - STATION 2	NO2-L-IC-N-VA	0.0013	0.0010	mg/L	HTD	20-Nov-19	13:00		26-Nov-19	1231775	✗	✗	Water	Anions and Nutrients

Results of Analysis L2386179

Job Reference	ENVIRONMENTAL MONITORING COURSE
Report To	Eric Demers, Vancouver Island University
Date Received	21-Nov-2019 12:00
Report Date	28-Nov-2019 16:40
Report Version	1

Parameter	ALS ID	Client Sample ID	ALS Test Code	Results	Detection Limit	Units	Qual	Date Sampled	Time Sampled	Prep Date	Analysis Date	QC Lot	QC Eval	Hold Time Eval	Matrix	Class
Total Nitrogen	L2386179-5	COTTLE CREEK - STATION 2	N-T-COL-VA	0.477	0.030	mg/L		20-Nov-19	13:00	26-Nov-19	27-Nov-19	1232951	✓	✓	Water	Anions and Nutrients
Orthophosphate-Dissolved (as P)	L2386179-5	COTTLE CREEK - STATION 2	PO4-DO-COL-VA	<0.0010	0.0010	mg/L		20-Nov-19	13:00		23-Nov-19	1231786	✓	✓	Water	Anions and Nutrients
Phosphorus (P)-Total	L2386179-5	COTTLE CREEK - STATION 2	P-T-PRES-COL-VA	0.0122	0.0020	mg/L		20-Nov-19	13:00		26-Nov-19	1232942	✓	✓	Water	Anions and Nutrients
Total Metals (Water)																
Aluminum (Al)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Antimony (Sb)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Arsenic (As)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Barium (Ba)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Beryllium (Be)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.0050	0.0050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Bismuth (Bi)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Boron (B)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.10	0.10	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Cadmium (Cd)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Calcium (Ca)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	14.8	0.050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Chromium (Cr)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Cobalt (Co)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Copper (Cu)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Iron (Fe)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	0.686	0.030	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Lead (Pb)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.050	0.050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Lithium (Li)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Magnesium (Mg)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	4.18	0.10	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Manganese (Mn)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	0.102	0.0050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Molybdenum (Mo)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.030	0.030	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Nickel (Ni)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.050	0.050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Phosphorus (P)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.30	0.30	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Potassium (K)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<2.0	2.0	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Selenium (Se)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Silicon (Si)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	5.83	0.10	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Silver (Ag)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Sodium (Na)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	10.8	2.0	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Strontium (Sr)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	0.0604	0.0050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Thallium (Tl)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Tin (Sn)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.030	0.030	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Titanium (Ti)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Vanadium (V)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.030	0.030	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Zinc (Zn)-Total	L2386179-5	COTTLE CREEK - STATION 2	MET-TOT-ICP-VA	<0.0050	0.0050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Physical Tests (Water)																
Conductivity	L2386179-6	COTTLE CREEK - STATION 4	EC-PCT-VA	171	2.0	uS/cm		20-Nov-19	13:00		23-Nov-19	1231782	✓	✓	Water	Physical Tests
Hardness (as CaCO3)	L2386179-6	COTTLE CREEK - STATION 4	HARDNESS-CALC-VA	58.4	0.50	mg/L	HTC	20-Nov-19	13:00		26-Nov-19		✓	✓	Water	Physical Tests
pH	L2386179-6	COTTLE CREEK - STATION 4	PH-PCT-VA	7.84	0.10	pH		20-Nov-19	13:00		23-Nov-19	1231782	✓	*	Water	Physical Tests
Anions and Nutrients (Water)																
Ammonia, Total (as N)	L2386179-6	COTTLE CREEK - STATION 4	NH3-F-VA	0.0070	0.0050	mg/L		20-Nov-19	13:00		26-Nov-19	1232940	✓	✓	Water	Anions and Nutrients
Nitrate (as N)	L2386179-6	COTTLE CREEK - STATION 4	NO3-L-IC-N-VA	0.448	0.0050	mg/L		20-Nov-19	13:00		23-Nov-19	1231775	✓	✓	Water	Anions and Nutrients
Nitrite (as N)	L2386179-6	COTTLE CREEK - STATION 4	NO2-L-IC-N-VA	0.0013	0.0010	mg/L	HTD	20-Nov-19	13:00		26-Nov-19	1234856	✓	*	Water	Anions and Nutrients
Nitrite (as N)	L2386179-6	COTTLE CREEK - STATION 4	NO2-L-IC-N-VA	0.0013	0.0010	mg/L	HTD	20-Nov-19	13:00		26-Nov-19	1231775	*	*	Water	Anions and Nutrients
Total Nitrogen	L2386179-6	COTTLE CREEK - STATION 4	N-T-COL-VA	0.703	0.030	mg/L		20-Nov-19	13:00	26-Nov-19	27-Nov-19	1232951	✓	✓	Water	Anions and Nutrients
Orthophosphate-Dissolved (as P)	L2386179-6	COTTLE CREEK - STATION 4	PO4-DO-COL-VA	<0.0010	0.0010	mg/L		20-Nov-19	13:00		23-Nov-19	1231786	✓	✓	Water	Anions and Nutrients
Phosphorus (P)-Total	L2386179-6	COTTLE CREEK - STATION 4	P-T-PRES-COL-VA	0.0106	0.0020	mg/L		20-Nov-19	13:00		26-Nov-19	1232942	✓	✓	Water	Anions and Nutrients
Total Metals (Water)																
Aluminum (Al)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Antimony (Sb)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Arsenic (As)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Barium (Ba)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Beryllium (Be)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.0050	0.0050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals

Results of Analysis L2386179

Job Reference ENVIRONMENTAL MONITORING COURSE
Report To Eric Demers, Vancouver Island University
Date Received 21-Nov-2019 12:00
Report Date 28-Nov-2019 16:40
Report Version 1

Parameter	ALS ID	Client Sample ID	ALS Test Code	Results	Detection Limit	Units	Qual	Date Sampled	Time Sampled	Prep Date	Analysis Date	QC Lot	QC Eval	Hold Time Eval	Matrix	Class
Bismuth (Bi)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Boron (B)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.10	0.10	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Cadmium (Cd)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Calcium (Ca)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	16.0	0.050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Chromium (Cr)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Cobalt (Co)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Copper (Cu)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Iron (Fe)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	0.504	0.030	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Lead (Pb)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.050	0.050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Lithium (Li)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Magnesium (Mg)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	4.50	0.10	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Manganese (Mn)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	0.0254	0.0050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Molybdenum (Mo)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.030	0.030	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Nickel (Ni)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.050	0.050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Phosphorus (P)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.30	0.30	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Potassium (K)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<2.0	2.0	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Selenium (Se)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Silicon (Si)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	6.12	0.10	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Silver (Ag)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Sodium (Na)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	11.6	2.0	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Strontium (Sr)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	0.0626	0.0050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Thallium (Tl)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.20	0.20	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Tin (Sn)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.030	0.030	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Titanium (Ti)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.010	0.010	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Vanadium (V)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.030	0.030	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals
Zinc (Zn)-Total	L2386179-6	COTTLE CREEK - STATION 4	MET-TOT-ICP-VA	<0.0050	0.0050	mg/L		20-Nov-19	13:00		25-Nov-19	1231736	✓	✓	Water	Total Metals

ALS Methods for Second Sampling Event:

Methodology L2386179

Job Reference	ENVIRONMENTAL MONITORING COURSE
Report To	Eric Demers, Vancouver Island University
Date Received	21-Nov-2019 12:00
Report Date	28-Nov-2019 16:40
Report Version	1

