Oliver Creek Watershed Assessment Report
2016

PREPARED BY:
Scott Drebit (GIS Technician/Planner)

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ACKNOWLEDGEMENTS

The Lakehead Region Conservation Authority would like to acknowledge the residents of the Oliver Creek watershed who allowed Lakehead Region Conservation Authority staff access to their property and who were eager to share valuable information about the condition and health of Oliver Creek.

The 2016 Oliver Creek Watershed Assessment was prepared by Scott Drebit, GIS Technician/Planner of the Lakehead Region Conservation Authority. Simon Shankie, Watershed Manager of the LRCA, also provided guidance, input and revisions towards the completion of this report. Gene Kent, Special Projects Coordinator of the LRCA, assisted with identification and sampling of the soils, and completed the section on Geology.

This report has been prepared in-house at the Lakehead Region Conservation Authority for internal purposes to document the condition of the Oliver Creek watershed in 2016.
EXECUTIVE SUMMARY

The Oliver Creek watershed is located within the Municipality of Neebing and Municipality of Oliver Paipoonge. The watershed covers a drainage area of approximately 47.8 square kilometres. Oliver Creek is approximately 29.9 kilometres in length and is a meandering creek, which travels from Oliver Lake into the Kaministiquia River. The gradient is steep in the upper reaches (within the first 2.0 kilometres) then the creek valley gradually widens until a flatter lowland area is reached. The general slope of the watershed is 0.78 percent.

The majority of the Oliver Creek watershed is privately owned land (84.8 percent) and the remainder is Crown land (15.2 percent). The watershed is mainly designated as either Rural or Agricultural land use by the Official Plans of the Municipality of Neebing and Municipality of Oliver Paipoonge.

The surficial geology distribution of the Oliver Creek watershed changes from bedrock (36.9 percent) in the headwaters area of Oliver Lake, to talus slopes (7.4 percent) on the edge of the highlands, with moraine (24.7 percent), glaciolacustrine plain (30.9 percent) immediately southeast of Highway 588 and alluvial (0.1 percent) at the confluence of Oliver Creek at the Kaministiquia River.

The bedrock formation is mostly composed of sedimentary rocks (56.8 percent), but there are also mafic and related intrusive rocks (43.2 percent).

The Oliver Creek watershed is composed of eight different soil types. The most abundant soil type is silt loam, which covers 15.9 square kilometres (35.1 percent) of the watershed. Moderately course sandy loam is the second most abundant, covering 15.7 square kilometres (34.5 percent) of the watershed. Rock is the third most abundant, covering 6.3 square kilometres (13.9 percent) of the watershed. The remaining soil is made up of clay, clay loam, fine sandy loam, silty clay loam and organic, which together cover 7.5 square kilometres (16.5 percent).

The Oliver Creek watershed is located within the boundaries of the Great Lakes and Boreal forest regions. The most common tree species in the watershed are white spruce, jack pine, black spruce, balsam poplar and trembling aspen. There are a variety of other plants present in the watershed including ferns, shrubs, herbs, mosses and lichens.

For this report, eight sample sites located within the Oliver Creek watershed were chosen based on a variety of attributes including: accessibility, physical features, land use designation, and proximity to man-made features that may alter water quality, as
well as headwaters used as a base reference. Site 1 was located near the confluence of the Oliver Creek at the Kaministiquia River. Sites 2, 4, 6 and 7 were located on the main channel. Sites 3 and 5 were located on different tributaries. Site 8 was located at Oliver Lake, the headwaters of the watershed.

At each of the eight sample locations, surface water samples and field measurements were collected on June 14 and July 14, 2016. Surface water samples were analyzed by ALS Laboratory Group for conductivity, total dissolved solids, turbidity, total ammonia, nitrate, nitrite, total phosphorus, Escherichia coli (E. coli), total coliforms and a full metal scan. Field measurements taken using a YSI Pro DSS Multi-Parameter Probe included: water temperature, pH, conductivity, turbidity, oxidation-reduction potential and dissolved oxygen. Field and laboratory results were compared to the Ministry of Environment and Climate Change’s Provincial Water Quality Objectives (PWQO), 1994 and the Canadian Water Quality Guidelines for the Protection of Aquatic Life: Summary Table, produced by the Canadian Council of Resources and Environmental Ministers (CCREM), updated 2012. Parameters that exceeded the PWQOs included: phosphorous, E. coli, total coliforms, aluminum and iron.

Phosphorus exceeded the PWQO criterion (0.03 mg/L) at Sites 1, 2 and 3. Phosphorus ranged from <0.003 mg/L (Site 8) to 0.24 mg/L (Site 3). The elevated levels of phosphorous may be due to high clay content in the creek, since phosphorus sorption capacity can increase with clay content.

PWQO criterion for E. coli bacteria levels below 100 counts per 100 mL of water are considered safe for swimming and bathing. During the June sampling period, Site 7 (108 counts/100 mL) exceeded the criterion. During the July sampling period, Site 3 (687 counts/100 mL) exceeded the criterion. It was noted at Site 7 that a beaver dam was present upstream and a farm was located upstream of Site 3; however, there were no exceedances of E.coli at the farthest downstream sample locations.

As there is no current PWQO for total coliforms, results were compared to the pre-1994 PWQO criterion (1,000 MPN/100 mL). Every site in 2016 for both sampling periods exceeded the criterion with the exception of Site 8. The total coliform concentrations in 2016 ranged from 53 MPN/100mL to >2,420 MPN/100 mL for the watershed.

The PWQO criterion for aluminum is 0.075 mg/L. During the June sampling period all sites were above the criterion except for Sites 7 and 8. During the July sampling period, all sites were above except for Site 8. Aluminum concentrations ranged from 0.016 mg/L (Site 8) to 0.331 mg/L (Site 6). These values are typically associated with fine sediments.

All sites were above the PWQO criterion of 0.30 mg/L for iron during both the sampling periods, with the exception of Site 8. Iron concentrations ranged from 0.028 mg/L (Site
8) to 1.510 mg/L (Site 5) for the watershed. Iron exceedances are common in the region, due to natural sources.

The flora and fauna inventory indicated that the Oliver Creek watershed supports a healthy population of diverse plants and animals. The stream banks were stable and showed little signs of erosion. The one bridge located on East Oliver Lake Road was in good and stable condition and all culverts were also in good condition. The culverts at Sites 2 and 3 (C2 and C3) should be monitored in the future as they appear to be deteriorating.

The Oliver Creek watershed was also assessed using the Guide to Developing Conservation Authority Watershed Report Cards, 2011. Using this guideline, surface water quality and forest conditions for the Oliver Creek watershed were used to determine a grade for the watershed. Surface water quality maintained a good rating with minimal exceedances of phosphorus and *E. coli* present within the Oliver Creek watershed. Forest condition scored a good rating with high forest coverage and a low percentage of riparian forest cover. Overall the quality of the Oliver Creek watershed in 2016 was determined to be in good health and graded a B based on the surface water quality and a B based on the forest condition.

At the time of sampling in 2016 the Oliver Creek watershed was considered to be in good health.

Upon completion of the 2016 Oliver Creek Watershed Assessment, the following recommendations have been made for consideration:

- Staff and funding permitting, it is recommended that an update to the 2016 Oliver Creek Watershed Assessment be completed in the next five to ten years.
- Benthic analysis indicates water quality over an extended period of time and should be considered for future watershed assessments.
- Additional sampling should be conducted in the spring to observe the water quality differences between high and low flow seasons.
- A copy of this report should be provided to the Municipality of Oliver Paipoonge and the Municipality of Neebing for reference purposes. The Report should be kept on file at the LRCA Administration Office for review by interested parties.
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1 INTRODUCTION

The Oliver Creek watershed is located within the Municipality of Neebing and the Municipality of Oliver Paipoonge as shown on Map M-1: Key Plan Map. Areas regulated by the Lakehead Region Conservation Authority (LRCA) and Municipal boundaries can be found on Map M-2: Regulated Areas.

A watershed can be defined as all the land and water within the confines of a drainage divide. In essence, the Oliver Creek watershed consists of all the surrounding land that naturally drains its streams, wetlands and precipitation runoff into the Kaministiquia River which then flows into Lake Superior.

The headwaters of the main branch is initiated by Oliver Lake, which is within the boundaries of the geographic Township of Scoble in the Municipality of Neebing. The watershed covers a drainage area of approximately 47.8 square kilometres. The prevailing soil type throughout the watershed is silty loam and sandy loam. Most of the watershed is dominated by white spruce, white birch, balsam poplar and trembling aspen. The Oliver Creek runs approximately 29.9 kilometres in length and meanders through poorly defined and flat drainage courses, to well defined valleys.

The goal of this report is to document the conditions of the watershed, especially surface water quality, as observed in June and July of 2016. This information will ultimately be used to develop and maintain programs to sustain a healthy ecosystem consistent with the Natural Hazards and Natural Heritage Policies of the Province of Ontario. The main objectives of this assessment report are to:

- Summarize the physical, biological and socio-economic attributes of the watershed;
- Collect surface water quality data;
- Collect field measurements;
- Conduct an inventory of the forest ecosystem and fauna observed within the watershed;
- Conduct an inventory of soil, streambed substrate and stream bank cover observed within the watershed;
- Document active erosion sites;
- Document the physical condition of all Oliver Creek water crossings (bridges/culverts); and
- Interpret results to record the health status of the watershed
2 BACKGROUND

2.1 Physical Attributes

2.1.1 Topography

Oliver Creek originates in the area southwest of Candy Mountain and Knob Hill. A large Logan diabase sill forms a mesa and topographic high stretching from Stanley Hill southwestward to Oliver Lake. Oliver Creek flows in a northerly direction, joining with the Kaministiquia River approximately 34.0 kilometres upstream from Lake Superior. The highest point in the watershed is approximately 502.7 metres above sea level north of Hunter Lane (308619 N, 5353148 E). The lowest point in elevation can be found near the confluence of the Kaministiquia River and Oliver Creek, at 206.3 metres above sea level (312670 N, 5359560 E). The general slope of the watershed is 0.78 percent. Although the Nor’Wester Mountains form the height of land along the western and southern extremes of the watershed, the northern part of the Oliver Creek watershed consists of a low relief glaciolacustrine lake plain composed of sandy loam deposits (LRCA, 2008). The transition area in between the outcrop ridge and sandy loam soils consists of moraine deposits. Map M-3 illustrates the Oliver Creek watershed topography.

2.1.2 Geology & Soils

2.1.2.1 Bedrock

The Oliver Creek Watershed begins in an area of high elevation bounded by the bedrock ridges of Candy Mountain and Knob Hill to the east. The southwest edge of the watershed has steep gradients and is bounded by mountains. Most of the watershed area is underlain by Paleo-Proterozoic rocks of the Animikie Group consisting of argillaceous shales of the Rove Formation as well as mudstone, greywacke, argillite and siltstone. These rocks are between 1,600 to 2,200 million years in age. The sedimentary rocks form lowland valleys in the northern portion of the watershed.

Logan Diabase Sills outcrops are found on the southwest side of the watershed. The diabase rocks are about 1,100 million years old, and are both the youngest and hardest (erosion resistant) rocks in the area. These diabase sills form flat top mountains called mesas. The diabase rock, which forms the mesas, were intruded as flat lying magma in between layers of sedimentary rock. The overlying sediments have eroded away over the last billion years leaving the igneous rock exposed along the tops of the mesas. The hard diabase sills form steep talus slopes where erosion has occurred along the edge of the mountains. A broken area of shale regolith can be seen at the base of some of the
mesas; this may form the bedrock interface throughout the watershed. The shale rock and regolith layers are permeable; this means that bedrock source water wells in the area could be affected by groundwater runoff infiltrating into the rock. Figure 1: Rock Formations South of Thunder Bay shows a cross-section of the rock formations which has led to the development of the mesas and valleys in the area south of Thunder Bay. Map M-4 illustrates the Oliver Creek watershed bedrock geology.

2.1.2.2 Surficial Geology & Soils

Most of the underlying sedimentary bedrock in the Oliver Creek Watershed is deeply eroded; the visible geology consists of Holocene Age sediments. The substrates or sediments were laid down as glacial outwash and lake bottom deposits called glaciolacustrine horizons. Map M-5: Surficial Geology is based on the Northern Ontario Engineering Geology Terrain Study (NOEGTS); it details the main types overburden as well as their glacial/fluvial origins. The distribution of surficial layers changes from bedrock (36.9 percent) in the headwaters area of Oliver Creek, to talus slopes (7.4 percent) on the edge of the highlands, with moraine (24.7 percent), glaciolacustrine plain (30.9 percent) immediately southeast of Highway 588 and alluvial (0.1 percent) at the confluence of Oliver Creek at the Kaministiquia River.

The majority of the sediments and soils have been deposited by Oliver Creek and by historical flooding of the area by Glacial Lake Kaministiquia and Glacial Lake Minong. During the time period of 8,000 to 10,000 years ago, thick beds of silt, sand and loam material were deposited on the glacial lake bottom. These lacustrine soils now form the lowlands of the watershed.

Soil logging in this Watershed Assessment Report was completed to test the extent of the NOEGTS soil types; the soil logging was completed using criteria derived from the “Field Guide to the Substrates of Ontario” (MNRF, March 2015). Soil samples were taken and logged using a 1.2 metre soil auger. The depth of the organic layer as well as the depth, composition and characteristics of the A, B and C soil horizons were logged at the eight water sampling sites along Oliver Creek. Map M-6: Soils illustrates the location of the eight soil sampling sites. The majority of soils consist of silty loam with areas of moderately fine loam and minor occurrences of silty clay loam at sites 4 and 5. The provincial layer indicates clay soils in the northern portion of the watershed. Clay soils were not encountered at any of the auger sites 1 to 4; this suggests there may be inconsistencies in the provincial layer.

The soil testing results and photographs of each soil profile are shown in Appendix A: Soil Logging Summary and Photography. The soils do not have a well developed organic layer in the Oliver Creek Watershed. Sites 5 and 6 had a thin organic horizon.
averages five to ten centimetres in thickness close to the creek. The “A” horizon soils are generally less than 1 metre in thickness and often transition directly to the “C” horizon, which represents the mineral soils from the last glacial period. Site 1 shows a substrate of a typical moraine. The high percentage of cobbles and sand is typical of ground moraine with some reworking by fluvial processes.

The silty loam and sandy loam underlying the majority of the watershed shown on Map M-6: Soils is a fair characterization of the watershed and has been confirmed by the sampling program.

2.1.3 Climate

The climate of the Oliver Creek watershed is similar to the Thunder Bay region, in that it is a modified continental climate influenced by Lake Superior. From the months of July to March the westerly winds prevail, whereas the easterly winds prevail the remainder of the year (LRCA, 1985). These winds modify the climate of Thunder Bay and the surrounding regions. The mean daily temperatures (degrees Celsius) and precipitation levels (millimetres) were recorded at the Thunder Bay Airport from 1971 to 2000 (Environment Canada, 2016) as shown in Table 2.1-1. This table also summarizes the extreme daily precipitation in millimetres recorded within a 24-hour period and the date it occurred.

Table 2.1-1: Average Monthly Temperature and Precipitation for Thunder Bay, 1971-2000

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily (degrees Celsius)</td>
<td>-14.8</td>
<td>-12</td>
<td>-5.5</td>
<td>2.9</td>
<td>9.5</td>
<td>14</td>
<td>17.6</td>
<td>16.6</td>
<td>11</td>
<td>5</td>
<td>-3</td>
<td>-11.6</td>
</tr>
</tbody>
</table>

| Precipitation | Total Precipitation (millimetres) | 31.3 | 24.9 | 41.6 | 41.5 | 66.5 | 85.7 | 89 | 87.5 | 88 | 62.6 | 55.6 | 37.5 |
| Extreme Max. Daily Precipitation (millimetres) | 51.6 | 33.5 | 41.9 | 69.3 | 76.2 | 49.3 | 53.8 | 87.1 | 131.2 | 47.8 | 63 | 42.7 |

The average monthly temperatures (degrees Celsius) and precipitation levels (millimetres) were recorded at the Thunder Bay Airport for 2016 (Environment Canada, 2016), as shown below.
Table 2.1-2: Average Monthly Temperature and Precipitation for Thunder Bay, January-July 2016

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>July</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Temperature</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily (degrees Celsius)</td>
<td>-10.6</td>
<td>-11.0</td>
<td>-3.0</td>
<td>1.1</td>
<td>10.1</td>
<td>14.5</td>
<td>18.6</td>
</tr>
<tr>
<td><strong>Precipitation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Precipitation (millimetres)</td>
<td>35.2</td>
<td>41.1</td>
<td>37.9</td>
<td>21.8</td>
<td>51.5</td>
<td>212.7</td>
<td>70.7</td>
</tr>
</tbody>
</table>

The average monthly temperature for the June and July sampling periods was 16.6 degrees Celsius and the average monthly precipitation was 141.7 millimetres. In comparison with the historical data, the 2016 temperature was within 0.8 degrees Celsius of the average for June and July. The 2016 precipitation for June was 127 millimetres higher than the historical average precipitation. The precipitation for July 2015 was 18.3 millimetres less than recorded historical average precipitation. In general, temperatures in June and July were very near normal while received precipitation for June was above average and July was below average.