ALS Test Code	ALS Test Description	Lab Location	Matrix	Method Reference	Methodology Description
Physical Tests (Water)					
EC-PCT-VA	Conductivity (Automated)	Vancouver	Water	APHA 2510 Auto. Conduc.	This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.
HARDNESS-CALC-VA	Hardness	Vancouver	Water	APHA 2340B	Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.
PH-PCT-VA	pH by Meter (Automated)	Vancouver	Water	APHA 4500-H pH Value	This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode It is recommended that this analysis be conducted in the field.
Anions and Nutrients (Water)					
N-T-COL-VA	Total Nitrogen in water by Colour	Vancouver	Water	APHA4500-P(J)/NEMI9171/USGS03-4174	This analysis is carried out using procedures adapted from APHA Method 4500-P (J) "Persulphate Method for Simultaneous Determination of Total Nitrogen and Total Phosphorus" and National Environmental Methods Index - Nemi method 5735.
NH3-F-VA	Ammonia in Water by Fluorescence	Vancouver	Water	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC	This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.
NO2-L-IC-N-VA	Nitrite in Water by IC (Low Level)	Vancouver	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
NO3-L-IC-N-VA	Nitrate in Water by IC (Low Level)	Vancouver	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
P-T-PRES-COL-VA	Total P in Water by Colour	Vancouver	Water	APHA 4500-P Phosphorus	This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample. Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples. Arsenic (5+), at elevated levels, is a positive interference on colourimetric phosphate analysis.
PO4-DO-COL-VA	Diss. Orthophosphate in Water by Colour	Vancouver	Water	APHA 4500-P Phosphorus	This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter. Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples. Arsenic (5+), at elevated levels, is a positive interference on colourimetric phosphate analysis.
Total Metals (Water)					
MET-TOT-ICP-VA	Total Metals in Water by ICPOES	Vancouver	Water	EPA SW-846 3005A/6010B	This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Appendix C – ALS Lab Chain of Custody Confirmations

Chain of Custody from First Sampling Event:

Page 1 of 3
31-OCT-19 21:57 (MT)

Sample Receipt Confirmation

Report Distribution:

Company Name: Vancouver Island University
Contact: Eric Demers
Address: Nanaimo Campus, 900 Fifth Street
Nanaimo, BC, V9R 5S5
Phone: 250-753-3245
Fax: 250-740-6482
Email: eric.demers@viu.ca
EDD Email: –
Distribution: Hard Copy: N Email: Y Fax: N EDD: N

Invoice Distribution:

Acct Name: Vancouver Island University
Contact: Accounts Payable
Address: Nanaimo Campus, 900 Fifth Street
Nanaimo, BC, V9R 5S5
Phone: –
Fax: –
Invoice Email: eric.demers@viu.ca
Project #: N/A
Account #: MAL100

Client Information:

Job Reference #: ENVIRONMENTAL MONITORING COURSE
Project PO #:
Legal Site Description: N/A
Quote #: N/A
Date Sampled: 30-OCT-19
Date Received: 31-OCT-19
Sampled By: Students
Chain Of Custody: –

Workorder Summary:

Lab Work Order #: **L2374854**
Estimated completion date: 07-NOV-19
15 Samples received at ALS in **VANCOUVER**
Client Job #: ENVIRONMENTAL MONITORING COUR
Account Manager: Amber Springer, B.Sc
Estimated sample disposal date: See Sample Disposal Information section below

Note: *There are* **sample integrity issues** *with your samples submitted. Please see Sample Integrity Observations below for more details.*

Lab Sample ID	Client Sample ID	Date Sampled	Date Received	Sample Due Date	Priority Flag	Sample Type
L2374854-1	BECK CREEK-STATION 1	30-OCT-19 09:00	31-OCT-19 08:30	07-NOV-19		Water
L2374854-2	BECK CREEK-STATION 2	30-OCT-19 09:00	31-OCT-19 08:30	07-NOV-19		Water
L2374854-3	BECK CREEK-STATION 3	30-OCT-19 09:00	31-OCT-19 08:30	07-NOV-19		Water
L2374854-4	COTTLE CREEK-STATION 1	30-OCT-19 09:00	31-OCT-19 08:30	07-NOV-19		Water
L2374854-5	COTTLE CREEK-STATION 2	30-OCT-19 09:00	31-OCT-19 08:30	07-NOV-19		Water
L2374854-6	COTTLE CREEK-STATION 4	30-OCT-19 09:00	31-OCT-19 08:30	07-NOV-19		Water
L2374854-7	ENGLISHMAN RIVER -STATION1	30-OCT-19 09:00	31-OCT-19 08:30	07-NOV-19		Water
L2374854-8	ENGLISHMAN RIVER -STATION2	30-OCT-19 09:00	31-OCT-19 08:30	07-NOV-19		Water
L2374854-9	ENGLISHMAN RIVER -STATION4	30-OCT-19 09:00	31-OCT-19 08:30	07-NOV-19		Water
L2374854-10	MILLSTONE RIVER - STATION 1	30-OCT-19 09:00	31-OCT-19 08:30	07-NOV-19		Water
L2374854-11	MILLSTONE RIVER - STATION 2	30-OCT-19 09:00	31-OCT-19 08:30	07-NOV-19		Water
L2374854-12	MILLSTONE RIVER - STATION 4	30-OCT-19 09:00	31-OCT-19 08:30	07-NOV-19		Water
L2374854-13	RICHARDS CREEK- STATION 1	30-OCT-19 09:00	31-OCT-19 08:30	07-NOV-19		Water
L2374854-14	RICHARDS CREEK- STATION 2	30-OCT-19 09:00	31-OCT-19 08:30	07-NOV-19		Water
L2374854-15	RICHARDS CREEK- STATION 3	30-OCT-19 09:00	31-OCT-19 08:30	07-NOV-19		Water

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RIGHT SOLUTIONS

Analysis Requested :	Anions by Ion Chromatography	Hardness	Total Metals in Water by ICPOES	Total Nitrogen in water by Colour	Ammonia in Water by Fluorescence	Total P in Water by Colour	Conductivity [Automated]	pH by Meter [Automated]	Diss. Orthophosphate in Water by Colour	Sample Handling and Disposal Fee
BECK CREEK-STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
BECK CREEK-STATION 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
BECK CREEK-STATION 3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
COTTLE CREEK-STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
COTTLE CREEK-STATION 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
COTTLE CREEK-STATION 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ENGLISHMAN RIVER - STATION1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ENGLISHMAN RIVER - STATION2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ENGLISHMAN RIVER - STATION4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MILLSTONE RIVER - STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MILLSTONE RIVER - STATION 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MILLSTONE RIVER - STATION 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
RICHARDS CREEK-STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
RICHARDS CREEK-STATION 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
RICHARDS CREEK-STATION 3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Hold Time Exceedences:

The following samples have exceeded recommended holding times prior to sample receipt.

Analysis Requested	Lab Sample ID	Recommended Hold Time	Date Sampled	Date Received
pH by Meter (Automated)	L2374854-1, 1, 2, 2, 3, 3, 4, 4, 5, 5, 6, 6, 7, 7, 8, 8, 9, 9, 10, 10, 11, 11, 12, 12, 13, 13, 14, 14, 15, 15	0.25 hours	30-OCT-19	31-OCT-19

Sample Integrity Observations:

Observation	Details

Sample Integrity Observations:

Discrepancy between CofC and label	Nutrition and metal bottles for sample Richards Creek - station 1 ,Richards Creek - station 2 and Richards Creek - station 3 are labelled as both total and dissolved. Because only total analysis is requested, the bottles will be labelled as such. If other analysis is required, please contact your AM.
Extra samples/bottles received but not listed on COC	Received nutrition and metal bottles for sample Englishman River - Station 3. These bottles will be labelled as sample Englishman River - Station 2 by process of elimination.
Samples listed on COC but not received	Did not receive nutrition and metal bottles for sample Englishman River - Station 2.

Sample Disposal Information:

Where possible, ALS will store samples for the following durations, measured from date of sample submission: 45 days for Soil and Water samples; 6 months for Tissue/Biota samples; 14 days for air samples collected on re-usable media; and 3 days for water samples submitted for microbiological testing. Longer storage times are available upon request.

For information about ALS accreditations and certifications please contact your Account Manager or visit our webpage at www.alsglobal.com (see Canada downloads).

ALS Group strives to deliver on-time results to our clients at all times. However, there are times when due to capacity issues or other unforeseen circumstances we are unable to meet our expected turnaround times. The information above is related to a recent workorder you have submitted to our laboratory. In the event that you have an inquiry, please refer to the Lab Work Order # when calling your Account Manager.