2.1.4 Hydrology

The Oliver Creek is 29.9 kilometres in length and the watershed covers an area of approximately 47.8 square kilometres, and flows in a general northeasterly direction to its confluence with the Kaministiquia River, approximately 34 kilometres upstream from Lake Superior. The surface water drainage area has been estimated at 2.5 square kilometres and a wetland area of 2.5 square kilometres. There are no provincially significant wetlands within the watershed.

2.2 Biological Attributes

2.2.1 Flora

The Oliver Creek watershed is located within the boundaries of the Great Lakes forest region and the Boreal forest region as shown on the Canada’s Forest Regions map (Figure 2). The trees, which comprise the Great Lakes forest region, are primarily white pine, red pine and yellow birch. Although the watershed is geographically located in this forest region, the tree species observed are more indicative of a Boreal forest region, as the trees present are predominantly black spruce, jack pine, white birch and trembling aspen. This discrepancy is likely due to the fact that the watershed is relatively close to the Boreal forest region and mechanisms such as local climate (slope, aspect), site condition (soil characteristics), disturbance regimes and species interaction can affect the species distribution in the area. The coarse scale of the Canada’s Forest Regions distribution map is only a basic division of the forest types; there is no discrete line that separates the two zones. Factors such as the ones mentioned above could easily alter forest types, which are located between two zones.
There are a variety of other plant species present in the Oliver Creek watershed including ferns, shrubs, herbs, mosses and lichens. Plant species identified at the sample sites are listed in Appendix B: Common and Scientific Names of Identified Flora and Fauna.

### 2.2.2 Fauna

The Oliver Creek watershed provides breeding grounds for a variety of wildlife. Species of amphibians, reptiles, and butterflies that have been sighted in the watershed and surrounding area historically and recently are listed below in Table 2.2-1. There is also a complete list of the wildlife observed in the watershed in Appendix B: Common and Scientific Names of Identified Flora and Fauna. The Oliver Creek watershed is part of the Ontario Ministry of Natural Resources and Forestry (OMNRF) Wildlife Management Unit 13 and Fisheries Management Zone 6.

<table>
<thead>
<tr>
<th>Table 2.2-1 : Common Reptiles, Amphibians, and Butterflies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species Name</td>
</tr>
<tr>
<td>-----------------------</td>
</tr>
<tr>
<td><strong>Amphibians and Reptiles</strong></td>
</tr>
<tr>
<td>Blue-Spotted Salamander</td>
</tr>
<tr>
<td>Jefferson Salamander</td>
</tr>
<tr>
<td>Snapping Turtle</td>
</tr>
<tr>
<td>Western Painted Turtle</td>
</tr>
<tr>
<td>Eastern Garter Snake</td>
</tr>
<tr>
<td>Eastern Newt</td>
</tr>
<tr>
<td>Mudpuppy</td>
</tr>
<tr>
<td>American Toad</td>
</tr>
<tr>
<td>Boreal Chorus Frog</td>
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<tr>
<td>Gray Tree Frog</td>
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<tr>
<td>Northern Leopard Frog</td>
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<td>Spring Peeper</td>
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<tr>
<td>Wood Frog</td>
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<tr>
<td><strong>Butterflies</strong></td>
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<tr>
<td>Juvenile’s Duskywing</td>
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<td>European Skipper</td>
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<td>Long Dash Skipper</td>
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<td>Canadian Tiger Swallowtail</td>
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<td>Mustard White</td>
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<td>Cabbage White</td>
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<td>Clouded Sulphur</td>
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<tr>
<td>Atlantis Fritillary</td>
</tr>
<tr>
<td>Northern Crescent</td>
</tr>
</tbody>
</table>
Table 2.2-1: Common Reptiles, Amphibians, and Butterflies

<table>
<thead>
<tr>
<th>Species Name</th>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satyr Comma</td>
<td>Polygonia satyrus</td>
<td></td>
</tr>
<tr>
<td>Mourning Cloak</td>
<td>Nymphalis antiopa</td>
<td></td>
</tr>
<tr>
<td>Milbert’s Tortoiseshell</td>
<td>Algais milberti</td>
<td></td>
</tr>
<tr>
<td>American Lady</td>
<td>Vanessa virginiensis</td>
<td></td>
</tr>
<tr>
<td>Painted Lady</td>
<td>Vanessa cardui</td>
<td></td>
</tr>
<tr>
<td>Red Admiral</td>
<td>Vanessa atalanta</td>
<td></td>
</tr>
<tr>
<td>White Admiral</td>
<td>Limenitis arthemis</td>
<td></td>
</tr>
<tr>
<td>Northern Pearly-Eye</td>
<td>Lethe anthedon</td>
<td></td>
</tr>
<tr>
<td>Common Wood-Nymph</td>
<td>Cercyonis pegala</td>
<td></td>
</tr>
<tr>
<td>Monarch</td>
<td>Danaus plexippus</td>
<td></td>
</tr>
</tbody>
</table>


2.2.3 Species at Risk

Ontario has more than 200 species at risk living in its forests and lakes, all at varying degrees of risk. There are approximately 19 species at risk in the Thunder Bay region that have potential to exist within the Oliver Creek watershed. The surrounding area is considered in addition to the watershed boundary limits, as it is also Boreal forest region, which would allow for movement of individuals in and out of the watershed boundary. Below is a table showing the species at risk in the Thunder Bay region.

Table 2.2-2: Species at Risk

<table>
<thead>
<tr>
<th>Species Name</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Status of Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>American White Pelican</td>
<td>Pelecanus erythrorhynchos</td>
<td></td>
<td>Threatened</td>
</tr>
<tr>
<td>Bald Eagle</td>
<td>Haliaeetus leucocephalus</td>
<td></td>
<td>Special Concern</td>
</tr>
<tr>
<td>Barn Swallow</td>
<td>Hirundo rustica</td>
<td></td>
<td>Threatened</td>
</tr>
<tr>
<td>Black Tern</td>
<td>Chlidonias niger</td>
<td></td>
<td>Special Concern</td>
</tr>
<tr>
<td>Bobolink</td>
<td>Dolichonyx ozyvorus</td>
<td></td>
<td>Threatened</td>
</tr>
<tr>
<td>Eastern Whip-poor-will</td>
<td>Antrostomas vociferus</td>
<td></td>
<td>Threatened</td>
</tr>
<tr>
<td>Golden Eagle</td>
<td>Aquila chrysaetos</td>
<td></td>
<td>Endangered</td>
</tr>
<tr>
<td>Least Bittern</td>
<td>Ixobrychus exilis</td>
<td></td>
<td>Threatened</td>
</tr>
<tr>
<td>Loggerhead Shrike</td>
<td>Lanius ludovicianus</td>
<td></td>
<td>Endangered</td>
</tr>
<tr>
<td>Peregrine Falcon</td>
<td>Falco peregrinus</td>
<td></td>
<td>Special Concern</td>
</tr>
<tr>
<td>Yellow Rail</td>
<td>Coturnicops noveboracensis</td>
<td></td>
<td>Special Concern</td>
</tr>
<tr>
<td>Lake Sturgeon</td>
<td>Acipenser fulvescens</td>
<td></td>
<td>Special Concern</td>
</tr>
<tr>
<td>Northern Brook Lamprey</td>
<td>Ichthyomyzon fossor</td>
<td></td>
<td>Special Concern</td>
</tr>
<tr>
<td>Shortjaw Cisco</td>
<td>Coregonus zenithicus</td>
<td></td>
<td>Threatened</td>
</tr>
<tr>
<td>American Badger</td>
<td>Taxidea taxus</td>
<td></td>
<td>Endangered</td>
</tr>
<tr>
<td>Wolverine</td>
<td>Gulo gulo</td>
<td></td>
<td>Threatened</td>
</tr>
<tr>
<td>Caribou, Boreal population</td>
<td>Rangifer tarandus</td>
<td></td>
<td>Threatened</td>
</tr>
<tr>
<td>Pitcher’s Thistle</td>
<td>Cirsiuim pitcheri</td>
<td></td>
<td>Threatened</td>
</tr>
<tr>
<td>Snapping Turtle</td>
<td>Chelydra serpentina</td>
<td></td>
<td>Special Concern</td>
</tr>
</tbody>
</table>

Source: Ontario Ministry of Natural Resources and Forestry - Species at Risk in Thunder Bay Region, 2016
2.2.4 Invasive Species

Invasive species are a threat to native plants and animals and can disturb entire ecosystems. They are introduced and spread as a result of movement of people and goods around the world, increased urbanization, improved transportation routes and through recreational activities. Some of the ways invasive species can enter Ontario include:

- All-terrain vehicles
- Aquarium, water garden and pet trades
- Ballast water of ships
- Canals and changes to waterways
- Gardening and landscaping
- Release of live fish and bait
- Transport of topsoil
- Recreational and commercial boating
- Transport of animal carcasses or products made from them
- Transport of raw wood and other forest products

Invasive species that were observed in the Kaministiquia River, Lake Superior or the District of Thunder Bay, Ontario may be present in the Oliver Creek watershed, according to the Canada/Ontario Invasive Species Centre, OMNRF and the Ontario Federation of Anglers and Hunters’ Early Detection and Distribution Mapping System, are listed in the table below.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinese Mitten Crab</td>
<td>Eriocheir sinensis</td>
</tr>
<tr>
<td>Common Reed</td>
<td>Phragmites australis</td>
</tr>
<tr>
<td>Eurasian Ruffe</td>
<td>Gymnocephalus cernua</td>
</tr>
<tr>
<td>European Common Reed</td>
<td>Phragmites australis ssp. australis</td>
</tr>
<tr>
<td>European Flounder</td>
<td>Platichthys flesus</td>
</tr>
<tr>
<td>Flowering-Rush</td>
<td>Butomus umbellatus</td>
</tr>
<tr>
<td>Goldfish</td>
<td>Carassius auratus</td>
</tr>
<tr>
<td>Himalayan Balsam</td>
<td>Impatiens glandulifera</td>
</tr>
<tr>
<td>Japanese Knotweed</td>
<td>Reynoutria japonica</td>
</tr>
<tr>
<td>New Zealand Mud Snail</td>
<td>Potamopyrgus antipodarum</td>
</tr>
<tr>
<td>Purple Loosestrife</td>
<td>Lythrum salicaria</td>
</tr>
<tr>
<td>Rainbow Smelt</td>
<td>Osmerus mordax</td>
</tr>
<tr>
<td>Round Goby</td>
<td>Neogobius melanostomus</td>
</tr>
<tr>
<td>Rusty Crayfish</td>
<td>Orconectes rusticus</td>
</tr>
<tr>
<td>Spiny Water Flea</td>
<td>Bythotrephes longimanus</td>
</tr>
<tr>
<td>Three Spine Stickleback</td>
<td>Gasterosteus aculeatus</td>
</tr>
<tr>
<td>Tubenose Goby</td>
<td>Proterorhinus marmoratus</td>
</tr>
</tbody>
</table>
### Table 2.2-3: Invasive Species

<table>
<thead>
<tr>
<th>Species Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Perch</td>
<td><em>Morone Americana</em></td>
</tr>
<tr>
<td>Yellow Sweet-Clover</td>
<td><em>Melilotus officinalis</em></td>
</tr>
<tr>
<td>Zebra Mussel</td>
<td><em>Dreissena polymorpha</em></td>
</tr>
</tbody>
</table>


### 2.3 Socio-Economic Attributes

#### 2.3.1 Planning & Development Controls

**Land Tenure**

The majority of the Oliver Creek watershed is privately owned land (84.8 percent). Provincially owned crown land constitutes 15.19 percent. Land ownership in the watershed is illustrated on Map 7: Land Ownership.

**Areas of Jurisdiction**

The hydrological boundaries of the Oliver Creek watershed fall within the Municipality of Neebing and the Municipality of Oliver Paipoonge. Map 7: Land Ownership, illustrates the location of the Oliver Creek watershed within these areas. Table 2.3-1 below outlines the watershed area within each boundary.

<table>
<thead>
<tr>
<th>Geographic Boundaries</th>
<th>Total Municipal Area (km²)</th>
<th>Municipal Area within Oliver Creek Watershed (km²)</th>
<th>Municipal Area within Oliver Creek Watershed (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipality of Neebing</td>
<td>877.60</td>
<td>29.30</td>
<td>61.22</td>
</tr>
<tr>
<td>Municipality of Oliver Paipoonge</td>
<td>350.76</td>
<td>18.56</td>
<td>52.88</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1228.36</strong></td>
<td><strong>47.86</strong></td>
<td><strong>38.78</strong></td>
</tr>
</tbody>
</table>

Within the regulated area, the Authority administers the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses O. Reg 180/06 under the Conservations Authorities Act. Areas considered regulated include: Provincially Significant Wetlands and 120 metres adjacent, all watercourses, all land zoned Hazard Land, Use Limitation or Environmental Protection, steep slopes and 15 metres landward and one kilometre lakeward from the 100 year flood level on Lake Superior (i.e. 183.9 metres Geodetic Survey of Canada), as shown on Map 2: Regulated Area. Activities within the approximate regulated area may require a permit from the Authority.
2.3.1.1 Land Use Designation/Zoning

Municipal Official Plans contain long term goals and policies that serve as guidelines for future land use and development. The Oliver Creek watershed is affected by the Municipality of Neebing, and the Municipality of Oliver Paipoonge Official Plan and Zoning by-laws. Land use designations within the Oliver Creek watershed can be found on Map 8: Zoning.

The policies of the Official Plan and all land use designations are implemented through zoning by-laws. Zoning provides an additional level of detail, particularly with respect to the range of permitted uses and any specific conditions which must be satisfied such as buffering, suitable distances between uses and parking requirements.

Within the Municipality of Neebing the Oliver Creek watershed has been zoned as:
- Recreation 1 (S1) Zone
- Rural (R) Zone
- Institutional (I) Zone
- Use Limitation (UL) Zone

The following definitions are taken from the Municipality of Neebing Zoning By-Law No. 860-2010, dated August 2010.

**Recreation 1 (S1) Zone**

On existing lots of record as of the date of passing of this By-law, no person shall within any Recreation 1 (S1) Zone use any lot or erect, alter or use any building or structure for any purpose except in accordance with the following: Permitted Uses: (1) a recreational dwelling (2) a recreational modular home (3) a guest cottage (4) a bed and breakfast (5) a boat house (6) buildings, structures and uses accessory to the above uses in accordance with Section 2.1.

**Rural (R) Zone**

No person shall within any Rural (RU) Zone use any lot or erect, alter or use any building or structure for any purpose except in accordance with the following: Permitted Uses: (1) a single dwelling (2) a modular dwelling (3) agricultural use (4) forestry use (5) stables, riding academies (6) watershed management and conservation uses (7) a home occupation (8) a home industry (9) a guest cottage (10) a bed and breakfast (11) mineral exploration(12) wind farms (13) buildings, structures and uses accessory to the above uses in accordance with Section 2.1.
**Institutional (I) Zone**

No person shall within any Institutional (I) Zone use any lot or erect, alter or use any building or structure for any purpose except in accordance with the following: Permitted Uses: (1) a public or private school (2) a cemetery (3) a Federal, Provincial, or Municipal building, garage or office (4) a fire station (5) a church (6) a community hall (7) assembly hall, club or fraternal organization (8) buildings, structures and uses accessory to the above in accordance with Section 2.1 including a restaurant in a community centre.

**Use Limitation (UL) Zone**

No person shall within any Use Limitation (UL) Zone use any lot or erect, alter or use any building or structure for human habitation. Buildings or structures may be used for the following: Permitted Uses: (1) agricultural use (2) conservation use (3) forestry use (4) watershed management (5) watershed protection (6) public parks (7) outdoor passive recreational uses (8) mineral exploration (9) wind farm (10) dwellings existing on the date of passing of this By-law, and uses, buildings and structures accessory thereto.

Within the Municipality of Oliver Paipoonge the Oliver Creek watershed has been zoned as:
- Paipoonge General Agricultural (PAG) Zone
- Paipoonge Rural (PRU) Zone
- Paipoonge Use Limitation (PUL) Zone

The following definitions are taken from the Municipality of Oliver Paipoonge Zoning By-Law 185-01.