ALS Group appreciates your business. Thank you for the opportunity to work with you.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2374854-COFC

COC Number: 17 -

Page 1 of

Report To	Contact and company name below will appear on the final report	Report Format / Distribution	
Company:	Vancouver Island University	Select Report Format:	☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)
Contact:	Eric Demers	Quality Control (QC) Report with Report	☑ YES ☐ NO
Phone:	250-753-3245	☐ Compare Results to Criteria on Report - provide details below if box checked	
	Company address below will appear on the final report	Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Street:	900 Fifth Street	Email 1 or Fax	eric.demers@viu.ca
City/Province:	Nanaimo, BC	Email 2	
Postal Code:	V9R 5S5	Email 3	
Invoice To	Same as Report To ☑ YES ☐ NO	Invoice Distribution	
	Copy of Invoice with Report ☐ YES ☑ NO	Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Company:		Email 1 or Fax	eric.demers@viu.ca
Contact:		Email 2	

Project Information		Oil and Gas Required Fields (client use)	
ALS Account # / Quote #:		AFE/Cost Center:	PO#
Job #:	Environmental Monitoring Course	Major/Minor Code:	Routing Code:
PO / AFE:		Requisitioner:	
LSD:		Location:	
ALS Lab Work Order # (lab use only):		ALS Contact: Amber Springer	Sampler: Students

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)

Standard TAT is 15 business days. DTOX analysis standard TAT is 5 business days

PRIORITY (Business Days)		DTOX Analysis (Business days)	
15 day [Regular]	☑	5 Business day - DTOX [R - Regular]	☐
10 day [P-50%]	☐	3 Business day - DTOX [E - 100%]	☐
5 day [E-100%]	☐		

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	GENERAL PARAMETERS	NUTRIENTS (P)	TOTAL METALS (P)	SAMPLES ON HOLD	SUSPECTED HAZARD (see Special Instructions)
	Beck Creek - Station 1	30-Oct-19	9:00	Water	3	R	R	R		
	Beck Creek - Station 2	30-Oct-19	9:00	Water	3	R	R	R		
	Beck Creek - Station 3	30-Oct-19	9:00	Water	3	R	R	R		
	Cottle Creek - Station 1	30-Oct-19	13:00	Water	3	R	R	R		
	Cottle Creek - Station 2	30-Oct-19	13:00	Water	3	R	R	R		
	Cottle Creek - Station 4	30-Oct-19	13:00	Water	3	R	R	R		
	Englishman River - Station 1	30-Oct-19	9:00	Water	3	R	R	R		
	Englishman River - Station 2	30-Oct-19	9:00	Water	3	R	R	R		
	Englishman River - Station 4	30-Oct-19	9:00	Water	3	R	R	R		
	Millstone River - Station 1	29-Oct-19	13:00	Water	3	R	R	R		
	Millstone River - Station 2	29-Oct-19	13:00	Water	3	R	R	R		
	Millstone River - Station 4	29-Oct-19	13:00	Water	3	R	R	R		

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☐ NO

Are samples for human consumption/ use? ☐ YES ☐ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

Detection limits: ammonia [MDL = 0.005 mg/L], nitrite [MDL = 0.001 mg/L], orthophosphate [MDL = 0.001 mg/L], total phosphorus [MDL = 0.002 mg/L], total nitrogen.

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 8.5, 9.3

FINAL COOLER TEMPERATURES °C:

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Eric Demers	Date: 30 Oct. 2019, 17:00	Time:	Received by: JW	Date: Oct.31/19	Time: 8:30 am	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION — WHITE - LABORATORY COPY — YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2374854-COFC

COC Number: 17 -

Page 1 of

Report To	Contact and company name below will appear on the final report
Company:	Vancouver Island University
Contact:	Eric Demers
Phone:	250-753-3245
	Company address below will appear on the final report
Street:	900 Fifth Street
City/Province:	Nanaimo, BC
Postal Code:	V9R 5S5
Invoice To	Same as Report To ☑ YES ☐ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	
Contact:	

Report Format / Distribution

Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax eric.demers@viu.ca

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax eric.demers@viu.ca

Email 2

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)

Standard TAT is 15 business days. DTOX analysis standard TAT is 5 business days

PRIORITY (Business Days)		DTOX Analysis (Business days)	
15 day [Regular]	☑	5 Business day - DTOX [R - Regular]	☐
10 day [P-50%]	☐	3 Business day - DTOX [E - 100%]	☐
5 day [E-100%]	☐		

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #: Environmental Monitoring Course

PO / AFE:

LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center:	PO#
Major/Minor Code:	Routing Code:
Requisitioner:	
Location:	

ALS Lab Work Order # (lab use only):

ALS Contact: Amber Springer | Sampler: Students

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	GENERAL PARAMETERS	NUTRIENTS (P)	TOTAL METALS (P)	SAMPLES ON HOLD	SUSPECTED HAZARD (see Special Instructions)
	Richards Creek - Station 1	28-Oct-19	13:00	Water	3	R	R	R		
	Richards Creek - Station 2	28-Oct-19	13:00	Water	3	R	R	R		
	Richards Creek - Station 3	28-Oct-19	13:00	Water	3	R	R	R		

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☐ NO

Are samples for human consumption/ use? ☐ YES ☐ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

Detection limits: ammonia [MDL = 0.005 mg/L], nitrite [MDL = 0.001 mg/L], orthophosphate [MDL = 0.001 mg/L], total phosphorus [MDL = 0.002 mg/L], total nitrogen.

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 8.5 9.3

FINAL COOLER TEMPERATURES °C:

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Eric Demers	Date: 30 Oct. 2019, 17:00	Time:	Received by: JW	Date: Oct 31/19	Time: 830am	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Chain of Custody from Second Sampling Event:

Sample Receipt Confirmation

Page 1 of 3
23-NOV-19 16:12 (MT)

Report Distribution:

Company Name: Vancouver Island University
Contact: Eric Demers
Address: Nanaimo Campus, 900 Fifth Street
Nanaimo, BC, V9R 5S5
Phone: 250-753-3245
Fax: 250-740-6482
Email: eric.demers@viu.ca
EDD Email: --
Distribution: Hard Copy: N Email: Y Fax: N EDD: N

Invoice Distribution:

Acct Name: Vancouver Island University
Contact: Accounts Payable
Address: Nanaimo Campus, 900 Fifth Street
Nanaimo, BC, V9R 5S5
Phone: --
Fax: --
Invoice Email: eric.demers@viu.ca
Project #: N/A
Account #: MAL100

Client Information:

Job Reference #: ENVIRONMENTAL MONITORING COURSE
Project PO #:
Legal Site Description: N/A
Quote #: N/A
Date Sampled: 18-NOV-19
Date Received: 21-NOV-19
Sampled By: Students
Chain Of Custody: --

Workorder Summary:

Lab Work Order #: **L2386179**
Estimated completion date: 28-NOV-19
15 Samples received at ALS in **VANCOUVER**
Client Job #: ENVIRONMENTAL MONITORING COUR
Account Manager: Amber Springer, B.Sc
Estimated sample disposal date: See Sample Disposal Information section below.