**Paipoonge General Agricultural (PAG) Zone**

No person shall within any PAG Zone use any lot or erect, alter or use any building or structure for any purpose except in accordance with the following: Permitted Uses: (i) agriculture (ii) forestry (iii) stables, riding academies, dog kennels (iv) watershed management and conservation uses (v) an accessory dwelling unit on a viable farm operation (vi) a staff house on a viable farm operation (vii) a single detached dwelling (viii) an apartment within an accessory building as permitted by subsection (v) above (ix) a home occupation (x) a home industry (xi) buildings, structures and uses accessory to the above uses in accordance with Section 4.1(a).

**Paipoonge Rural (PRU) Zone**
No person shall within any PRU Zone use any lot or erect, alter or use any building or structure for any purpose except in accordance with the following: Permitted Uses: (i) agriculture (ii) forestry (iii) stables, riding academies, dog kennels (iv) watershed management and conservation uses (v) single detached dwelling (vi) an accessory dwelling to a use listed in (i), (ii), or (iii); (vii) a home occupation (viii) a home industry (ix) buildings, structures and uses accessory to the above uses in accordance with Section 4.1(a).

**Paipoonge Use Limitation (PUL) Zone**

No person shall within any PUL Zone use any lot for any purpose except in accordance with the following: Permitted Uses: (i) agriculture (ii) conservation (iii) forestry (iv) wildlife management (v) watershed protection (vi) public and private parks (vii) golf course (viii) ski area (ix) other outdoor recreation uses. Other Provisions: No buildings or structures shall be permitted in the Use Limitation (UL) Zone except where such are intended for: (i) flood or erosion control (ii) watercourse protection works (iii) back stabilization projects.
3 METHODS AND MATERIALS

A summary of the sampling techniques used is included in Appendix C: Techniques for Data Collection.

3.1 Site Selection

Eight sites were chosen along the Oliver Creek watershed to assess the overall health of the watershed. Each site was chosen based on its accessibility and its proximity to natural or man-made features that may alter water quality. Site locations can be found on Map M-9: Site Plan.

3.2 Quantitative Assessment

Several parameters were measured to assess surface water quality of Oliver Creek. Surface water samples were collected in laboratory supplied bottles by LRCA staff and summer students and transported on ice, to ALS Laboratory Group, 1081 Barton Street, Thunder Bay, Ontario. An analysis was conducted on the samples to determine conductivity, total dissolved solids (TDS), turbidity, nutrients (ammonia-total nitrogen, nitrate, nitrite and phosphorus), bacteria (E. coli and total coliforms) and total metals.

Sampling was conducted on two separate occasions for each site, to enable comparisons and reveal discrepancies. The first data set was collected on June 14, 2016. The second data set was collected on July 14, 2016.

Methodology for water sample collection was based on the Provincial Water Quality Monitoring Network (PWQMN), Ministry of the Environment and Climate Change, protocol. Grab samples were collected away from the stream bank in the main current by wading or by using a reaching pole. Effort was taken to enter the stream downstream of the sampling location in order to disturb as little sediment as possible. Additionally, samples were taken upstream from any water crossings and/or outlet culverts and were taken facing upstream into the current. In cases where current was not detectable (stagnant water) or current was flowing in the opposite direction (influenced by wind direction), samples were still collected facing upstream. Samples were collected at a depth of 0.3 metres below the surface of the water to avoid capturing any floating debris.

ALS Laboratory Group provided five collection bottles for each site to conduct the following tests: routine, nutrient, metal and bacterial analysis. The routine analysis sample bottles and lids were rinsed twice before a true sample was collected. The ALS Laboratory Group pre-charged the nutrient sample bottles with sulfuric acid and the total metals bottles were pre-charged with nitric acid to preserve the samples taken,
and were not rinsed before filling. Bottles for bacterial analysis were also not rinsed as they were pre-charged with sodium thiosulphate preservative and special care was taken not to open the bottle until the true sample was to be filled. All filled sample bottles were transported on ice for delivery to the laboratory.

Field parameters of water temperature, pH, conductivity, dissolved oxygen, salinity, and oxygen reduction potential were measured using an YSI ProDSS multi-parameter water quality sampler at the same time as water sample collection. The following additional field parameters were also measured: air temperature by mercury thermometer, channel width using a measuring-tape reel, channel depth using a weighted measuring tape reel and velocity was measured using a stick, measuring tape, stopwatch and appropriate calculations. Velocity was only measured for water running downstream (not in ponds producing only windblown results). A description of the water quality parameters are attached in Appendix D: Summary of Water Quality Parameters.

3.3 Applicable Criteria

Surface water quality results from the Oliver Creek watershed were compared to applicable criteria published in the *Provincial Water Quality Objectives* (PWQO) by the Ontario Ministry of Environment and Climate Change (MOECC), July 1994. The goal of the PWQO is to “ensure that the surface waters of the province are of the quality which is satisfactory for aquatic life and recreation”.

The applicable criteria published in the PWQO water quality guidelines are attached in Appendix E: Water Quality Guidelines. Total Coliform results were compared to the pre-1994 PWQO, as there are no current criteria.

3.4 Qualitative Assessment

Watershed health can also be assessed by qualitative monitoring (i.e. visual inspection). The composition of in-stream substrate, forest soil, stream bank riparian community, shoreline vegetation and condition of the stream bank can all affect water quality. The presence or absence of certain flora and fauna can indicate the status of the watershed to provide suitable habitat. Nine field guides were used to identify terrestrial and aquatic species. Each site was given a Vegetation Type (V-type) allocation based on the *Field Guide to the Forest Ecosystem Classification for Northwestern Ontario* (Sims et al. 1997). Sites were assessed based on vegetation that could be seen from the site, with no distinct sample area, using a dichotomous key. It is important to note that these classifications are a general overview of a larger area and no site was exactly the same as another. Differences or inconsistencies between the V-types should be expected. Vegetation Types for each site are attached in Appendix F: Forest Ecosystem
Classification. Common and Latin names of plant species are attached in Appendix D: Common and Scientific Names of Identified Flora and Fauna. Fauna was assessed by identifying the species and number of individuals observed at each site.

An inventory of Oliver Creek water crossings (bridges and culverts) was conducted. Physical dimensions were measured, Universal Transverse Mercator (UTM) coordinates and pictures were taken and general observations were noted including high water marks, stability of fill and any restriction of flow. Culvert and bridge locations can be found on Map M-10: Bridge and Culvert Sites. The bridge and culvert assessments are attached in Appendix G: Culvert Assessments and Appendix H: Bridge Assessments.

3.5 Watershed Report Card Rating

The Conservation Authorities in Ontario have developed the Watershed Report Card (WRC) as a means of reporting and designating watershed health through the use of environmental indicators and to utilize the information to better target programs and measure environmental change. Four resource categories are measured in the Watershed Report Cards, which include surface water quality, forest conditions, wetland conditions, and groundwater quality. The grading system for each resource category is recognized as A-Excellent; B-Good; C-Fair; D-Poor; F-Very Poor.

Surface water quality and forest conditions were identified for the Oliver Creek watershed. The three indicators used to assess surface water quality for the watershed are total phosphorus, *Escherichia coli* (*E. coli*), and benthic macroinvertebrates (data not available). The average point score of the surface water indicators is used to determine the overall surface water quality grade. No wetland or groundwater data was available for the watershed.

Forest conditions utilize three indicators to determine the grade for the quality of the forest, which include forest coverage, forest interior percentage and percentage of riparian zone forested. Forest cover is the percentage of the watershed that is forested. Forest interior is the area of forest that lies more than 100 metres from a forest edge. Forest riparian zone measures the amount of forest cover within 30 metres adjacent to all open watercourses. Northern Ontario Forest Cover criteria are currently being developed.
### Table 3.5-1: 2011 Surface Water Quality Indicator Guidelines

<table>
<thead>
<tr>
<th>Total Phosphorus (mg/L)</th>
<th>E. coli (#/100 mL)</th>
<th>Benthic Invertebrates</th>
<th>Point Score</th>
<th>Grade</th>
<th>Final Points</th>
<th>Final Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.020</td>
<td>0-30</td>
<td>0.00-4.25</td>
<td>5</td>
<td>A</td>
<td>&gt;4.4</td>
<td>A</td>
</tr>
<tr>
<td>0.020-0.030</td>
<td>31-100</td>
<td>4.26-5.00</td>
<td>4</td>
<td>B</td>
<td>3.5 - 4.4</td>
<td>B</td>
</tr>
<tr>
<td>0.031-0.060</td>
<td>101-300</td>
<td>5.01-5.75</td>
<td>3</td>
<td>C</td>
<td>2.5 - 3.4</td>
<td>C</td>
</tr>
<tr>
<td>0.061-0.180</td>
<td>301-1000</td>
<td>5.76-6.50</td>
<td>2</td>
<td>D</td>
<td>1.5 - 2.4</td>
<td>D</td>
</tr>
<tr>
<td>&gt;0.180</td>
<td>&gt;1000</td>
<td>6.51-10.00</td>
<td>1</td>
<td>F</td>
<td>&lt;1.5</td>
<td>F</td>
</tr>
</tbody>
</table>

### Table 3.5-2: 2011 Forest Conditions Indicator Guidelines

<table>
<thead>
<tr>
<th>% Forest Cover</th>
<th>% Forest Interior</th>
<th>% Riparian Zone Forested</th>
<th>Point Score</th>
<th>Grade</th>
<th>Final Points</th>
<th>Final Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;35.0</td>
<td>&gt;11.5</td>
<td>&gt;57.5</td>
<td>5</td>
<td>A</td>
<td>&gt;4.4</td>
<td>A</td>
</tr>
<tr>
<td>25.1 - 35.0</td>
<td>8.6 - 11.5</td>
<td>42.6 - 57.5</td>
<td>4</td>
<td>B</td>
<td>3.5 - 4.4</td>
<td>B</td>
</tr>
<tr>
<td>15.1 - 25.0</td>
<td>5.6 - 8.5</td>
<td>27.6 - 42.5</td>
<td>3</td>
<td>C</td>
<td>2.5 - 3.4</td>
<td>C</td>
</tr>
<tr>
<td>5.0 - 15.0</td>
<td>2.5 - 5.5</td>
<td>12.5 - 27.5</td>
<td>2</td>
<td>D</td>
<td>1.5 - 2.4</td>
<td>D</td>
</tr>
<tr>
<td>&lt;5.0</td>
<td>&lt;2.5</td>
<td>&lt;12.5</td>
<td>1</td>
<td>F</td>
<td>&lt;1.5</td>
<td>F</td>
</tr>
</tbody>
</table>

### 3.6 Materials

Materials used during the assessment included:

- Auger
- Chest waders
- Cooler and ice packs
- Clipboard and observation chart paper
- Dip net
- Digital camera
- Field guides
- Fluorescent orange vests
- Latex gloves
- Measuring tape reel
- Mercury thermometer
- Metre stick
- Writing utensils
- Reaching pole
- Road map
- Sampling bottles and preservative provided by ALS Laboratory Group
- Scissors
- Stick (to measure velocity)
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- Stopwatch
- Trimble Geo XH GPS
- YSI Pro DSS metre
- Ziploc bags

Field Guides:

- Field Guide to the Forest Ecosystem Classification for Northwestern Ontario (Sims et al., 1997)
- Terrestrial and Wetland Ecosites of Northwestern Ontario (G. Racey et al., 1996)
- Wetland Plants of Ontario (Newmaster et al., 1997)
- Atlas of the Breeding Birds of Ontario (Cadman et al., 2007)
- Newcomb’s Wildflower Guide (Newcomb, 1977)
- Forest Plants of Northeastern Ontario (Legasy et al., 1995)
- Bugs of Ontario (Acorn, 2003)
- Shrubs of Ontario (Heimburger & Soper, 1982)
- Trees in Canada (Farrar, 1995)
4 RESULTS

Site photos from each sampling site are attached in Appendix I: Site Photography. The laboratory water quality results and PWQO criteria have been compared and attached in Appendix J: Laboratory Water Quality Results Summary Tables. The original Laboratory Certificates of Analysis and Analytical Reports have been attached in Appendix K: Laboratory Certificates of Analysis and Test Results.

The results for the Oliver Creek watershed are summarized in the tables below for each site.

4.1 Site 1

Site 1 was located near the confluence of Oliver Creek at the Kaministiquia River and was accessed from River Road. The substrate at this site included clay, silt, sand, gravel and boulders. The banks of the shoreline were stable with abundant vegetation in the riparian zone including balsam fir, trembling aspen, white birch, alder, chokecherry and red osier dogwood. Erosion on the banks of the creek downstream of the bridge was apparent. There were only a few visible emergent aquatic plants present at the sample area; however, they were too far away to identify. The soil type present at this site in the “A” Horizon was sand; the “B” Horizon was sandy gravel; the “C” Horizon was cobble.

The laboratory results from the July 14, 2016 sampling period showed that phosphorus exceeded the PWQO criterion (0.03 mg/L) with a value of 0.03 mg/L. Total coliforms, aluminum and iron all exceeded the PWQO guidelines on both June 14, 2016 and July 14, 2016 sampling periods. Total coliforms were above the pre-1994 PWQO criterion (1,000 MPN/100mL) with a value of 1,410 MPN/100mL on June 14, 2016 and >2,420 MPN/100mL on July 14, 2016. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.195 mg/L on June 14, 2016 and 0.201 mg/L on July 14, 2016. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 0.937 mg/L on June 14, 2016 and 1.290 mg/L on July 14, 2016.

<table>
<thead>
<tr>
<th>Table 4.1-1: Location References for Site 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location Description</td>
</tr>
<tr>
<td>UTM Coordinates</td>
</tr>
<tr>
<td>Altitude/Elevation</td>
</tr>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>-------------------------------</td>
</tr>
<tr>
<td>Water Temperature</td>
</tr>
<tr>
<td>Conductivity</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
</tr>
<tr>
<td>pH</td>
</tr>
<tr>
<td>Turbidity</td>
</tr>
<tr>
<td>Air Temperature</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
</tr>
<tr>
<td>Channel Width</td>
</tr>
<tr>
<td>Channel Depth</td>
</tr>
<tr>
<td>Velocity</td>
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**Table 4.1-3:** Laboratory Water Quality Results for Site 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>PWQO Guidelines</th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacteriological</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><em>Escherichia Coli</em></td>
<td>MPN/100mL</td>
<td>100</td>
<td>33</td>
<td>37</td>
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<tr>
<td>Total Coliforms</td>
<td>MPN/100mL</td>
<td>1,000 (prior to 1994)</td>
<td><strong>1410</strong></td>
<td>&gt;2420</td>
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<tr>
<td><strong>Physical</strong></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Conductivity (EC)</td>
<td>uS/cm</td>
<td>N/A</td>
<td>150</td>
<td>170</td>
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<tr>
<td>pH</td>
<td></td>
<td>6.5-8.5</td>
<td>7.84</td>
<td>8.13</td>
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<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>N/A</td>
<td>109</td>
<td>127</td>
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<td>Turbidity</td>
<td>NTU</td>
<td>4.47</td>
<td>5.44</td>
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<td><strong>Nutrients and Anions</strong></td>
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<tr>
<td>Ammonia-N, Total</td>
<td>mg/L</td>
<td>N/A</td>
<td>0.021</td>
<td>&lt;0.020</td>
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<tr>
<td>Un-ionized Ammonia</td>
<td>mg/L</td>
<td>0.2</td>
<td>0.00063</td>
<td>&lt;0.0008</td>
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<td>Chloride (Cl)</td>
<td>mg/L</td>
<td>N/A</td>
<td>5.62</td>
<td>5.10</td>
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<tr>
<td>Nitrate-N (NO₃-N)</td>
<td>mg/L</td>
<td>N/A</td>
<td>&lt;0.020</td>
<td>0.072</td>
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<tr>
<td>Nitrite-N (NO₂-N)</td>
<td>mg/L</td>
<td>N/A</td>
<td>&lt;0.010</td>
<td>&lt;0.010</td>
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<tr>
<td>Phosphorus (P)-Total</td>
<td>mg/L</td>
<td>0.03</td>
<td>0.02</td>
<td><strong>0.03</strong></td>
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<td>Sulfate (SO₄)</td>
<td>mg/L</td>
<td>N/A</td>
<td>8.34</td>
<td>6.65</td>
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<tr>
<td><strong>Metals</strong></td>
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<tr>
<td>Aluminum (Al)</td>
<td>mg/L</td>
<td>0.075</td>
<td><strong>0.195</strong></td>
<td><strong>0.201</strong></td>
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<tr>
<td>Cadmium (Cd)</td>
<td>mg/L</td>
<td>0.0001 (0-100 mg/L CaCO₃)</td>
<td>0.000046</td>
<td>0.000064</td>
</tr>
<tr>
<td></td>
<td>mg/L</td>
<td>0.0005 (&gt;100 mg/L CaCO₃)</td>
<td></td>
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<tr>
<td>Cobalt (Co)</td>
<td>mg/L</td>
<td>0.009</td>
<td>0.0016</td>
<td>0.0019</td>
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<tr>
<td>Copper (Cu)</td>
<td>mg/L</td>
<td>0.005 (interim)</td>
<td>0.0037</td>
<td>0.0044</td>
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<tr>
<td>Iron (Fe)</td>
<td>mg/L</td>
<td>0.300</td>
<td><strong>0.937</strong></td>
<td><strong>1.290</strong></td>
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<tr>
<td>Lead (Pb)</td>
<td>mg/L</td>
<td>0.003 (90-80 mg/L CaCO₃)</td>
<td>0.00015</td>
<td>0.00021</td>
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<tr>
<td></td>
<td>mg/L</td>
<td>0.005 (&gt;80 mg/L CaCO₃)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>mg/L</td>
<td>N/A</td>
<td>3.76</td>
<td>4.24</td>
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</table>