Lab Sample ID	Client Sample ID	Date Sampled	Date Received	Sample Due Date	Priority Flag	Sample Type
L2386179-1	BECK CREEK - STATION 1	20-NOV-19 09:00	21-NOV-19 12:00	28-NOV-19		Water
L2386179-2	BECK CREEK - STATION 2	20-NOV-19 09:00	21-NOV-19 12:00	28-NOV-19		Water
L2386179-3	BECK CREEK - STATION 3	20-NOV-19 09:00	21-NOV-19 12:00	28-NOV-19		Water
L2386179-4	COTTLE CREEK - STATION 1	20-NOV-19 13:00	21-NOV-19 12:00	28-NOV-19		Water
L2386179-5	COTTLE CREEK - STATION 2	20-NOV-19 13:00	21-NOV-19 12:00	28-NOV-19		Water
L2386179-6	COTTLE CREEK - STATION 4	20-NOV-19 13:00	21-NOV-19 12:00	28-NOV-19		Water
L2386179-7	ENGLISHMAN RIVER - STATION 1	20-NOV-19 09:00	21-NOV-19 12:00	28-NOV-19		Water
L2386179-8	ENGLISHMAN RIVER - STATION 2	20-NOV-19 09:00	21-NOV-19 12:00	28-NOV-19		Water
L2386179-9	ENGLISHMAN RIVER - STATION 4	20-NOV-19 09:00	21-NOV-19 12:00	28-NOV-19		Water
L2386179-10	MILESTONE RIVER - STATION 1	19-NOV-19 13:00	21-NOV-19 12:00	28-NOV-19		Water
L2386179-11	MILESTONE RIVER - STATION 2	19-NOV-19 13:00	21-NOV-19 12:00	28-NOV-19		Water
L2386179-12	MILESTONE RIVER - STATION 4	19-NOV-19 13:00	21-NOV-19 12:00	28-NOV-19		Water
L2386179-13	RICHARDS CREEK - STATION 1	18-NOV-19 13:00	21-NOV-19 12:00	28-NOV-19		Water
L2386179-14	RICHARDS CREEK - STATION 3	18-NOV-19 13:00	21-NOV-19 12:00	28-NOV-19		Water
L2386179-15	RICHARDS CREEK - STATION 4	18-NOV-19 13:00	21-NOV-19 12:00	28-NOV-19		Water

Analysis Requested :

	Conductivity [Automated]	Conductivity Screen [Internal Use Only]	Hardness	Total Metals in Water by ICPOES	Total Nitrogen in water by Colour	Ammonia in Water by Fluorescence	Nitrite in Water by IC [Low Level]	Nitrate in Water by IC [Low Level]	Total P in Water by Colour	pH by Meter [Automated]	Diss. Orthophosphate in Water by Colour	Sample Handling and Disposal Fee
BECK CREEK - STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
BECK CREEK - STATION 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
BECK CREEK - STATION 3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
COTTLE CREEK - STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
COTTLE CREEK - STATION 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
COTTLE CREEK - STATION 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ENGLISHMAN RIVER - STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ENGLISHMAN RIVER - STATION 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ENGLISHMAN RIVER - STATION 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MILESTONE RIVER - STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MILESTONE RIVER - STATION 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MILESTONE RIVER - STATION 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
RICHARDS CREEK - STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
RICHARDS CREEK - STATION 3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
RICHARDS CREEK - STATION 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Hold Time Exceedences:

The following samples have exceeded recommended holding times prior to sample receipt.

Analysis Requested	Lab Sample ID	Recommended Hold Time	Date Sampled	Date Received
pH by Meter (Automated)	L2386179-13, 13, 14, 14, 15, 15	0.25 hours	18-NOV-19	21-NOV-19
pH by Meter (Automated)	L2386179-10, 10, 11, 11, 12, 12	0.25 hours	19-NOV-19	21-NOV-19
pH by Meter (Automated)	L2386179-1, 1, 2, 2, 3, 3, 4, 4, 5, 5, 6, 6, 7, 7, 8, 8, 9, 9	0.25 hours	20-NOV-19	21-NOV-19

Sample Integrity Observations: No observations were identified for this work order submission.

Sample Disposal Information:

Where possible, ALS will store samples for the following durations, measured from date of sample submission: 45 days for Soil and Water samples; 6 months for Tissue/Biota samples; 14 days for air samples collected on re-usable media; and 3 days for water samples submitted for microbiological testing. Longer storage times are available upon request.

For information about ALS accreditations and certifications please contact your Account Manager or visit our webpage at www.alsglobal.com (see Canada downloads).

ALS Group strives to deliver on-time results to our clients at all times. However, there are times when due to capacity issues or other unforeseen circumstances we are unable to meet our expected turnaround times. The information above is related to a recent workorder you have submitted to our laboratory. In the event that you have an inquiry, please refer to the Lab Work Order # when calling your Account Manager.

ALS Group appreciates your business. Thank you for the opportunity to work with you.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L2386179-COFC

COC Number: 17 -

Page 1 of 2

Report To	Contact and company name below will appear on the final report	Report Format / Distribution	
Company:	Vancouver Island University	Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)	
Contact:	Eric Demers	Quality Control (QC) Report with Report ☑ YES ☐ NO	
Phone:	250-753-3245	☐ Compare Results to Criteria on Report - provide details below if box checked	
	Company address below will appear on the final report	Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	
Street:	900 Fifth Street	Email 1 or Fax eric.demers@viu.ca	
City/Province:	Nanaimo, BC	Email 2	
Postal Code:	V9R 5S5	Email 3	
Invoice To	Same as Report To ☑ YES ☐ NO	Invoice Distribution	
	Copy of Invoice with Report ☐ YES ☑ NO	Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	
Company:		Email 1 or Fax eric.demers@viu.ca	
Contact:		Email 2	
	Project Information	Oil and Gas Required Fields (client use)	
ALS Account # / Quote #:		AFE/Cost Center:	PO#
Job #:	Environmental Monitoring Course	Major/Minor Code:	Routing Code:
PO / AFE:		Requisitioner:	
LSD:		Location:	
ALS Lab Work Order # (lab use only):		ALS Contact: Amber Springer	Sampler: Students

...low - Contact your AM to confirm all E&P TATs (surcharges may apply)

Standard TAT is 15 business days. DTOX analysis standard TAT is 5 business days

PRIORITY (Business Days)		DTOX Analysis (Business days)	
15 day [Regular]	☑	5 Business day - DTOX [R - Regular]	☐
10 day [P-50%]	☐	3 Business day - DTOX [E - 100%]	☐
5 day [E-100%]	☐		

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	GENERAL PARAMETERS	NUTRIENTS (P)	TOTAL METALS (P)	SAMPLES ON HOLD	SUSPECTED HAZARD (see Special Instructions)
	Beck Creek - Station 1	20-Nov-19	9:00	Water	3	R	R	R		
	Beck Creek - Station 2	20-Nov-19	9:00	Water	3	R	R	R		
	Beck Creek - Station 3	20-Nov-19	9:00	Water	3	R	R	R		
	Cottle Creek - Station 1	20-Nov-19	13:00	Water	3	R	R	R		
	Cottle Creek - Station 2	20-Nov-19	13:00	Water	3	R	R	R		
	Cottle Creek - Station 4	20-Nov-19	13:00	Water	3	R	R	R		
	Englishman River - Station 1	20-Nov-19	9:00	Water	3	R	R	R		
	Englishman River - Station 2	20-Nov-19	9:00	Water	3	R	R	R		
	Englishman River - Station 4	20-Nov-19	9:00	Water	3	R	R	R		
	Millstone River - Station 1	19-Nov-19	13:00	Water	3	R	R	R		
	Millstone River - Station 2	19-Nov-19	13:00	Water	3	R	R	R		
	Millstone River - Station 4	19-Nov-19	13:00	Water	3	R	R	R		

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☐ NO

Are samples for human consumption/ use? ☐ YES ☐ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

Detection limits: ammonia [MDL = 0.005 mg/L], nitrite [MDL = 0.001 mg/L], orthophosphate [MDL = 0.001 mg/L], total phosphorus [MDL = 0.002 mg/L], total nitrogen.

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C | FINAL COOLER TEMPERATURES °C: 9.0

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Eric Demers	Date: 20 Nov. 2019, 17:00	Time:	Received by:	Date:	Time:	Received by: Th	Date: 21 Nov 19	Time: 12:00 PM

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION — WHITE - LABORATORY COPY — YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form
Canada Toll Free: 1 800 668 9878

L2386179-COFC

COC Number: 17 -
Page 2 of 2

Report To	Contact and company name below will appear on the final report
Company:	Vancouver Island University
Contact:	Eric Demers
Phone:	250-753-3245
	Company address below will appear on the final report
Street:	900 Fifth Street
City/Province:	Nanaimo, BC
Postal Code:	V9R 5S5
Invoice To	Same as Report To ☑ YES ☐ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	
Contact:	

Report Format / Distribution
Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax eric.demers@viu.ca
Email 2
Email 3

Invoice Distribution
Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax eric.demers@viu.ca
Email 2

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)
Standard TAT is 15 business days. DTOX analysis standard TAT is 5 business days

PRIORITY (Business Days)		DTOX Analysis (Business days)	
15 day [Regular]	☑	5 Business day - DTOX [R - Regular]	☐
10 day [P-50%]	☐	3 Business day - DTOX [E - 100%]	☐
5 day [E-100%]	☐		

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm
For tests that can not be performed according to the service level selected, you will be contacted.