**Bold** indicates exceedance above PWQO guidelines.
Table 4.1-4: Flora Observed at Site 1

<table>
<thead>
<tr>
<th>FEC V-Type: V14 Balsam Fir Mixedwood</th>
<th>25% stream cover</th>
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<tbody>
<tr>
<td><strong>Forest Density / Stream Cover</strong></td>
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</tr>
<tr>
<td><strong>Terrestrial Species</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Trees</strong></td>
<td></td>
</tr>
<tr>
<td>White Spruce</td>
<td></td>
</tr>
<tr>
<td>Balsam Fir</td>
<td></td>
</tr>
<tr>
<td>Trembling Aspen</td>
<td></td>
</tr>
<tr>
<td>White Birch</td>
<td></td>
</tr>
<tr>
<td>Balsam Poplar</td>
<td></td>
</tr>
<tr>
<td><strong>Shrubs</strong></td>
<td></td>
</tr>
<tr>
<td>Chokecherry</td>
<td></td>
</tr>
<tr>
<td>Red Osier Dogwood</td>
<td></td>
</tr>
<tr>
<td>Speckled Alder</td>
<td></td>
</tr>
<tr>
<td>Wild Red Raspberry</td>
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<tr>
<td><strong>Herbs</strong></td>
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<tr>
<td>Dandelion</td>
<td></td>
</tr>
<tr>
<td>Rough-Stemmed Goldenrod Cow Vetch</td>
<td></td>
</tr>
<tr>
<td><strong>Ferns / Horsetails / Mosses / Grasses</strong></td>
<td></td>
</tr>
<tr>
<td>Meadow Horsetail</td>
<td></td>
</tr>
<tr>
<td><strong>Aquatic Macrophytes and Algae</strong></td>
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</tr>
<tr>
<td>Emergent</td>
<td>Floating Algae</td>
</tr>
<tr>
<td>Rooted Floating</td>
<td>Filaments</td>
</tr>
<tr>
<td>Submerged</td>
<td>Attached Algae</td>
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<tr>
<td>Free Floating</td>
<td>Slimes or Crusts</td>
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Table 4.1-5: Fauna Observed at Site 1

<table>
<thead>
<tr>
<th>Fauna Species</th>
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</thead>
<tbody>
<tr>
<td><strong>Amphibians</strong></td>
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</tr>
<tr>
<td><strong>Birds</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Crustaceans</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Fish</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Insects</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Mammals</strong></td>
<td>Chipmunk</td>
</tr>
<tr>
<td><strong>Mollusca</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Reptiles</strong></td>
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</tbody>
</table>

Table 4.1-6: Physical Features Observed at Site 1

<table>
<thead>
<tr>
<th>In-stream Substrate</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bedrock</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Boulder</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Cobbles</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Gravel</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Sand</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Silt</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Organic</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Clay</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bank Stability/Erosion</strong></td>
<td>Erosion downstream from the sampling site</td>
</tr>
</tbody>
</table>

4.2 Site 2

Site 2 was located on the north side of Barrie Drive, across from 457 Barrie Drive. The substrate at this site included gravel, cobbles, boulders and bedrock. The banks of the shoreline were stable with abundant vegetation in the riparian zone including white spruce, jack pine, white birch, balsam fir, trembling aspen, willow, red osier dogwood and speckled alder. The soil type present at this site in the “A” Horizon was sandy loam; the “C” Horizon was rock.

The laboratory results from the July 14, 2016 sampling period showed that phosphorus exceeded the PWQO criterion (0.03 mg/L) with a value of 0.03 mg/L. Total coliforms,
aluminum and iron all exceeded the PWQO guidelines on both June 14, 2016 and July 14, 2016 sampling periods. Total coliforms were above the pre-1994 PWQO criterion (1,000 MPN/100mL) with a value of 2,420 MPN/100mL on June 14, 2016 and >2,420 MPN/100mL on July 14, 2016. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.219 mg/L on June 14, 2016 and 0.200 mg/L on July 14, 2016. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 0.966 mg/L on June 14, 2016.

### Table 4.2-1: Location References for Site 2

<table>
<thead>
<tr>
<th>Location Description</th>
<th>North side of Barrie Drive – Across from 457 Barrie Drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTM Coordinates</td>
<td>Northing 5357660 Easting 312283</td>
</tr>
<tr>
<td>Altitude/Elevation</td>
<td>238.60 metres above sea level</td>
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### Table 4.2-2: Field Measurements for Site 2

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Date: 14-JUN-16</th>
<th>Time: 14:25</th>
<th>Date: 14-JUL-16</th>
<th>Time: 11:50</th>
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</thead>
<tbody>
<tr>
<td>Water Temperature</td>
<td>°C</td>
<td>15.5</td>
<td>19.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductivity</td>
<td>uS/cm</td>
<td>144.4</td>
<td>162.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>mg/L</td>
<td>9.49</td>
<td>8.46</td>
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<tr>
<td>Dissolved Oxygen</td>
<td>%</td>
<td>95.0</td>
<td>92.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>7.80</td>
<td>7.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>4.8</td>
<td>5.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Temperature</td>
<td>°C</td>
<td>16</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>93.966</td>
<td>105.350</td>
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</tr>
<tr>
<td>Channel Width</td>
<td>m</td>
<td>3.5</td>
<td>3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Channel Depth</td>
<td>m</td>
<td>0.35</td>
<td>0.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity</td>
<td>m/s</td>
<td>1.11</td>
<td>0.92</td>
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### Table 4.2-3: Laboratory Water Quality Results for Site 2

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>PWQO Guidelines</th>
<th>Date: 14-JUN-16</th>
<th>Time: 14:25</th>
<th>Date: 14-JUL-16</th>
<th>Time: 14:25</th>
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<tbody>
<tr>
<td><strong>Bacteriological</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Escherichia Coli</em></td>
<td>MPN/100mL</td>
<td>100</td>
<td>68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Coliforms</td>
<td>MPN/100mL</td>
<td>1,000 (prior to 1994)</td>
<td>2420</td>
<td>&gt;2420</td>
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<tr>
<td><strong>Physical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductivity (EC)</td>
<td>uS/cm</td>
<td>N/A</td>
<td>143</td>
<td>162</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>6.5-8.5</td>
<td>7.70</td>
<td>7.89</td>
<td></td>
<td></td>
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<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>N/A</td>
<td>105</td>
<td>122</td>
<td></td>
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<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>N/A</td>
<td>4.90</td>
<td>5.69</td>
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<td><strong>Nutrients and Anions</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia-N, Total</td>
<td>mg/L</td>
<td>N/A</td>
<td>0.035</td>
<td>&lt;0.020</td>
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<tr>
<td>Un-ionized Ammonia</td>
<td>mg/L</td>
<td>0.2</td>
<td>0.0010</td>
<td>&lt;0.0007</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>mg/L</td>
<td>N/A</td>
<td>4.19</td>
<td>4.57</td>
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<tr>
<td>Nitrate-N (NO₃-N)</td>
<td>mg/L</td>
<td>N/A</td>
<td>&lt;0.020</td>
<td>0.087</td>
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<tr>
<td>Nitrite-N (NO₂-N)</td>
<td>mg/L</td>
<td>N/A</td>
<td>&lt;0.010</td>
<td>&lt;0.010</td>
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<tr>
<td>Phosphorus (P)-Total</td>
<td>mg/L</td>
<td>0.03</td>
<td>0.02</td>
<td>0.03</td>
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<tr>
<td>Sulfate (SO₄)</td>
<td>mg/L</td>
<td>N/A</td>
<td>8.44</td>
<td>6.62</td>
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<td></td>
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<tr>
<td><strong>Metals</strong></td>
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</tr>
<tr>
<td>Aluminum (Al)</td>
<td>mg/L</td>
<td>0.219</td>
<td>0.200</td>
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</table>
### Table 4.2.3: Laboratory Water Quality Results for Site 2

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>PWQO Guidelines</th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Cd</strong> (mg/L)</td>
<td>0.000051</td>
<td>0.000063</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.00005 (0-100 mg/L CaCO₃)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.00005 (&gt;100 mg/L CaCO₃)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Co</strong> (mg/L)</td>
<td>0.00017</td>
<td>0.00020</td>
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<td></td>
<td>0.00009</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Cu</strong> (mg/L)</td>
<td>0.0038</td>
<td>0.0040</td>
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<td></td>
<td></td>
<td>0.0005 (interim)</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Fe</strong> (mg/L)</td>
<td>0.966</td>
<td>1.260</td>
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<tr>
<td></td>
<td></td>
<td>0.300</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Pb</strong> (mg/L)</td>
<td>0.00016</td>
<td>0.00025</td>
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<tr>
<td></td>
<td></td>
<td>0.003 (30-80 mg/L CaCO₃)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.00016 (&gt;80 mg/L CaCO₃)</td>
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<td></td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>mg/L</td>
<td>N/A</td>
<td>3.63</td>
<td>3.74</td>
</tr>
</tbody>
</table>

**Bold** indicates exceedance above PWQO guidelines

### Table 4.2.4: Flora Observed at Site 2

**FEC V-Type:** V15 White Spruce Mixedwood

<table>
<thead>
<tr>
<th>Forest Density / Stream Cover</th>
<th>40% stream cover</th>
</tr>
</thead>
</table>

#### Terrestrial Species

<table>
<thead>
<tr>
<th>Trees</th>
<th>Shrubs</th>
<th>Herbs</th>
<th>Ferns / Horsetails / Mosses / Grasses</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Birch</td>
<td>Speckled Alder</td>
<td>Cow Vetch</td>
<td></td>
</tr>
<tr>
<td>Jack Pine</td>
<td>Willow Spp.</td>
<td>Dandelion</td>
<td></td>
</tr>
<tr>
<td>White Spruce</td>
<td>Wild Red Raspberry</td>
<td>Red Clover</td>
<td></td>
</tr>
<tr>
<td>Trembling Aspen</td>
<td>Red Osier Dogwood</td>
<td>Ox-Eye Daisy</td>
<td></td>
</tr>
<tr>
<td>Balsam Poplar</td>
<td>Prickly Wild Rose</td>
<td>Swamp Thistle</td>
<td></td>
</tr>
<tr>
<td>Balsam Fir</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Aquatic Macrophytes and Algae

<table>
<thead>
<tr>
<th>Emergent</th>
<th>Floating Algae</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rooted Floating</td>
<td>Filaments</td>
<td>-</td>
</tr>
<tr>
<td>Submerged</td>
<td>Attached Algae</td>
<td>-</td>
</tr>
<tr>
<td>Free Floating</td>
<td>Slimes or Crusts</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 4.2.5: Fauna Observed at Site 2

#### Fauna Species

<table>
<thead>
<tr>
<th>Amphibians</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birds</td>
<td>-</td>
</tr>
<tr>
<td>Crustaceans</td>
<td>-</td>
</tr>
<tr>
<td>Fish</td>
<td>-</td>
</tr>
<tr>
<td>Insects</td>
<td>-</td>
</tr>
<tr>
<td>Mammals</td>
<td>-</td>
</tr>
<tr>
<td>Mollusca</td>
<td>-</td>
</tr>
<tr>
<td>Reptiles</td>
<td>-</td>
</tr>
</tbody>
</table>
### 4.3 Site 3

Site 3 was located on the south side of Barrie Drive, beside the driveway to 617 Barrie Drive. The substrate at this site included gravel, sand, silt and clay. The banks of the shoreline were stable with abundant vegetation in the riparian zone including white spruce, willow, pincherry, red osier dogwood, clover and rough-stemmed goldenrod. The soil type present at this site in the “A” Horizon and “B” Horizon was sandy loam.

The laboratory results from the July 14, 2016 sampling period showed that *E. coli* exceeded the PWQO criterion of 100 MPN/100mL with a value of 687 MPN/100mL. It was noted a farm was located upstream. Total coliforms, aluminum, iron and phosphorus all exceeded the PWQO guidelines on both June 14, 2016 and July 14, 2016 sampling periods. Total coliforms were above the pre-1994 PWQO criterion (1,000 MPN/100mL) with a value of >2,420 MPN/100mL on June 14, 2016 and >2,420 MPN/100mL on July 14, 2016. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.105 mg/L on June 14, 2016 and 0.110 mg/L on July 14, 2016. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 0.712 mg/L on June 14, 2016 and 0.912 mg/L on July 14, 2016. Phosphorus exceeded the PWQO criterion (0.03 mg/L) with a value of 0.16 mg/L on June 14, 2016 and 0.24 mg/L on July 14, 2016.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Temperature °C</td>
<td>13.5</td>
<td>16.8</td>
</tr>
<tr>
<td>Conductivity µS/cm</td>
<td>466.3</td>
<td>552</td>
</tr>
<tr>
<td>Dissolved Oxygen mg/L</td>
<td>9.39</td>
<td>7.31</td>
</tr>
<tr>
<td>Dissolved Oxygen %</td>
<td>90.2</td>
<td>76.1</td>
</tr>
<tr>
<td>pH</td>
<td>7.77</td>
<td>7.77</td>
</tr>
<tr>
<td>Turbidity NTU</td>
<td>2.5</td>
<td>3.2</td>
</tr>
<tr>
<td>Air Temperature °C</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>Total Dissolved Solids mg/L</td>
<td>303.127</td>
<td>358.935</td>
</tr>
<tr>
<td>Channel Width m</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Channel Depth m</td>
<td>0.16</td>
<td>0.3</td>
</tr>
</tbody>
</table>

### Table 4.2-6: Physical Features Observed at Site 2

<table>
<thead>
<tr>
<th>In-stream Substrate</th>
<th>Bedrock</th>
<th>Boulder</th>
<th>Cobbles</th>
<th>Gravel</th>
<th>Sand</th>
<th>Silt</th>
<th>Organic</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50%</td>
<td>20%</td>
<td>15%</td>
<td>15%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bank Stability/ Erosion</td>
<td>Stable / abundant vegetation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 4.3-1: Location References for Site 3

<table>
<thead>
<tr>
<th>Location Description</th>
<th>South side of Barrie Drive, beside the driveway to 617 Barrie Drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTM Coordinates</td>
<td>Northing 5357694 Easting 310732</td>
</tr>
<tr>
<td>Altitude/Elevation</td>
<td>250.44 metres above sea level</td>
</tr>
</tbody>
</table>

### Table 4.3-2: Field Measurements for Site 3

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time: 14:05</td>
<td>Time: 11:35</td>
</tr>
<tr>
<td>Water Temperature °C</td>
<td>13.5</td>
<td>16.8</td>
</tr>
<tr>
<td>Conductivity µS/cm</td>
<td>466.3</td>
<td>552</td>
</tr>
<tr>
<td>Dissolved Oxygen mg/L</td>
<td>9.39</td>
<td>7.31</td>
</tr>
<tr>
<td>Dissolved Oxygen %</td>
<td>90.2</td>
<td>76.1</td>
</tr>
<tr>
<td>pH</td>
<td>7.77</td>
<td>7.77</td>
</tr>
<tr>
<td>Turbidity NTU</td>
<td>2.5</td>
<td>3.2</td>
</tr>
<tr>
<td>Air Temperature °C</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>303.127</td>
<td>358.935</td>
</tr>
<tr>
<td>Channel Width m</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Channel Depth m</td>
<td>0.16</td>
<td>0.3</td>
</tr>
</tbody>
</table>
### Table 4.3.2: Field Measurements for Site 3

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity</td>
<td>m/s</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