Project Information
ALS Account # / Quote #:
Job #: Environmental Monitoring Course
PO / AFE:
LSD:

Oil and Gas Required Fields (client use)
AFE/Cost Center: PO#
Major/Minor Code: Routing Code:
Requisitioner:
Location:

ALS Lab Work Order # (lab use only):
ALS Contact: Amber Springer Sampler: Students

Analysis Request
Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	GENERAL PARAMETERS	NUTRIENTS (P)	TOTAL METALS (P)	SAMPLES ON HOLD	SUSPECTED HAZARD (see Special Instructions)
	Richards Creek - Station 1	18-Nov-19	13:00	Water	3	R	R	R		
	Richards Creek - Station 3	18-Nov-19	13:00	Water	3	R	R	R		
	Richards Creek - Station 4	18-Nov-19	13:00	Water	3	R	R	R		

Drinking Water (DW) Samples[1] (client use)
Are samples taken from a Regulated DW System? ☐ YES ☐ NO
Are samples for human consumption/ use? ☐ YES ☐ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)
Detection limits: ammonia [MDL = 0.005 mg/L], nitrite [MDL = 0.001 mg/L], orthophosphate [MDL = 0.001 mg/L], total phosphorus [MDL = 0.002 mg/L], total nitrogen.

SAMPLE CONDITION AS RECEIVED (lab use only)
Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐
INITIAL COOLER TEMPERATURES °C
FINAL COOLER TEMPERATURES °C: 9°C

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Eric Demers	Date: 20 Nov. 2019, 17:00	Time:	Received by:	Date:	Time:	Received by: Th	Date: 21 Nov 19	Time: 12:00 PM

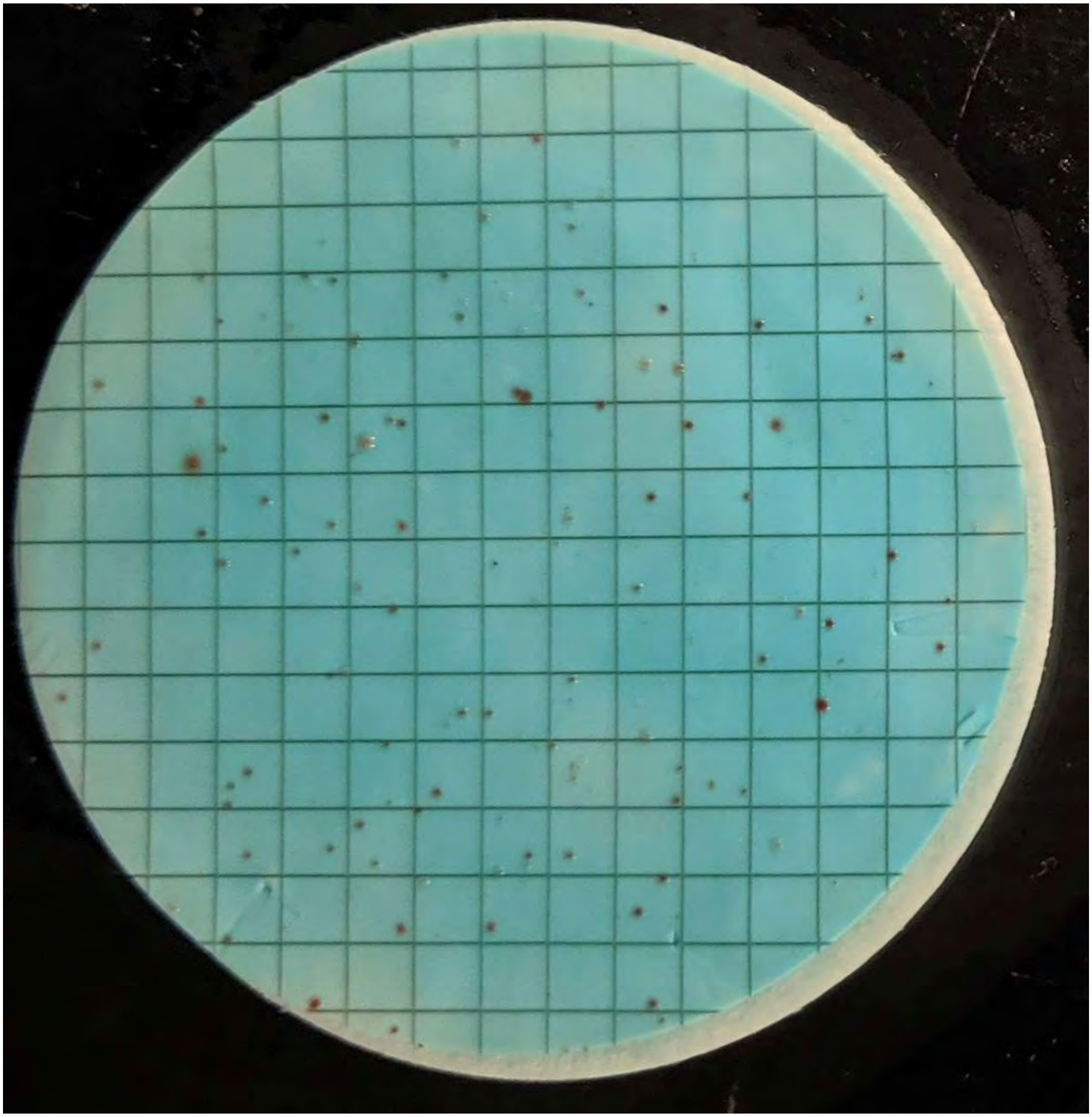
REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION — WHITE - LABORATORY COPY — YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

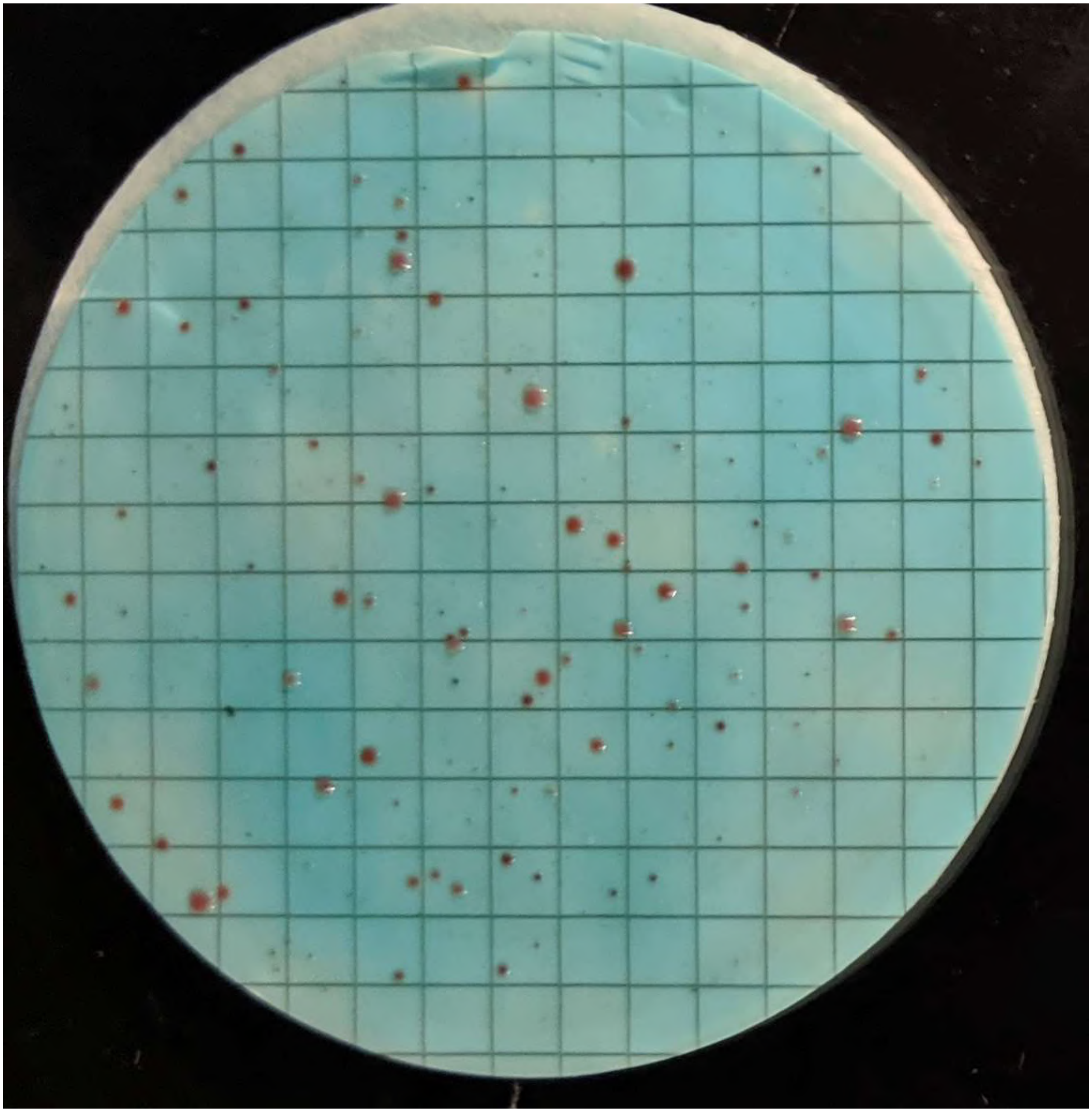
1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Appendix D – Microbiological Coliform Plates