### Table 4.3.3: Laboratory Water Quality Results for Site 3

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>PWQO Guidelines</th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacteriological</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Escherichia Coli</em></td>
<td>MPN/100mL</td>
<td>100</td>
<td>24</td>
<td>687</td>
</tr>
<tr>
<td>Total Coliforms</td>
<td>MPN/100mL</td>
<td>1,000 (prior to 1994)</td>
<td>&gt;2420</td>
<td>&gt;2420</td>
</tr>
<tr>
<td><strong>Physical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductivity (EC)</td>
<td>uS/cm</td>
<td>N/A</td>
<td>461</td>
<td>552</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>6.5-8.5</td>
<td>7.93</td>
<td>7.96</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>N/A</td>
<td>290</td>
<td>356</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>N/A</td>
<td>3.13</td>
<td>3.71</td>
</tr>
<tr>
<td><strong>Metals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia-N, Total</td>
<td>mg/L</td>
<td>N/A</td>
<td>0.051</td>
<td>0.037</td>
</tr>
<tr>
<td>Un-ionized Ammonia</td>
<td>mg/L</td>
<td>0.2</td>
<td>0.0013</td>
<td>0.0012</td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>mg/L</td>
<td>N/A</td>
<td>13.9</td>
<td>13.7</td>
</tr>
<tr>
<td>Nitrate-N (NO3-N)</td>
<td>mg/L</td>
<td>N/A</td>
<td>0.027</td>
<td>0.137</td>
</tr>
<tr>
<td>Nitrite-N 2-N</td>
<td>mg/L</td>
<td>N/A</td>
<td>&lt;0.010</td>
<td>&lt;0.010</td>
</tr>
<tr>
<td>Phosphorus (P)-Total</td>
<td>mg/L</td>
<td>0.03</td>
<td>0.16</td>
<td>0.24</td>
</tr>
<tr>
<td>Sulfate (SO4)</td>
<td>mg/L</td>
<td>N/A</td>
<td>23.5</td>
<td>19.4</td>
</tr>
<tr>
<td><strong>Aluminum (Al)</strong></td>
<td>mg/L</td>
<td>0.075</td>
<td>0.105</td>
<td>0.110</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>mg/L</td>
<td>0.0001 (0-100 mg/L CaCO₃)</td>
<td>0.000073</td>
<td>0.000068</td>
</tr>
<tr>
<td></td>
<td>mg/L</td>
<td>0.0005 (&gt;100 mg/L CaCO₃)</td>
<td>0.000055</td>
<td>0.000068</td>
</tr>
<tr>
<td>Cobalt (Co)</td>
<td>mg/L</td>
<td>0.0009</td>
<td>0.00077</td>
<td>0.00053</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>mg/L</td>
<td>0.005 (interim)</td>
<td>0.0030</td>
<td>0.0029</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>mg/L</td>
<td>0.300</td>
<td>0.712</td>
<td>0.912</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>mg/L</td>
<td>0.003 (30-80 mg/L CaCO₃)</td>
<td>0.000005</td>
<td>0.000006</td>
</tr>
<tr>
<td></td>
<td>mg/L</td>
<td>0.005 (&gt;80 mg/L CaCO₃)</td>
<td>&lt;0.00005</td>
<td>&lt;0.00005</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>mg/L</td>
<td>N/A</td>
<td>9.13</td>
<td>9.91</td>
</tr>
</tbody>
</table>

**Bold** indicates exceedance above PWQO guidelines

### Table 4.3.4: Flora Observed at Site 3

**FEC V-Type:** N/A

<table>
<thead>
<tr>
<th>Forest Density / Stream Cover</th>
<th>Terrestrial Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>75% stream cover</td>
<td></td>
</tr>
</tbody>
</table>

**Trees**

- Balsam Poplar
- Trembling Aspen
- White Spruce
- Red Osier Dogwood
- Willow Spp.
- Pincherry
- Red Clover
- Dandelion
- Rough-Stemmed Goldenrod
- White Clover
- Swamp Thistle

**Aquatic Macrophytes and Algae**

<table>
<thead>
<tr>
<th>Emergent</th>
<th>Floating Algae</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rooted Floating</td>
<td>Filaments</td>
<td>-</td>
</tr>
</tbody>
</table>
### Table 4.3-4: Flora Observed at Site 3

<table>
<thead>
<tr>
<th>Submergent</th>
<th>Attached Algae</th>
<th>Free Floating</th>
<th>Slimes or Crusts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 4.3-5: Fauna Observed at Site 3

<table>
<thead>
<tr>
<th>Fauna Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphibians</td>
</tr>
<tr>
<td>Birds</td>
</tr>
<tr>
<td>Crustaceans</td>
</tr>
<tr>
<td>Fish</td>
</tr>
<tr>
<td>Insects</td>
</tr>
<tr>
<td>Mammals</td>
</tr>
<tr>
<td>Mollusca</td>
</tr>
<tr>
<td>Reptiles</td>
</tr>
</tbody>
</table>

### Table 4.3-6: Physical Features Observed at Site 3

<table>
<thead>
<tr>
<th>In-stream Substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedrock</td>
</tr>
<tr>
<td>Boulder</td>
</tr>
<tr>
<td>Cobbles</td>
</tr>
<tr>
<td>Gravel</td>
</tr>
<tr>
<td>Sand</td>
</tr>
<tr>
<td>Silt</td>
</tr>
<tr>
<td>Organic</td>
</tr>
<tr>
<td>Clay</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bank Stability/ Erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stable/ abundant vegetation</td>
</tr>
</tbody>
</table>

### 4.4 Site 4

Site 4 was located on the south side of Barrie Drive, approximately 105 metres from 741 Barrie Drive. The substrate at this site included gravel, sand, silt and clay. The banks of the shoreline were stable with abundant vegetation in the riparian zone including white spruce, willow, chokecherry, speckled alder and clover. The soil type present at this site in the “A” Horizon was loamy sand; the “C” Horizon was silty clay loam.

The laboratory results showed that total coliforms, aluminum and iron all exceeded the PWQO guidelines on both June 14, 2016 and July 14, 2016 sampling periods. Total coliforms were above the pre-1994 PWQO criterion (1,000 MPN/100mL) with a value of >2,420 MPN/100mL on June 14, 2016 and >2,420 MPN/100mL on July 14, 2016. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.280 mg/L on June 14, 2016 and 0.226 mg/L on July 14, 2016. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 0.963 mg/L on June 14, 2016 and 1.200 mg/L on July 14, 2016.

### Table 4.4-1: Location References for Site 4

<table>
<thead>
<tr>
<th>Location Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>South side of Barrie Drive, approximately 105 metres from 741 Barrie Drive</td>
</tr>
<tr>
<td>UTM Coordinates</td>
</tr>
<tr>
<td>Northing 5357730 Easting 309619</td>
</tr>
<tr>
<td>Altitude/Elevation</td>
</tr>
<tr>
<td>250.09 metres above sea level</td>
</tr>
</tbody>
</table>
### Table 4.4-2: Field Measurements for Site 4

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Time: 13:30</td>
<td>Time: 11:20</td>
</tr>
<tr>
<td>Water Temperature</td>
<td>°C</td>
<td>15.1</td>
<td>19.4</td>
</tr>
<tr>
<td>Conductivity</td>
<td>uS/cm</td>
<td>110.6</td>
<td>120.1</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>mg/L</td>
<td>9.40</td>
<td>7.97</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>%</td>
<td>93.5</td>
<td>86.7</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>7.63</td>
<td>7.65</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>5.2</td>
<td>5.3</td>
</tr>
<tr>
<td>Air Temperature</td>
<td>°C</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>71.896</td>
<td>78.045</td>
</tr>
<tr>
<td>Channel Width</td>
<td>m</td>
<td>3.4</td>
<td>3.4</td>
</tr>
<tr>
<td>Channel Depth</td>
<td>m</td>
<td>0.28</td>
<td>0.36</td>
</tr>
<tr>
<td>Velocity</td>
<td>m/s</td>
<td>0.40</td>
<td>0.47</td>
</tr>
</tbody>
</table>

### Table 4.4-3: Laboratory Water Quality Results for Site 4

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>PWQO Guidelines</th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Time: 13:30</td>
<td>Time: 11:20</td>
</tr>
<tr>
<td><strong>Bacteriological</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Escherichia Coli</em></td>
<td>MPN/100mL</td>
<td>100</td>
<td>58</td>
<td>56</td>
</tr>
<tr>
<td>Total Coliforms</td>
<td>MPN/100mL</td>
<td>&gt;2420 (prior to 1994)</td>
<td>&gt;2420</td>
<td></td>
</tr>
<tr>
<td><strong>Physical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductivity (EC)</td>
<td>uS/cm</td>
<td>N/A</td>
<td>111</td>
<td>121</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>6.5-8.5</td>
<td>7.64</td>
<td>7.64</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>N/A</td>
<td>86</td>
<td>107</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>N/A</td>
<td>5.02</td>
<td>5.67</td>
</tr>
<tr>
<td><strong>Nutrients and Anions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia-N, Total</td>
<td>mg/L</td>
<td>N/A</td>
<td>0.026</td>
<td>&lt;0.020</td>
</tr>
<tr>
<td>Un-ionized Ammonia</td>
<td>mg/L</td>
<td>0.2</td>
<td>0.0002</td>
<td>&lt;0.0002</td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>mg/L</td>
<td>N/A</td>
<td>2.85</td>
<td>2.51</td>
</tr>
<tr>
<td>Nitrate-N (NO₃-N)</td>
<td>mg/L</td>
<td>N/A</td>
<td>0.012</td>
<td>0.072</td>
</tr>
<tr>
<td>Nitrite-N (NO₂-N)</td>
<td>mg/L</td>
<td>N/A</td>
<td>&lt;0.010</td>
<td>&lt;0.010</td>
</tr>
<tr>
<td>Phosphorus (P)-Total</td>
<td>mg/L</td>
<td>0.03</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Sulfate (SO₄)</td>
<td>mg/L</td>
<td>N/A</td>
<td>23.5</td>
<td>6.69</td>
</tr>
<tr>
<td><strong>Metals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum (Al)</td>
<td>mg/L</td>
<td>0.075</td>
<td>0.280</td>
<td>0.226</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>mg/L</td>
<td>0.0001 (≤100 mg/L CaCO₃)</td>
<td>0.000057</td>
<td>0.000072</td>
</tr>
<tr>
<td>Cobalt (Co)</td>
<td>mg/L</td>
<td>0.0009</td>
<td>0.00020</td>
<td>0.00020</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>mg/L</td>
<td>0.005 (interim)</td>
<td>0.0040</td>
<td>0.0040</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>mg/L</td>
<td>0.300</td>
<td>0.963</td>
<td>1.200</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>mg/L</td>
<td>0.003 (≤80 mg/L CaCO₃)</td>
<td>0.00019</td>
<td>0.00023</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>mg/L</td>
<td>N/A</td>
<td>2.52</td>
<td>2.49</td>
</tr>
</tbody>
</table>

**Bold** indicates exceedance above PWQO guidelines.
### Table 4.4-4: Flora Observed at Site 4

<table>
<thead>
<tr>
<th>Forest Density / Stream Cover</th>
<th>10% stream cover</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Terrestrial Species</strong></td>
<td></td>
</tr>
<tr>
<td>Trees</td>
<td></td>
</tr>
<tr>
<td>White Spruce</td>
<td></td>
</tr>
<tr>
<td>Willow spp.</td>
<td></td>
</tr>
<tr>
<td>Chokecherry</td>
<td></td>
</tr>
<tr>
<td>Speckled Alder</td>
<td></td>
</tr>
<tr>
<td>Shubs</td>
<td></td>
</tr>
<tr>
<td>Red Clover</td>
<td></td>
</tr>
<tr>
<td>Dandelion</td>
<td></td>
</tr>
<tr>
<td>Swamp Thistle</td>
<td></td>
</tr>
<tr>
<td>Cow Vetch</td>
<td></td>
</tr>
<tr>
<td>Rough-Stemmed Goldenrod</td>
<td></td>
</tr>
<tr>
<td>Herbs</td>
<td></td>
</tr>
<tr>
<td>Ferns / Horsetails / Mosses / Grasses</td>
<td></td>
</tr>
<tr>
<td>Aquatic Macrophytes and Algae</td>
<td></td>
</tr>
<tr>
<td>Emergent</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Rooted Floating</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Submergent</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Free Floating</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

### Table 4.4-5: Fauna Observed at Site 4

<table>
<thead>
<tr>
<th>Fauna Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphibians</td>
</tr>
<tr>
<td>Birds</td>
</tr>
<tr>
<td>Crustaceans</td>
</tr>
<tr>
<td>Fish</td>
</tr>
<tr>
<td>Insects</td>
</tr>
<tr>
<td>Mammals</td>
</tr>
<tr>
<td>Mollusca</td>
</tr>
<tr>
<td>Reptiles</td>
</tr>
</tbody>
</table>

### Table 4.4-6: Physical Features Observed at Site 4

<table>
<thead>
<tr>
<th>In-stream Substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedrock</td>
</tr>
<tr>
<td>Boulder</td>
</tr>
<tr>
<td>Cobble</td>
</tr>
<tr>
<td>Gravel</td>
</tr>
<tr>
<td>Sand</td>
</tr>
<tr>
<td>Silt</td>
</tr>
<tr>
<td>Organic</td>
</tr>
<tr>
<td>Clay</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bank Stability / Erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stable / abundant vegetation</td>
</tr>
</tbody>
</table>

### 4.5 Site 5

Site 5 was located on the west side of C-Line Road, approximately 130 metres from 19 C-Line Road. The substrate at this site included clay, silt, gravel, and cobbles. The banks of the shoreline were stable with abundant vegetation in the riparian zone including trembling aspen, white spruce, balsam fir, red osier dogwood, pincherry, speckled alder and clover. The soil type present at this site in the “A” Horizon was silty clay loam.

The laboratory results showed that total coliforms, aluminum and iron all exceeded the PWQO guidelines on both June 14, 2016 and July 14, 2016 sampling periods. Total coliforms were above the pre-1994 PWQO criterion (1,000 MPN/100mL) with a value of
2,420 MPN/100mL on June 14, 2016 and 2,420 MPN/100mL on July 14, 2016. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.123 mg/L on June 14, 2016 and 0.101 mg/L on July 14, 2016. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 1.040 mg/L on June 14, 2016 and 1.510 mg/L on July 14, 2016.

### Table 4.5-1: Location References for Site 5

<table>
<thead>
<tr>
<th>Location Description</th>
<th>UTM Coordinates</th>
<th>Altitude/Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>West side of C-Line Road, approximately 130 metres from 19 C-Line Road</td>
<td>Northing 5355789 Easting 308729</td>
<td>283.65 metres above sea level</td>
</tr>
</tbody>
</table>

### Table 4.5-2: Field Measurements for Site 5

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Time: 13:00</td>
<td>Time: 11:00</td>
</tr>
<tr>
<td>Water Temperature</td>
<td>ºC</td>
<td>15.8</td>
<td>19.9</td>
</tr>
<tr>
<td>Conductivity</td>
<td>uS/cm</td>
<td>93</td>
<td>101.4</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>mg/L</td>
<td>8.70</td>
<td>7.43</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>%</td>
<td>87.9</td>
<td>81.6</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>7.46</td>
<td>7.59</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Air Temperature</td>
<td>ºC</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>60.515</td>
<td>65.942</td>
</tr>
<tr>
<td>Channel Width</td>
<td>m</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Channel Depth</td>
<td>m</td>
<td>0.3</td>
<td>0.26</td>
</tr>
<tr>
<td>Velocity</td>
<td>m/s</td>
<td>0.19</td>
<td>0.30</td>
</tr>
</tbody>
</table>

### Table 4.5-3: Laboratory Water Quality Results for Site 5

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>PWQO Guidelines</th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Time: 13:00</td>
<td>Time: 11:00</td>
</tr>
<tr>
<td>Bacteriological</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Escherichia Coli</em></td>
<td>MPN/100mL</td>
<td>100</td>
<td>13</td>
<td>33</td>
</tr>
<tr>
<td>Total Coliforms</td>
<td>MPN/100mL</td>
<td>1,000 (prior to 1994)</td>
<td><strong>2420</strong></td>
<td><strong>2420</strong></td>
</tr>
<tr>
<td>Physical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductivity (EC)</td>
<td>uS/cm</td>
<td>N/A</td>
<td>93.2</td>
<td>102</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>6.5-8.5</td>
<td>7.42</td>
<td>7.55</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>N/A</td>
<td>88</td>
<td>92</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>N/A</td>
<td>2.59</td>
<td>2.77</td>
</tr>
<tr>
<td>Nutrients and Anions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia-N, Total</td>
<td>mg/L</td>
<td>N/A</td>
<td>0.026</td>
<td>&lt;0.020</td>
</tr>
<tr>
<td>Un-ionized Ammonia</td>
<td>mg/L</td>
<td>0.2</td>
<td>0.0002</td>
<td>&lt;0.0002</td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>mg/L</td>
<td>N/A</td>
<td>0.16</td>
<td>0.15</td>
</tr>
<tr>
<td>Nitrate-N (NO3-N)</td>
<td>mg/L</td>
<td>N/A</td>
<td>&lt;0.020</td>
<td>&lt;0.020</td>
</tr>
<tr>
<td>Nitrite-N (NO2-N)</td>
<td>mg/L</td>
<td>N/A</td>
<td>&lt;0.010</td>
<td>&lt;0.010</td>
</tr>
<tr>
<td>Phosphorus (P)-Total</td>
<td>mg/L</td>
<td>0.03</td>
<td>0.02</td>
<td>0.025</td>
</tr>
<tr>
<td>Sulfate (SO4)</td>
<td>mg/L</td>
<td>N/A</td>
<td>2.74</td>
<td>1.45</td>
</tr>
<tr>
<td>Metals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum (Al)</td>
<td>mg/L</td>
<td>0.075</td>
<td><strong>0.123</strong></td>
<td><strong>0.101</strong></td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>mg/L</td>
<td>0.0001 (0-100 mg/L CaCO3)</td>
<td>0.000062</td>
<td>0.000070</td>
</tr>
<tr>
<td></td>
<td>mg/L</td>
<td>0.0005 (&gt;100 mg/L CaCO3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cobalt (Co)</td>
<td>mg/L</td>
<td>0.0009</td>
<td>0.00019</td>
<td>0.00021</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>mg/L</td>
<td>0.005 (interim)</td>
<td>0.0040</td>
<td>0.0030</td>
</tr>
</tbody>
</table>
### Table 4.5-3: Laboratory Water Quality Results for Site 5