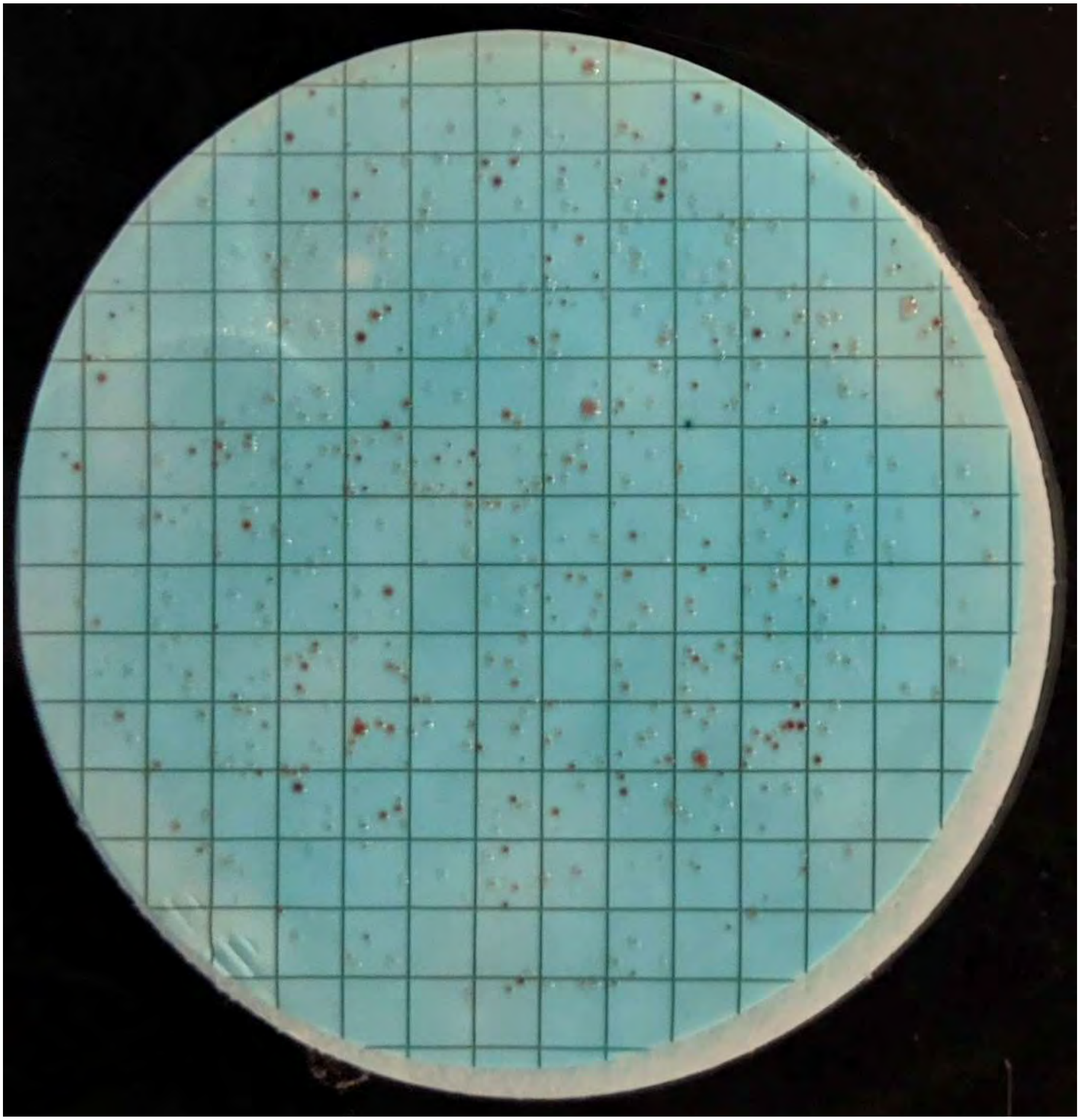
Site 1:



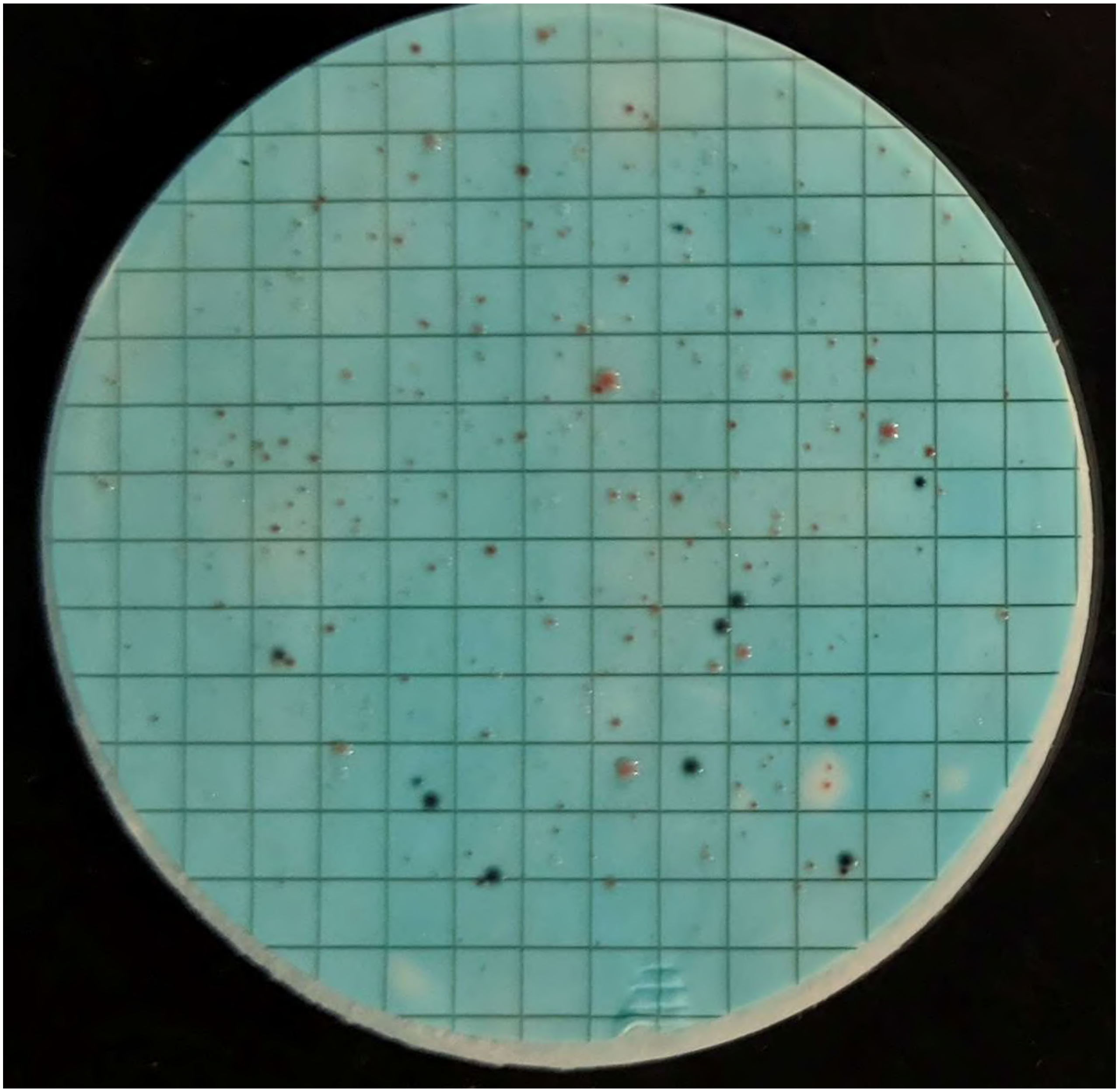
Site 2:



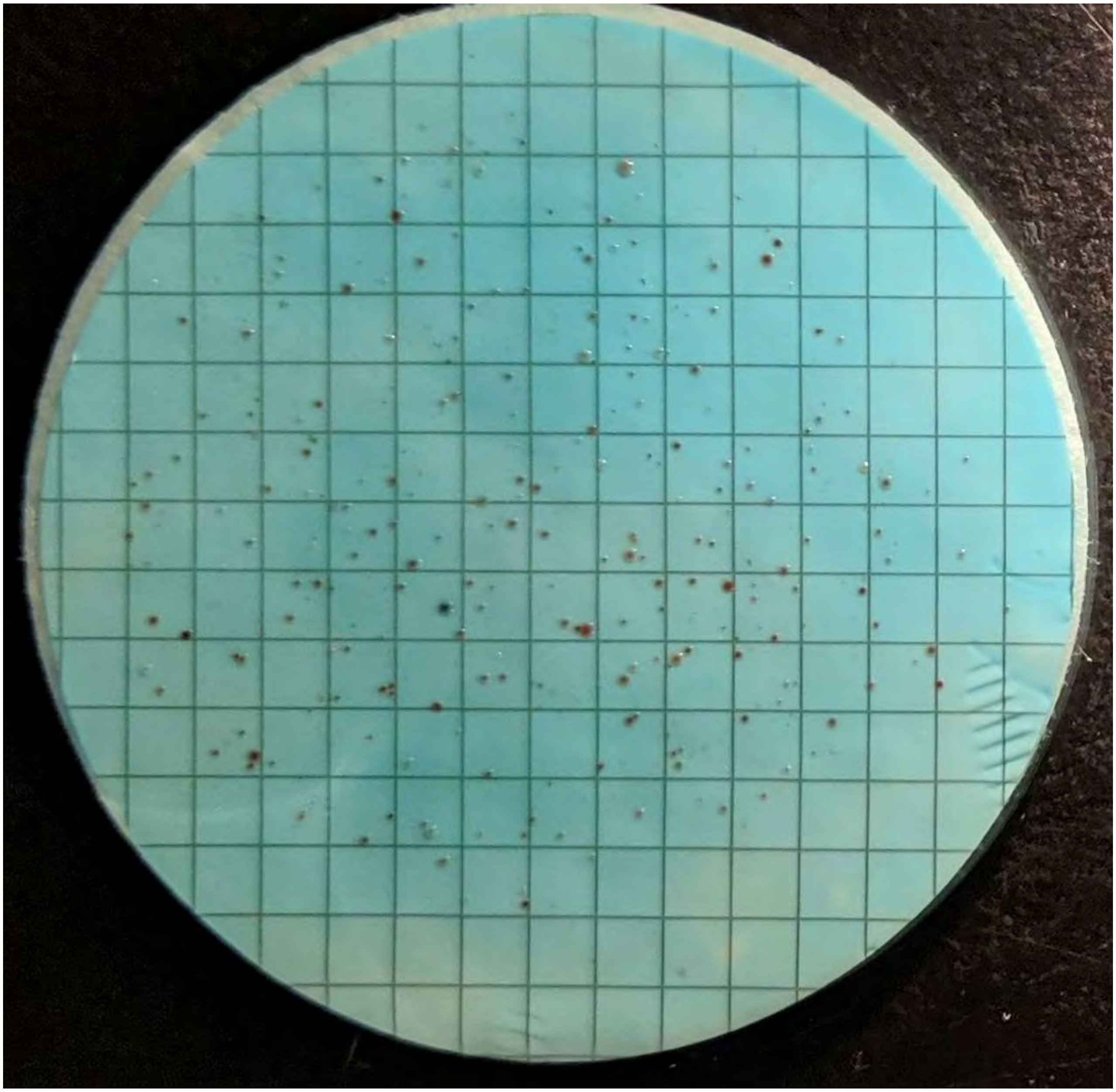
Site 3:



Site 4:



Replicate (Site 1):



INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Cottle Creek		Date: 10/30/19	
Station Name: Station 1		Flow status: Low	
Sampler Used: Hess Sampler	Number of replicates: 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates: 0.27 m^2	

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1 Pollution Intolerant	Caddisfly Larva (EPT)		
	Mayfly Nymph (EPT)	3	1
	Stonefly Nymph (EPT)	14	3
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		17	4
Category 2 Somewhat Pollution Tolerant	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	7	3
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)		
	Watersnipe Larva		
Sub-Total		7	3
Category 3 Pollution Tolerant	Aquatic Worm (oligochaete)	4	2
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	1	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		5	3
TOTAL		29	10

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: **29**

DENSITY: Invertebrate density per total area sampled:

29 ÷ 0.27 (From page 1) m^2 = **107.407** / m^2

PREDOMINANT TAXON: Invertebrate group with the highest number counted (in Col. C): **Stonefly Nymph**

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x 4 + 2 x 3 + 3 = **21**

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

0 + 1 + 3 = **4**

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

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

(EPT1 + EPT2 + EPT3) / CT

(0 + 3 + 14) / 29 = **0.586**

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** (S1) divided by CT.

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

Col. C for S1 / CT

14 / 29 = **0.482**

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S2, S3, S4, S5), then calculate the average.

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

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

Average Rating (Average of R1, R2, R3, R4): **2.75**

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: **Cottle Creek**		Date: **10/30/19**	
Station Name: **Station 2**		Flow status: **Low**	
Sampler Used: **Hess Sampler**	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.27 m^2	

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)		
	Mayfly Nymph (EPT)		
	Stonefly Nymph (EPT)		
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		0	0
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel	8	1
	Cranefly Larva	1	1
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva	1	1
	Fishfly Larva		
	Amphipod (freshwater shrimp)	2	1
	Watersnipe Larva		
Sub-Total		12	4
Category 3	Aquatic Worm (oligochaete)	8	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
Pollution Tolerant	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		8	1
TOTAL		20	5

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: **20**

DENSITY: Invertebrate density per total area sampled:

20 ÷ 0.27 (From page 1) m^2 = 74.074 / m^2

PREDOMINANT TAXON: Invertebrate group with the highest number counted (in Col. C): **Aquatic Clams/Worms**

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x 0 + 2 x 4 + 4 = **9**

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

0 + 0 + 0 = **0**

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

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

(EPT1 + EPT2 + EPT3) / CT

(0 + 0 + 0) / 20 = **0.000**

SECTION 3 - DIVERSITY

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

PREDOMINANT TAXON RATIO INDEX: Number of invertebrate in the **predominant taxon** (S1) divided by CT.

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

Col. C for S1 / CT

8 / 20 = **0.4**

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S2, S3, S4, S5), then calculate the average.