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>PWQO Guidelines</th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron (Fe)</td>
<td>mg/L</td>
<td>0.300</td>
<td>1.040</td>
<td>1.510</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>mg/L</td>
<td>0.003 (30-80 mg/L CaCO₃)</td>
<td>0.00011</td>
<td>0.00014</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>mg/L</td>
<td>N/A</td>
<td>1.67</td>
<td>1.59</td>
</tr>
</tbody>
</table>

**Bold** indicates exceedance above PWQO guidelines

### Table 4.5-4: Flora Observed at Site 5

**FEC V-Type:** V15 White Spruce Mixedwood

**Forest Density / Stream Cover:** 80% stream cover

#### Terrestrial Species

<table>
<thead>
<tr>
<th>Trees</th>
<th>Shrubs</th>
<th>Herbs</th>
<th>Ferns / Horsetails / Mosses / Grasses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balsam Poplar</td>
<td>Pincherry</td>
<td>Red Clover</td>
<td></td>
</tr>
<tr>
<td>Trembling Aspen</td>
<td>Willow spp.</td>
<td>Swamp Thistle</td>
<td></td>
</tr>
<tr>
<td>White Spruce</td>
<td>Speckled Alder</td>
<td>Cow Vetch</td>
<td></td>
</tr>
<tr>
<td>Balsam Fir</td>
<td>Red Osier Dogwood</td>
<td>Dandelion</td>
<td></td>
</tr>
<tr>
<td>White Birch</td>
<td>Wild Red Raspberry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Aquatic Macrophytes and Algae

<table>
<thead>
<tr>
<th></th>
<th>Emergent</th>
<th>Rooted Floating</th>
<th>Submerged</th>
<th>Free Floating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 4.5-5: Fauna Observed at Site 5

**Fauna Species**

<table>
<thead>
<tr>
<th>Amphibians</th>
<th>Birds</th>
<th>Crustaceans</th>
<th>Fish</th>
<th>Insects</th>
<th>Mammals</th>
<th>Mollusca</th>
<th>Reptiles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 4.5-6: Physical Features Observed at Site 5

**In-stream Substrate**

<table>
<thead>
<tr>
<th>Bedrock</th>
<th>Boulder</th>
<th>Cobble</th>
<th>Gravel</th>
<th>Sand</th>
<th>Silt</th>
<th>Organic</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>-</td>
<td>10%</td>
<td>10%</td>
<td>-</td>
<td>40%</td>
<td>-</td>
<td>40%</td>
</tr>
</tbody>
</table>

**Bank Stability/ Erosion**

Stable/ abundant vegetation
4.6 Site 6

Site 6 was located on the south side of Candy Mountain Road, approximately 65 metres from Oliver Creek Road. The substrate at this site included clay, silt, gravel, cobbles and boulders. The banks of the shoreline were stable with abundant vegetation in the riparian zone including black ash, white spruce, balsam fir, red osier dogwood, pin cherry, speckled alder and rough-stemmed goldenrod. The soil type present at this site in the “A” Horizon was sandy loam and “B” Horizon was loam.

The laboratory results showed that total coliforms, aluminum and iron all exceeded the PWQO guidelines on both June 14, 2016 and July 14, 2016 sampling periods. Total coliforms were above the pre-1994 PWQO criterion (1,000 MPN/100mL) with a value of 2,420 MPN/100mL on June 14, 2016 and 1,730 MPN/100mL on July 14, 2016. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.331 mg/L on June 14, 2016 and 0.262 mg/L on July 14, 2016. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 0.925 mg/L on June 14, 2016 and 0.343 mg/L on July 14, 2016.

Table 4.6-1: Location References for Site 6

<table>
<thead>
<tr>
<th>Location Description</th>
<th>South side of Candy Mountain Road, approximately 65 metres from Oliver Creek Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTM Coordinates</td>
<td>Northing 5355688 Easting 309852</td>
</tr>
<tr>
<td>Altitude/Elevation</td>
<td>276.69 metres above sea level</td>
</tr>
</tbody>
</table>

Table 4.6-2: Field Measurements for Site 6

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Date: 14-JUN-16</th>
<th>Time: 12:30</th>
<th>Date: 14-JUL-16</th>
<th>Time: 10:40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Temperature</td>
<td>°C</td>
<td>15</td>
<td>19.1</td>
<td>6.1</td>
<td>6.0</td>
</tr>
<tr>
<td>Conductivity</td>
<td>uS/cm</td>
<td>96.6</td>
<td>96.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>mg/L</td>
<td>9.67</td>
<td>8.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissolved Oxygen %</td>
<td>%</td>
<td>95.8</td>
<td>93.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>7.79</td>
<td>7.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>6.1</td>
<td>6.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Temperature</td>
<td>°C</td>
<td>14</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>62.812</td>
<td>63.160</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Channel Width</td>
<td>m</td>
<td>2.9</td>
<td>2.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Channel Depth</td>
<td>m</td>
<td>0.62</td>
<td>0.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity</td>
<td>m/s</td>
<td>0.19</td>
<td>0.14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.6-3: Laboratory Water Quality Results for Site 6

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>PWQO Guidelines</th>
<th>Date: 14-JUN-16</th>
<th>Time: 12:30</th>
<th>Date: 14-JUL-16</th>
<th>Time: 10:40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteriological</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Escherichia Coli</td>
<td>MPN/100mL</td>
<td>100</td>
<td>23</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Coliforms</td>
<td>MPN/100mL</td>
<td>1000 (prior to 1994)</td>
<td>2420</td>
<td>1730</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductivity (EC)</td>
<td>uS/cm</td>
<td>N/A</td>
<td>97.1</td>
<td>101</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>6.5-8.5</td>
<td>7.59</td>
<td>7.71</td>
<td></td>
<td></td>
</tr>
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</table>
### Table 4.6-3: Laboratory Water Quality Results for Site 6

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>PWQO Guidelines</th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>N/A</td>
<td>81</td>
<td>78</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>N/A</td>
<td>5.84</td>
<td>6.40</td>
</tr>
</tbody>
</table>

#### Nutrients and Anions

<table>
<thead>
<tr>
<th></th>
<th>mg/L</th>
<th></th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia-N, Total</td>
<td>N/A</td>
<td>&lt;0.020</td>
<td>81</td>
<td>78</td>
</tr>
<tr>
<td>Un-ionized Ammonia</td>
<td>0.2</td>
<td>&lt;0.0002</td>
<td>81</td>
<td>78</td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>N/A</td>
<td>3.03</td>
<td>5.84</td>
<td>6.40</td>
</tr>
<tr>
<td>Nitrate-N (NO₃-N)</td>
<td>N/A</td>
<td>&lt;0.020</td>
<td>81</td>
<td>78</td>
</tr>
<tr>
<td>Nitrite-N (NO₂-N)</td>
<td>N/A</td>
<td>&lt;0.010</td>
<td>81</td>
<td>78</td>
</tr>
<tr>
<td>Phosphorus (P)-Total</td>
<td>0.03</td>
<td>0.02</td>
<td>81</td>
<td>78</td>
</tr>
</tbody>
</table>

#### Metals

<table>
<thead>
<tr>
<th></th>
<th>mg/L</th>
<th></th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum (Al)</td>
<td>0.075</td>
<td>0.331</td>
<td>81</td>
<td>78</td>
</tr>
<tr>
<td>Cadmium (Cd) (interim)</td>
<td>0.0005</td>
<td>0.002</td>
<td>81</td>
<td>78</td>
</tr>
<tr>
<td>Cobalt (Co)</td>
<td>0.009</td>
<td>0.00018</td>
<td>81</td>
<td>78</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>0.005</td>
<td>0.0036</td>
<td>81</td>
<td>78</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>0.30</td>
<td>0.925</td>
<td>81</td>
<td>78</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>0.003</td>
<td>0.00020</td>
<td>81</td>
<td>78</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>N/A</td>
<td>2.42</td>
<td>81</td>
<td>78</td>
</tr>
</tbody>
</table>

**Bold** indicates exceedance above PWQO guidelines

### Table 4.6-4: Flora Observed at Site 6

**FEC V-Type: V2 Black Ash Hardwood and Mixedwood**

<table>
<thead>
<tr>
<th>Forest Density /Stream Cover</th>
<th>75% stream cover</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Terrestrial Species</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Trees</strong></td>
<td></td>
</tr>
<tr>
<td>Black Ash</td>
<td></td>
</tr>
<tr>
<td>Balsam Fir</td>
<td></td>
</tr>
<tr>
<td>White Spruce</td>
<td></td>
</tr>
<tr>
<td>White Pine</td>
<td></td>
</tr>
<tr>
<td>Trembling Aspen</td>
<td></td>
</tr>
<tr>
<td><strong>Shrubs</strong></td>
<td></td>
</tr>
<tr>
<td>Pincherry</td>
<td></td>
</tr>
<tr>
<td>Willow spp.</td>
<td></td>
</tr>
<tr>
<td>Speckled Alder</td>
<td></td>
</tr>
<tr>
<td>Red Osier Dogwood</td>
<td></td>
</tr>
<tr>
<td>Wild Red Raspberry</td>
<td></td>
</tr>
<tr>
<td><strong>Herbs</strong></td>
<td></td>
</tr>
<tr>
<td>Dandelion</td>
<td></td>
</tr>
<tr>
<td>Rough-Stemmed- Goldenrod</td>
<td></td>
</tr>
<tr>
<td>Cow Vetch</td>
<td></td>
</tr>
<tr>
<td>Red Clover</td>
<td></td>
</tr>
<tr>
<td><strong>Aquatic Macrophytes and Algae</strong></td>
<td></td>
</tr>
<tr>
<td>Emergent</td>
<td>Floating Algae</td>
</tr>
<tr>
<td>Rooted Floating</td>
<td>Filaments</td>
</tr>
<tr>
<td>Submerged</td>
<td>Attached Algae</td>
</tr>
<tr>
<td>Free Floating</td>
<td>Slimes or Crusts</td>
</tr>
</tbody>
</table>

### Table 4.6-5: Fauna Observed at Site 6

<table>
<thead>
<tr>
<th>Fauna Species</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphibians</td>
<td>-</td>
</tr>
<tr>
<td>Birds</td>
<td>-</td>
</tr>
<tr>
<td>Crustaceans</td>
<td>-</td>
</tr>
<tr>
<td>Fish</td>
<td>-</td>
</tr>
<tr>
<td>Insects</td>
<td>-</td>
</tr>
</tbody>
</table>
4.7 Site 7

Site 7 was located on the south side of Boundary Drive, approximately 60 metres from 1150 Boundary Drive. The substrate at this site included clay, organic, silt, gravel and cobbles. The banks of the shoreline were stable with abundant vegetation in the riparian zone including white spruce, black spruce, black ash, balsam fir, red osier dogwood, willow and rough-stemmed goldenrod. The soil type present at this site in the “A” Horizon was sandy loam; the “B” Horizon and “C” Horizon was loamy sand.

The laboratory results from the June 14, 2016 sampling period showed that *E. coli* exceeded the PWQO criterion of 100 MPN/100mL with a value of 108 MPN/100mL. It was noted that a beaver dam was present upstream. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.080 mg/L on July 14, 2016. Total coliforms and iron exceeded the PWQO guidelines on both June 14, 2016 and July 14, 2016 sampling periods. Total coliforms were above the pre-1994 PWQO criterion (1,000 MPN/100mL) with a value of 1,730 MPN/100mL on June 14, 2016 and 1,730 MPN/100mL on July 14, 2016. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 0.343 mg/L on June 14, 2016 and 0.585 mg/L on July 14, 2016.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Temperature</td>
<td>°C</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Time: 11:45</td>
<td></td>
<td>Time: 10:25</td>
<td>20.1</td>
</tr>
<tr>
<td>Conductivity</td>
<td>µS/cm</td>
<td>86.5</td>
<td>81.3</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>mg/L</td>
<td>88.8</td>
<td>7.68</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>89.9</td>
<td>84.6</td>
</tr>
</tbody>
</table>

---

## Table 4.6-6: Physical Features Observed at Site 6

<table>
<thead>
<tr>
<th>In-stream Substrate</th>
<th>Bedrock</th>
<th>Boulder</th>
<th>Cobbles</th>
<th>Gravel</th>
<th>Sand</th>
<th>Silt</th>
<th>Organic</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>5%</td>
<td>15%</td>
<td>10%</td>
<td>-</td>
<td>35%</td>
<td>-</td>
<td>35%</td>
<td></td>
</tr>
</tbody>
</table>

Bank Stability/Erosion: Stable/abundant vegetation

---

## Table 4.6-5: Fauna Observed at Site 6

<table>
<thead>
<tr>
<th>Fauna Species</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mammals</td>
<td>-</td>
</tr>
<tr>
<td>Mollusca</td>
<td>-</td>
</tr>
<tr>
<td>Reptiles</td>
<td>-</td>
</tr>
</tbody>
</table>
### Table 4.7-2: Field Measurements for Site 7

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Time: 11:45</td>
<td>Time: 10:25</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>7.45</td>
<td>7.52</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>1.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Air Temperature</td>
<td>ºC</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>54.721</td>
<td>52.483</td>
</tr>
<tr>
<td>Channel Width</td>
<td>m</td>
<td>6.1</td>
<td>6.1</td>
</tr>
<tr>
<td>Channel Depth</td>
<td>m</td>
<td>0.52</td>
<td>0.75</td>
</tr>
<tr>
<td>Velocity</td>
<td>m/s</td>
<td>0.23</td>
<td>0.14</td>
</tr>
</tbody>
</table>

### Table 4.7-3: Laboratory Water Quality Results for Site 7

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>PWQO Guidelines</th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Time: 11:45</td>
<td>Time: 10:25</td>
</tr>
<tr>
<td><strong>Bacteriological</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Escherichia Coli</em></td>
<td>MPN/100mL</td>
<td>100</td>
<td>108</td>
<td>99</td>
</tr>
<tr>
<td>Total Coliforms</td>
<td>MPN/100mL</td>
<td>1000 (prior to 1994)</td>
<td>1730</td>
<td>1730</td>
</tr>
<tr>
<td><strong>Physical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductivity (EC)</td>
<td>uS/cm</td>
<td>N/A</td>
<td>80.2</td>
<td>83.4</td>
</tr>
<tr>
<td>pH</td>
<td>6.5-8.5</td>
<td>N/A</td>
<td>7.34</td>
<td>7.50</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>N/A</td>
<td>55</td>
<td>61</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>N/A</td>
<td>1.46</td>
<td>2.74</td>
</tr>
<tr>
<td><strong>Nutrients and Anions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia-N, Total</td>
<td>mg/L</td>
<td>N/A</td>
<td>&lt;0.020</td>
<td>0.175</td>
</tr>
<tr>
<td>Un-ionized Ammonia</td>
<td>mg/L</td>
<td>0.2</td>
<td>&lt;0.0002</td>
<td>0.0021</td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>mg/L</td>
<td>N/A</td>
<td>2.94</td>
<td>2.15</td>
</tr>
<tr>
<td>Nitrate-N (NO₃-N)</td>
<td>mg/L</td>
<td>N/A</td>
<td>&lt;0.020</td>
<td>0.023</td>
</tr>
<tr>
<td>Nitrite-N (NO₂-N)</td>
<td>mg/L</td>
<td>N/A</td>
<td>&lt;0.010</td>
<td>&lt;0.010</td>
</tr>
<tr>
<td>Phosphorus (P)-Total</td>
<td>mg/L</td>
<td>0.03</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Sulfate (SO₄)</td>
<td>mg/L</td>
<td>N/A</td>
<td>6.07</td>
<td>5.82</td>
</tr>
<tr>
<td><strong>Metals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum (Al)</td>
<td>mg/L</td>
<td>0.075</td>
<td>0.064</td>
<td>0.080</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>mg/L</td>
<td>0.0001 (0-100 mg/L CaCO₃)</td>
<td>0.000023</td>
<td>0.000028</td>
</tr>
<tr>
<td></td>
<td>mg/L</td>
<td>0.0005 (&gt;100 mg/L CaCO₃)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cobalt (Co)</td>
<td>mg/L</td>
<td>0.0009</td>
<td>&lt;0.00010</td>
<td>0.00013</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>mg/L</td>
<td>0.005 (interim)</td>
<td>0.0018</td>
<td>0.0018</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>mg/L</td>
<td>0.300</td>
<td><strong>0.343</strong></td>
<td><strong>0.585</strong></td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>mg/L</td>
<td>0.003 (30-80 mg/L CaCO₃)</td>
<td>0.00005</td>
<td>0.00010</td>
</tr>
<tr>
<td></td>
<td>mg/L</td>
<td>0.005 (&gt;80 mg/L CaCO₃)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>mg/L</td>
<td>N/A</td>
<td>1.93</td>
<td>1.99</td>
</tr>
</tbody>
</table>

**Bold** indicates exceedance above PWQO guidelines.
Table 4.7-4: Flora Observed at Site 7

<table>
<thead>
<tr>
<th>Forest Density / Stream Cover</th>
<th>10% stream cover</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Terrestrial Species</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trees</strong></td>
<td><strong>Shrubs</strong></td>
</tr>
<tr>
<td>White Spruce</td>
<td>Willow Spp.</td>
</tr>
<tr>
<td>Black Ash</td>
<td>Speckled Alder</td>
</tr>
<tr>
<td>Black Spruce</td>
<td>Red Osier Dogwood</td>
</tr>
<tr>
<td>Trembling Aspen</td>
<td></td>
</tr>
<tr>
<td>Balsam Fir</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aquatic Macrophytes and Algae</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergent</td>
<td>Floating Algae</td>
</tr>
<tr>
<td>Rooted Floating</td>
<td>Filaments</td>
</tr>
<tr>
<td>Submergent</td>
<td>Attached Algae</td>
</tr>
<tr>
<td>Free Floating</td>
<td>Slimes or Crusts</td>
</tr>
</tbody>
</table>

Table 4.7-5: Fauna Observed at Site 7

<table>
<thead>
<tr>
<th>Fauna Species</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphibians</td>
<td></td>
</tr>
<tr>
<td>Birds</td>
<td></td>
</tr>
<tr>
<td>Crustaceans</td>
<td></td>
</tr>
<tr>
<td>Fish</td>
<td></td>
</tr>
<tr>
<td>Insects</td>
<td>Dragonfly</td>
</tr>
<tr>
<td>Mammals</td>
<td></td>
</tr>
<tr>
<td>Mollusca</td>
<td></td>
</tr>
<tr>
<td>Reptiles</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.7-6: Physical Features Observed at Site 7

<table>
<thead>
<tr>
<th>In-stream Substrate</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedrock</td>
<td></td>
</tr>
<tr>
<td>Boulder</td>
<td></td>
</tr>
<tr>
<td>Cobbles</td>
<td>5%</td>
</tr>
<tr>
<td>Gravel</td>
<td>15%</td>
</tr>
<tr>
<td>Sand</td>
<td>30%</td>
</tr>
<tr>
<td>Silt</td>
<td>30%</td>
</tr>
<tr>
<td>Organic</td>
<td>20%</td>
</tr>
<tr>
<td>Clay</td>
<td></td>
</tr>
</tbody>
</table>

| Bank Stability/ Erosion | Stable/ abundant vegetation |

4.8 Site 8

Site 8 was located on the northeast side of Oliver Lake and was accessed on East Oliver Lake Road, across from 196 East Oliver Lake Road. This site was a good representation of the headwaters of the watershed. The substrate at this site included clay, silt, sand, gravel and cobbles. Along the shore of the sampling area, there was rip rap present with little to no vegetation. The banks of the shoreline on the other side of the road were stable with abundant vegetation in the riparian zone including white spruce, balsam poplar, white birch, willow, speckled alder and clover. The soil type present at this site in the “B” Horizon and “C” Horizon was loamy sand.
The laboratory results showed that the June 14, 2016 and July 14, 2016 samples taken at this site did not exceed the PWQO guidelines for any parameters.

Table 4.8-1: Location References for Site 8

<table>
<thead>
<tr>
<th>Location Description</th>
<th>East Oliver Lake Road, at Oliver Lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTM Coordinates</td>
<td>Northing 5349812 Easting 309530</td>
</tr>
<tr>
<td>Altitude/Elevation</td>
<td>360.70 metres above sea level</td>
</tr>
</tbody>
</table>

Table 4.8-2: Field Measurements for Site 8

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Date: 14-JUN-16</th>
<th>Time: 11:10</th>
<th>Date: 14-JUL-16</th>
<th>Time: 10:05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Temperature</td>
<td>°C</td>
<td>14.5</td>
<td>20.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductivity</td>
<td>uS/cm</td>
<td>73.4</td>
<td>73.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>mg/L</td>
<td>10.32</td>
<td>8.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>%</td>
<td>101.2</td>
<td>95.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>7.82</td>
<td>7.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>0.5</td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Temperature</td>
<td>°C</td>
<td>14</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>47.718</td>
<td>47.901</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Channel Width</td>
<td>m</td>
<td>1.8</td>
<td>1.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Channel Depth</td>
<td>m</td>
<td>0.37</td>
<td>0.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity</td>
<td>m/s</td>
<td>0.76</td>
<td>0.77</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.8-3: Laboratory Water Quality Results for Site 8

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>PWQO Guidelines</th>
<th>Date: 14-JUN-16</th>
<th>Time: 11:10</th>
<th>Date: 14-JUL-16</th>
<th>Time: 10:05</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacteriological</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Escherichia Coli</em></td>
<td>MPN/100mL</td>
<td>100</td>
<td>&lt;1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Coliforms</td>
<td>MPN/100mL</td>
<td>1,000 (prior to 1994)</td>
<td>53</td>
<td>365</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Physical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductivity (EC)</td>
<td>uS/cm</td>
<td>N/A</td>
<td>74.1</td>
<td>76.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td></td>
<td>6.5-8.5</td>
<td>7.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>N/A</td>
<td>39</td>
<td>48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>N/A</td>
<td>0.46</td>
<td>0.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia-N, Total</td>
<td>mg/L</td>
<td>N/A</td>
<td>&lt;0.020</td>
<td>0.106</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Un-ionized Ammonia</td>
<td>mg/L</td>
<td>0.2</td>
<td>&lt;0.0002</td>
<td>0.0040</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>mg/L</td>
<td>N/A</td>
<td>2.23</td>
<td>1.91</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrate-N (NO₃-N)</td>
<td>mg/L</td>
<td>N/A</td>
<td>&lt;0.020</td>
<td>&lt;0.020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrite-N (NO₂-N)</td>
<td>mg/L</td>
<td>N/A</td>
<td>&lt;0.010</td>
<td>&lt;0.010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorus (P)-Total</td>
<td>mg/L</td>
<td>0.03</td>
<td>0.003</td>
<td>&lt;0.003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfate (SO₄)</td>
<td>mg/L</td>
<td>N/A</td>
<td>8.23</td>
<td>8.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Metals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum (Al)</td>
<td>mg/L</td>
<td>0.075</td>
<td>0.016</td>
<td>0.022</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>mg/L</td>
<td>0.0001 (0-100 mg/L CaCO₃)</td>
<td>&lt;0.0000005</td>
<td>0.000010</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>mg/L</td>
<td>0.0005 (&gt;100 mg/L CaCO₃)</td>
<td>&lt;0.0000005</td>
<td>0.000010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cobalt (Co)</td>
<td>mg/L</td>
<td>0.0009</td>
<td>&lt;0.0010</td>
<td>&lt;0.00010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>mg/L</td>
<td>0.005 (interim)</td>
<td>0.0012</td>
<td>0.0010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>mg/L</td>
<td>0.300</td>
<td>0.028</td>
<td>0.043</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 4.8-3: Laboratory Water Quality Results for Site 8

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>PWQO Guidelines</th>
<th>Date: 14-JUN-16</th>
<th>Date: 14-JUL-16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead (Pb)</td>
<td>mg/L</td>
<td>0.003 (30-80 mg/L CaCO₃)</td>
<td>&lt;0.00005</td>
<td>&lt;0.00005</td>
</tr>
<tr>
<td></td>
<td>mg/L</td>
<td>0.005 (&gt;80 mg/L CaCO₃)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>mg/L</td>
<td>N/A</td>
<td>1.80</td>
<td>1.82</td>
</tr>
</tbody>
</table>

*Bold* indicates exceedance above PWQO guidelines

### Table 4.8-4: Flora Observed at Site 8

**FEC V-Type:** V15 White Spruce Mixedwood

**Forest Density / Stream Cover:** 0% stream cover

#### Terrestrial Species

<table>
<thead>
<tr>
<th>Trees</th>
<th>Shrubs</th>
<th>Herbs</th>
<th>Ferns / Horsetails / Mosses / Grasses</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Spruce</td>
<td>Willow Spp.</td>
<td>Red Clover</td>
<td>Field Horsetail</td>
</tr>
<tr>
<td>White Birch</td>
<td>Speckled Alder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jack Pine</td>
<td>Narrow-Leaved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Pine</td>
<td>Meadowsweet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balsam Poplar</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Aquatic Macrophytes and Algae

<table>
<thead>
<tr>
<th></th>
<th>Floating Algae</th>
<th>Filaments</th>
<th>Attached Algae</th>
<th>Slimes or Crusts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergent</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rooted Floating</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Submergent</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Free Floating</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 4.8-5: Fauna Observed at Site 8

#### Fauna Species

<table>
<thead>
<tr>
<th>Amphibians</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birds</td>
<td>-</td>
</tr>
<tr>
<td>Crustaceans</td>
<td>-</td>
</tr>
<tr>
<td>Fish</td>
<td>Minnows</td>
</tr>
<tr>
<td>Insects</td>
<td>Water Beatles</td>
</tr>
<tr>
<td>Mammals</td>
<td>Red Squirrel</td>
</tr>
<tr>
<td>Mollusca</td>
<td>-</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Painted Turtle</td>
</tr>
</tbody>
</table>

### Table 4.8-6: Physical Features Observed at Site 8

#### In-stream Substrate

<table>
<thead>
<tr>
<th>Bedrock</th>
<th>Boulder</th>
<th>Cobble</th>
<th>Gravel</th>
<th>Sand</th>
<th>Silt</th>
<th>Organic</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>-</td>
<td>20%</td>
<td>20%</td>
<td>30%</td>
<td>15%</td>
<td>-</td>
<td>15%</td>
</tr>
</tbody>
</table>

*Bank Stability/ Erosion:* Stable/ abundant vegetation

### 4.9 Watershed Report Card Results

The overall surface water quality for the Oliver Creek watershed maintained a total averaged point score of 3.8. With minimal exceedances for phosphorus and for *E. coli,*
the rating of the surface water quality for the Oliver Creek watershed was determined to have a grade of B.

The forest coverage for the Oliver Creek watershed was 33.9 square kilometres (70.8 percent), interior forest coverage was 18.9 square kilometres (35.9 percent) and the riparian forest cover was 2.9 square kilometres (6.0 percent). These percentages generated a total point score of eleven (average of 3.7) for the forest conditions, which determined a grade of B.

<table>
<thead>
<tr>
<th>Site Number</th>
<th>Average Total Phosphorus (mg/L)</th>
<th>Average E. coli (MPN/100mL)</th>
<th>Average of Benthic Invertebrates</th>
<th>Total Point Score</th>
<th>Grade</th>
<th>Overall Surface Water Quality Grade</th>
<th>Final Points</th>
<th>Final Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0256</td>
<td>35</td>
<td>N/A</td>
<td>8</td>
<td>B</td>
<td>4</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.0260</td>
<td>73</td>
<td>N/A</td>
<td>8</td>
<td>B</td>
<td>4</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.1975</td>
<td>356</td>
<td>N/A</td>
<td>3</td>
<td>D</td>
<td>1.5</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.0208</td>
<td>57</td>
<td>N/A</td>
<td>8</td>
<td>B</td>
<td>4</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.0225</td>
<td>23</td>
<td>N/A</td>
<td>9</td>
<td>A</td>
<td>4.5</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.0202</td>
<td>37</td>
<td>N/A</td>
<td>8</td>
<td>B</td>
<td>4</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0.0095</td>
<td>104</td>
<td>N/A</td>
<td>8</td>
<td>B</td>
<td>4</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0.0015</td>
<td>2</td>
<td>N/A</td>
<td>10</td>
<td>A</td>
<td>5</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>% Forest Cover</th>
<th>% Forest Interior</th>
<th>% Riparian Zone Forested</th>
<th>Total Point Score</th>
<th>Grade</th>
<th>Final Points</th>
<th>Final Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>70.8</td>
<td>39.5</td>
<td>6.0</td>
<td>11</td>
<td>B</td>
<td>3.7</td>
<td>B</td>
</tr>
</tbody>
</table>
5 DISCUSSION

The Oliver Creek watershed was sampled at eight different locations, chosen based on accessibility and possible contamination sources, as well as attempting to reach all areas of the watershed. The first sampling period was on June 14, 2016 and the second sampling period on July 14, 2016.

The average air temperature for the June 14, 2016 sampling period was 15.1 degrees Celsius which exceeded the monthly average temperature of 14.5 degrees Celsius for June 2016 as well as the historical average of 14 degrees Celsius for June 1971-2000 in Thunder Bay. The average air temperature for the July sampling period was 18.6 degrees Celsius, which was the same as the monthly average temperature for July 2016 and exceeded the historical average of 17.6 degrees Celsius for July 1971-2000. Precipitation for the month of June totaled 212.7 millimetres, which was above the historical monthly average of 85.7 millimetres for Thunder Bay from June 1971-2000. In July, precipitation totaled 70.7 millimetres, which was below the historical monthly average of 89 millimetres for July 1971-2000. During the June and July sampling period, the sky was mostly overcast.

Water temperatures ranged from 13.5 degrees Celsius to 16.0 degrees Celsius in June and 19.1 degrees Celsius to 20.3 degrees Celsius in July, which can be seen on Figure 3: Oliver Creek Watershed Water Temperature. The stream depths observed ranged from 0.16 metres to 0.88 metres for both June and July. Water levels increased at Sites 1, 5, and 8 and decreased at Sites 3, 4, 6, and 7 between June and July.

All of the eight sample locations were water crossings that required a bridge or culvert to support the road. The only bridge was at Site 8. The bridge was made out of timber beams and did not appear to alter flow in a significant way, or change the natural stream course. Rip rap protection was used along the sides of the bridge and aided in bridge support as well as erosion and sedimentation control from road run-off. Culverts were present at Sites 1, 2, 3, 4, 5, 6 and 7. The culverts at these sites were in good condition and were large enough to withstand increased velocity and water levels from heavy rainfall. The culverts at Site 2 and 3 were starting to rust through on the bottom.

A vegetation assessment was carried out at each site, recording species present within view of each site. A summary of each site is included in Appendix F: Forest Ecosystem Classification. Forest Ecosystem Classification type V-15 White Spruce Mixedwood, was the most common and occurred at Sites 2, 5 and 8. The remaining sites still had a similar mixedwood forest type favouring coniferous species as opposed to hardwood. The dominant tree species within the Oliver Creek watershed included white spruce, balsam poplar, trembling aspen, jack pine and black spruce. The shrub layer was very diverse throughout the watershed, with many species present. Some commonly
observed species in the shrub layer were chokecherry, red osier dogwood, alder, raspberry, and willow species. The ground cover and herb layer included wildflowers typical of disturbed sites, most likely due to the habitat provided by roadsides. The most commonly observed herb and wildflower species included dandelion, ox-eyed daisy, swamp thistle, goldenrod, cow vetch, red and white clover. No invasive plant species or species at risk were seen at the sample sites within the Oliver Creek watershed.

Overall, the stream banks documented within the Oliver Creek watershed were stable. The main soil types were silty loam and sandy loam. Some of the sites were mainly silty but had vegetation right up to the edge of the water, while some had more boulder and cobble. Both types of substrate aid the banks by helping with slope stability and keeping erosion to a minimum.

The PWQO acceptable pH range is 6.5-8.5. The range within the Oliver Creek watershed was 7.45 to 8.22 as illustrated on Figure 4: pH Level at Oliver Creek Sample Sites. The average pH lies within a good water quality range.

Total Dissolved Solids (TDS) can be related to conductivity since the dissolved solids are what conduct an electric current through the water. The more dissolved solids present in a solution, the greater the conductive potential, as there are more ions present to carry the charge. The relationship can be seen in the watershed data when comparing between Figure 5: Conductivity at Oliver Creek Sample Sites and Figure 6: Total Dissolved Solids (TDS) at Oliver Creek Sample Sites, the highest reading for TDS and conductivity were at Site 3, and the lowest readings for both parameters were at Site 8.