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

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

Average Rating

Average of R1, R2, R3, R4

1.50

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Cottle Creek		Date: 10/30/19	
Station Name: Station 4		Flow status: Low	
Sampler Used: Hess Sampler	Number of replicates: 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates: 0.27 m^2	

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)		
	Mayfly Nymph (EPT)	15	3
	Stonefly Nymph (EPT)		
Pollution Intolerant	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		15	3
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
Somewhat Pollution Tolerant	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	17	1
	Watersnipe Larva		
Sub-Total		17	1
Category 3	Aquatic Worm (oligochaete)	20	3
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	3	1
Pollution Tolerant	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		23	4
TOTAL		55	8

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 55

DENSITY: Invertebrate density per total area sampled:

55 ÷ 0.27 m^2 (From page 1) = 203.704 / m^2

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

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x 3 + 2 x 1 + 4 = 15

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

0 + 3 + 0 = 3

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

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

(EPT1 + EPT2 + EPT3) / CT

(0 + 15 + 0) / 55 = 0.272

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** (S1) divided by CT.

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

Col. C for S1 / CT

20 / 55 = 0.36

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S2, S3, S4, S5), then calculate the average.

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

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

Average Rating

Average of R1, R2, R3, R4

2.25

Appendix F – Site Hazard Assessment

Team safety was always a top priority when out in the field. Whether it was traveling to sample sites, collecting samples or analysing results, safety procedures were implemented. These safety procedures/considerations included:

- At least one team member carried a cell phone
- At least one team member carried a GPS device
- Sign in/out with project coordinator Dr. Eric Demers (VIU)
- All team members had first aid training
- At least one first aid kit was on scene
- Team safety and activity briefings took place prior to site visits
- All team members wore appropriate clothing/gear

Sample sites 1-4 along Cottle Creek each exhibited specific site hazards that needed to be considered by the team when in the field. These hazards ranged in nature from busy vehicle traffic to steep or slippery access points and are summarized in the table below:

Site Specific Safety Hazards

	Site Number			
	#1	**#2**	**#3**	**#4**
Access to Sampling Site on Cottle Creek	Accessed down embankment West (upstream) of Landalt Rd., South of Arrowsmith Rd.	Accessed off Rock City Road, 1km hike to the outflow of Cottle Lake.	Accessed down from bridge crossing on East (downstream) side of Nottingham Rd.	Accessed via East (downstream) side of Stephenson Rd, 10m from fire hydrant.

On-Site Specific Hazards	Slippery in-stream logs and leaves, alder snags, brambles. Minimal traffic.	Slippery bridge.	Deeper water, marsh/boggy terrain, minimal traffic.	Old fencing, boulders, thick tree branches, moderate traffic.
Site Access Hazards	Steep, slippery, brambles, leaf litter, moss.	Minimal grade, no apparent hazards.	Medium grade, large boulders, moss, alders, brambles.	Minimal grade, fir tree branches, a few boulders.
In-Stream Hazards	Minimal, a few logs	Minimal, no apparent hazards.	Slippery grasses, boggy terrain.	Poor, many slippery rocks, deep water hole out of culvert.
Cottle Creek Flow/Depth at Initial Visit	Slow flow Shallow depth	Moderate flow Shallow depth	Moderate flow Medium depth	Moderate flow Deep out of culvert, shallow towards falls.

The team also followed the Site Safety Plan as listed provided by Dr. Eric Demers. Following this plan and incorporating the information discussed above, effectively ensured that the team overcame the hazards presented helped to ensure that safety remained a top priority.

Appendix G – BC Water Quality Guidelines

BRITISH COLUMBIA WATER QUALITY GUIDELINES

This table contains the guidelines for interpreting water quality in British Columbia. The guidelines represent the *maximum* allowable concentrations. References are provided on the next page.

Parameter	Guideline (mg/L)	Note	Reference
pH	6.5 - 9.0		1
Dissolved Oxygen (DO)	≥5.0 ≥9.0	All life stages other than buried embryo / alevin Buried embryo / alevin life stages	1
Turbidity	Variable	Max. increase 5 NTU; if background 8-50 NTU Max. increase 10%; if background ≥50 NTU	1
Alkalinity	0 - 10 10 - 20 ≥20	High acid sensitivity Moderate acid sensitivity Low acid sensitivity	2
Hardness	<60 >120	Soft water Hard water	3
Ammonia (NH_3)	Variable 19.7	Varies with temperature and pH. See Tables in reference. At pH 7 and 15°C	1
Nitrite (NO_2^-)	0.06 0.12 0.18 0.24 0.30 0.60	Chloride <2 mg/L Chloride 2 - 4 mg/L Chloride 4 - 6 mg/L Chloride 6 - 8 mg/L Chloride 8 - 10 mg/L Chloride ≥10 mg/L	1
Nitrate (NO_3^-)	32.8		1
Total Phosphorus (P)	<0.010 0.010 - 0.025 ≥0.025	Oligotrophic Mesotrophic Eutrophic	3
Aluminum (Al)	0.1 Variable	When pH ≥ 6.5 When pH <6.5: 2.718 ^ [1.6 - 3.327 x (pH) + 0.402 x (pH)^2]	1
Antimony (Sb)	0.009		2
Arsenic (As)	0.005		1
Barium (Ba)	1		2
Beryllium (Be)	0.00013		2
Boron (B)	1.2		1
Cadmium (Cd)	Variable	{2.718 ^ [1.03 × ln(hardness) - 5.274]} / 1000	1
Calcium (Ca)	<4 4 - 8 ≥8	High acid sensitivity Moderate acid sensitivity Low acid sensitivity	2
Chromium (Cr)	0.001	For the more toxic Chromium VI	2
Cobalt (Co)	0.11		1
Copper (Cu)	0.003		1
Iron (Fe)	1		1
Lead (Pb)	Variable	{2.718 ^ [1.273 × ln(hardness) - 1.46]} / 1000	1
Lithium (Li)	0.75	For irrigation	2
Manganese (Mn)	Variable	0.01102 x (hardness) + 0.54	1
Molybdenum (Mo)	2		1
Nickel (Ni)	0.025 Variable	When hardness ≤60 mg/L When hardness = 60 - 180 mg/L: {2.718 ^ [0.76 x ln(hardness)+1.06]} / 1000	2
Selenium	0.002		1
Silver (Ag)	0.0001 0.003	When hardness <100 mg/L When hardness ≥100 mg/L	2
Thallium	0.0008		2
Tin	0.000022		2
Vanadium	0.05	Marine aquatic life	2
Zinc (Zn)	0.033 Variable	When hardness < 90 mg/L When hardness ≥ 90 mg/L: [0.75 x (hardness - 90) + 33] / 1000	1

Appendix H – Discharge Calculations

Discharge Measurements – 1st Event – October 30th, 2019

Site:	Depth Measurements (cm):	Average Depth Measurement (m):	Average Wetted Width (m):	Cross Sectional Area (m^2)	Time (s):	Average travel time/5m (s):	Velocity (m/s):	Discharge (m^3/s):
1	3,4,3,1,1,3,4,3	0.026	0.39	0.01	3.6,3.3,4.6,3.88,3.68	3.812	1.30	0.013
2	1,2,5,8,11,11,10,12,7,3	0.07	1.05	0.0735	6.89,6.75,7.50,6.57,6.85	6.912	0.72	0.053
3	10,25,10,24,20,20,21,15,25,10	0.18	0.45	0.081	8.73,9.34,9.06,8.27,7.74	8.628	0.60	0.049
4	3,5,6,6,7,7,6,6,5,3	0.50	1.39	0.695	7.77,8.02,7.41,7.74,8.24	7.836	0.64	0.046

Discharge Measurements – 2nd Event – November 20th, 2019

Site:	Depth Measurements (cm):	Average Depth Measurement (m):	Average Wetted Width (m):	Cross Sectional Area (m^2)	Time (s):	Average travel time/5 m (s):	Velocity (m/s):	Discharge (m^3/s):
1	1,3,4,5,6,6,5,4,3,1	0.038	0.55	0.0209	3.55,3.93,3.68,3.67,3.79	3.72	1.34	0.03
2	10,8,717,21,17,9,10,13,15,17	0.137	1.45	0.1987	5.1,4.7,4.72,4.79,4.93	4.85	1.03	0.20
3	12,24,30,42,28,20,18,22,5,8	0.21	2.50	0.5250	11.9,11.23,12.61,11.17,10.75	11.53	0.43	0.23
4	3,6,10,15,16,16,15,10,6,3	0.10	1.70	0.1700	4.02,3.68,4.00,4.08,4.34	4.02	1.24	0.21