As a limiting nutrient to aquatic vegetation, phosphorus is important to monitor in watersheds to avoid excessive vegetation growth, which can lead to lowered dissolved oxygen. Phosphorus exceeded the PWQO of 0.03 mg/L during the June sampling period at Site 3 with a value of 0.16 mg/L. During the July sampling period Sites 1, 2, and 3 were all in exceedance with a range of 0.0311 mg/L to 0.2350 mg/L. The average concentration of phosphorus was 0.03 mg/L for all sites during the June sampling month and 0.0534 mg/L during the July sampling month. The elevated levels of phosphorus could be related to high clay content in the creek, since phosphorus sorption capacity can increase with clay content.

Monitoring of bacterial levels in surface water is often limited to *E. coli*, as this is the most common water-borne pathogen that can cause illness and death. The *E. coli* levels at Site 3 and Site 7 were in exceedance of the PWQO of 100 MPN/100mL. Site 3 had a value of 687 MPN/100mL on July 14, 2016 and Site 7 had a value of 108 MPN/100mL on June 14, 2016. The rest of the sampling sites did not show any exceedances. The presence of *E. coli* in the watershed ranged from <1 to 687 MPN/100mL. The *E. coli* levels are illustrated on Figure 7: Escherichia Coli Bacteria Counts at Oliver Creek Watershed.
Sample Sites. Presence of *E. coli* indicates a fecal contamination source nearby, but there are instances when fecal contamination occurs and testing does not show *E. coli* are present. It was noted at Site 7 that a beaver dam was present upstream and a farm was located upstream of Site 3; however, there were no exceedances of *E. coli* at the farthest downstream sample locations. Many studies have shown that the presence of farm animals near a stream can significantly influence bacteria counts. *E. coli* could also enter the watershed from leaking residential septic tanks and/or from manure. Total coliforms are among the flora present in the intestinal tract of animals and are often present in much greater numbers than potential pathogens, such as *E. coli*. Therefore, coliforms are easier to isolate and identify within a water sample. In order to better determine the possibility of contamination, total coliforms are measured in surface water as indicators of pathogenic bacteria contamination. No current PWQO exists for total coliforms. Total coliforms exceeded the pre-1994 PWQO of 1,000 MPN/100mL at all the sites with the exception of Site 8 during the June and July sampling period. The highest level of total coliforms present was >2,420 MPN/100mL at Sites 3 and 4 on June 14, 2016 and Sites 1, 2, 3 and 4 on July 14, 2016. Total coliforms ranged from 53 to >2,420 MPN/100mL.

Total ammonia ranged from <0.020 mg/L to 0.175 mg/L. Total ammonia does not have a singular criterion because its speciation between un-ionized and total forms are dependent on pH and temperature parameters. Total ammonia concentrations reported by the laboratory were converted into un-ionized ammonia concentrations using the conversion table provided in the PWQO guidelines. All un-ionized ammonia concentrations in the Oliver Creek watershed were <0.008 mg/L (with PWQO criterion of 0.020 mg/L). These guidelines were put in place for protection from direct toxic effects and do not consider indirect effects due to eutrophication (large algae blooms).

The PWQO criterion of 0.075 mg/L for aluminum was exceeded during the June sampling period at Sites 1, 2, 3, 4, 5 and 6, as well as Sites 1, 2, 3, 4, 5, 6 and 7 during the July sampling period. Aluminum concentrations ranged from 0.016 mg/L at Site 8 on June 14, 2016 to 0.331 mg/L at Site 6 on June 14, 2016. The average concentration of aluminum was 0.167 mg/L for all sites during the June sampling period and 0.1503 mg/L during the July sampling period.

All sites except for Site 8 were above the PWQO criterion of 0.3 mg/L for iron during both the sampling months of June and July, 2016. Iron concentrations ranged between 0.028 mg/L at Site 8 on June 14, 2016 and 1.510 mg/L at Site 5 on July 14, 2016. The average concentration of iron was 0.739 mg/L for the June sampling period and 0.995 mg/L for the July sampling period.

High aluminum and iron levels may be caused by the underlying geology. These metals may naturally dissociate from mineral-rich rocks. The exceedances are likely a result of natural source and are commonly high within the region.
The overall health of the Oliver Creek watershed was determined using the ratings from surface water quality and forest conditions, which were combined to give a grade for the Watershed Report Card. Given the number of exceedances for phosphorus and E. coli, the overall health of the Oliver Creek watershed surface water quality has received a rating (B) for its Watershed Report Card rating. The Oliver Creek forest conditions based on forest coverage, forest interior, and riparian zone forested, were determined to also result in a rating of (B). Based on this rating and other observed conditions, the Oliver Creek watershed has been determined to have good overall health.
6 CONCLUSION

The Oliver Creek watershed was determined to be in good condition with minimal evident anthropogenic impacts. Surface water quality at the time of the study was good, with the exceedances of the Provincial Water Quality Objectives being mostly attributed to natural sources. Plant species composition seems characteristic of the boreal forest, with diversity at each site among the overstory, understory and herb layer. A more comprehensive fauna study would give a clear indication of the species and populations present, but at the time of the study, multiple species were observed giving a good representation of a typical boreal forest area. Water levels appeared consistent with previous water markings. Erosion was not typically a concern, as the stream banks were stable. Stream cover was often provided by shrubs and trees growing along the creek banks which also helped prevent erosion. Bridges and culverts were in stable condition with no immediate concern for maintenance.
7 RECOMMENDATIONS

Upon completion of the 2016 Oliver Creek Watershed Assessment, the following recommendations have been made for considerations:

- Staff and funding permitting it is recommended that an update to the 2016 Oliver Creek Watershed Assessment be completed in the next five to ten years.
- Benthic analysis indicates water quality over an extended period of time and should be considered for future watershed assessments.
- Additional sampling should be conducted in the spring to observe the water quality differences between high and low flow seasons.
- A copy of this report should be provided to the Municipality of Neebing and Municipality of Oliver Paipoonge for reference purposes. The report should be kept on file at the LRCA Administration Office for review by interested parties.
8 REFERENCES


Figures
The Oliver Creek Watershed forms in an erosional valley of soft Animikie Shales bounded to the south by mesas and cuestas of hard igneous diabase sills.

Figure 1: Rock Formations South of Thunder Bay

Figure 2: Canada’s Forest Regions (Canadian Forest Service, 2013)
Figure 3: pH Level at Oliver Creek Sample Sites

Figure 4: Water Temperature °C at Oliver Creek Sample Sites
Figure 4: Water Temperature at Oliver Creek Sample Sites

Figure 5: Total Dissolved Solids at Oliver Creek Sample Sites

Figure 6: Conductivity at Oliver Creek Sample Sites
Figure 8: *Escherichia Coli* Bacteria Counts at Oliver Creek Sample Sites
Maps
Oliver Creek Watershed

M-6: Soils

Legend

- Sampling Sites
- Elgin Lake
- Otter Creek
- Silver Creek
- Oliver Creek
- Oliver Lake
- MUNICIPALITY OF NEEBING
- MUNICIPALITY OF OLIVER
- PAIPOONGE
- TOWNSHIP OF O'CONNOR
- TOWNSHIP OF GILLIES

Drainage

- Water Body
- Provincially Significant Wetland
- Wetland
- Stream
- River
- Ditch

Soils

- Organic (O)
- Clay (c)
- Clay Loam (cl)
- Clay Loamy (cl)
- Fine Sandy Loam (fsl)
- Sandy Loam (sil)
- Loamy Sand (ls)
- Peaty Phase (pp)
- Rock (r)
- Coarse Sand and Loamy Sand (s)
- Silty Clay Loam (sicl)
- Silt Loam (sil)
- Moderately Coarse Sandy Loam (sl)
- Very Fine Sandy Loam (vfsl)
- Gravel (g)
- Gravelly Sand (gs)
- Gravelly Sand Loam (gsl)
- Medium to Moderately Fine Loam (l)
- Datum: NAD 83
- Projection: UTM Zone 16N
- Date: March 2017
- Copyright 2017, LRCA

This map is illustrative only. Do not rely on it as being a precise or a total depiction of routes or features, nor as a guide to navigation.

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130 Conservation Rd.
Thunder Bay, ON
P7B 6T8

Base data used under license through the members of the Ontario Geospatial Data Exchange.
Zoning Information based on the best available information, not all zones may be depicted.
Appendix A:
Soil Logging Summary and Photography
## Appendix A: Soil Logging Summary and Photography

### Soil Logging Summary

<table>
<thead>
<tr>
<th>SITE ID</th>
<th>Organic Layer “O”</th>
<th>“A” Horizon</th>
<th>“B” Horizon</th>
<th>“C” Horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td>OC1</td>
<td></td>
<td>0-10cm Sand (S)</td>
<td>10-70cm Sandy Gravel (SG)</td>
<td>70cm-&gt; cobbles</td>
</tr>
<tr>
<td>OC2</td>
<td></td>
<td>0-10cm brown Sandy Loam (SL)</td>
<td></td>
<td>10cm-&gt; Rock (r) shale</td>
</tr>
<tr>
<td>OC3</td>
<td></td>
<td>0-30cm Sandy Loam (SL)</td>
<td>30-90cm Sandy Loam (SL) &gt;10% Coarse</td>
<td></td>
</tr>
<tr>
<td>OC4</td>
<td></td>
<td>0-50cm Loamy sand (LS)</td>
<td></td>
<td>50-90cm Silty Clay Loam (SiCl)</td>
</tr>
<tr>
<td>OC5</td>
<td>0-15cm Mesic Organic (O)</td>
<td>15-25cm Silty Clay loam (SiCl)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OC6</td>
<td>0-5cm Organic (O)</td>
<td>5-40cm Sandy Loam (SL)</td>
<td>40-100cm Loam(L)&gt;50% Coarse</td>
<td></td>
</tr>
<tr>
<td>OC7</td>
<td>0-5cm Sandy Loam (SL)</td>
<td>5-60cm Loamy Sand (LS)</td>
<td></td>
<td>60-95cm Loamy Sand (LS)</td>
</tr>
<tr>
<td>OC8</td>
<td></td>
<td>0-45cm Loamy Sand (LS)</td>
<td></td>
<td>45-95cm Loamy Sand (LS)</td>
</tr>
</tbody>
</table>
Soil Photography

Site 1
Site 2

Site 2 – Shale Bedrock
Site 5

Site 6
Appendix B:
Common and Scientific Names of Identified Flora and Fauna
Appendix B: Common and Scientific Names of Identified Flora and Fauna

<table>
<thead>
<tr>
<th>Flora</th>
<th>Common Name</th>
<th>Scientific (Latin) Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trees</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apple spp.</td>
<td></td>
<td><em>Malus spp.</em></td>
</tr>
<tr>
<td>Balsam poplar</td>
<td></td>
<td><em>Populus balsamifera</em></td>
</tr>
<tr>
<td>Black ash</td>
<td></td>
<td><em>Fraxinus nigra</em></td>
</tr>
<tr>
<td>Black spruce</td>
<td></td>
<td><em>Picea mariana</em></td>
</tr>
<tr>
<td>Jack pine</td>
<td></td>
<td><em>Pinus banksiana</em></td>
</tr>
<tr>
<td>Tamarack</td>
<td></td>
<td><em>Larix laricina</em></td>
</tr>
<tr>
<td>Trembling aspen</td>
<td></td>
<td><em>Populus tremuloides</em></td>
</tr>
<tr>
<td>White birch</td>
<td></td>
<td><em>Betula papyrifera</em></td>
</tr>
<tr>
<td>White pine</td>
<td></td>
<td><em>Pinus strobus</em></td>
</tr>
<tr>
<td>White spruce</td>
<td></td>
<td><em>Picea glauca</em></td>
</tr>
<tr>
<td><strong>Shrubs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beaked hazel</td>
<td></td>
<td><em>Corylus cornuta</em></td>
</tr>
<tr>
<td>Bush honeysuckle</td>
<td></td>
<td><em>Diervilla lonicera</em></td>
</tr>
<tr>
<td>Canada goldenrod</td>
<td></td>
<td><em>Solidago canadensis</em></td>
</tr>
<tr>
<td>Fringed bindweed</td>
<td></td>
<td><em>Polygonum cilinode</em></td>
</tr>
<tr>
<td>Green alder</td>
<td></td>
<td><em>Alnus viridis</em></td>
</tr>
<tr>
<td>Highbush cranberry</td>
<td></td>
<td><em>Viburnum trilobum</em></td>
</tr>
<tr>
<td>Showy mountain-ash</td>
<td></td>
<td><em>Sorbus americana</em></td>
</tr>
<tr>
<td>Mountain maple</td>
<td></td>
<td><em>Acer spicatum</em></td>
</tr>
<tr>
<td>Northern wild black current</td>
<td></td>
<td><em>Ribes hudsonianum</em></td>
</tr>
<tr>
<td>Pin cherry</td>
<td></td>
<td><em>Prunus pensylvanica</em></td>
</tr>
<tr>
<td>Prickly wild rose</td>
<td></td>
<td><em>Rosa acicularis</em></td>
</tr>
<tr>
<td>Red-osier dogwood</td>
<td></td>
<td><em>Cornus stolonifera</em></td>
</tr>
<tr>
<td>Saskatoon (serviceberry)</td>
<td></td>
<td><em>Amelanchier alnifolia</em></td>
</tr>
<tr>
<td>Speckled alder</td>
<td></td>
<td><em>Alnus rugosa</em></td>
</tr>
<tr>
<td>Virginia creeper</td>
<td></td>
<td><em>Parthenocissus quinquefolia</em></td>
</tr>
<tr>
<td>Wild red raspberry</td>
<td></td>
<td><em>Rubus idaeus</em></td>
</tr>
<tr>
<td>Willow spp.</td>
<td></td>
<td><em>Salix spp.</em></td>
</tr>
<tr>
<td><strong>Herbs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American vetch</td>
<td></td>
<td><em>Vicia americana</em></td>
</tr>
<tr>
<td>Canada anemone</td>
<td></td>
<td><em>Anemone canadensis</em></td>
</tr>
<tr>
<td>Canada goldenrod</td>
<td></td>
<td><em>Solidago canadensis</em></td>
</tr>
<tr>
<td>Common strawberry</td>
<td></td>
<td><em>Fragaria virginiana</em></td>
</tr>
<tr>
<td>Cow parsnip</td>
<td></td>
<td><em>Heracleum lanatum</em></td>
</tr>
<tr>
<td>Cow vetch</td>
<td></td>
<td><em>Vivia cracca</em></td>
</tr>
<tr>
<td>Dandelion</td>
<td></td>
<td><em>Taraxacum officinale</em></td>
</tr>
<tr>
<td>Common Name</td>
<td>Scientific (Latin) Name</td>
<td></td>
</tr>
<tr>
<td>--------------------</td>
<td>----------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Herbs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mullein</td>
<td>Verbascum thapsus</td>
<td></td>
</tr>
<tr>
<td>Northern bluebell</td>
<td>Mertensia paniculata</td>
<td></td>
</tr>
<tr>
<td>Large leaved aster</td>
<td>Aster macrophyllus</td>
<td></td>
</tr>
<tr>
<td>Lupines</td>
<td>Lupinus albus</td>
<td></td>
</tr>
<tr>
<td>Orange hawkweed</td>
<td>Hieracium aurantiacum</td>
<td></td>
</tr>
<tr>
<td>Ox-eye daisy</td>
<td>Leucanthemum vulgare</td>
<td></td>
</tr>
<tr>
<td>Red clover</td>
<td>Trifolium pratense</td>
<td></td>
</tr>
<tr>
<td>Rose-twisted stalk</td>
<td>Streptopus amplexifolius</td>
<td></td>
</tr>
<tr>
<td>Rough Bedstraw</td>
<td>Galium asprellum</td>
<td></td>
</tr>
<tr>
<td>Sweet coltsfoot</td>
<td>Petasites frigidus</td>
<td></td>
</tr>
<tr>
<td>Swamp thistle</td>
<td>Cirsium muticum</td>
<td></td>
</tr>
<tr>
<td>Wild Columbine</td>
<td>Aquilegia canadensis</td>
<td></td>
</tr>
<tr>
<td>Wild Pea</td>
<td>Lathyrus palustris</td>
<td></td>
</tr>
<tr>
<td>Woodland strawberry</td>
<td>Fragaria vesca</td>
<td></td>
</tr>
<tr>
<td>Yarrow</td>
<td>Achillea millefolium</td>
<td></td>
</tr>
<tr>
<td>Yellow hawkweed</td>
<td>Hieracium pratense</td>
<td></td>
</tr>
<tr>
<td><strong>Ferns/Mosses/Graminoids/Lichens</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulrush spp.</td>
<td>Scirpus spp.</td>
<td></td>
</tr>
<tr>
<td>Common reed</td>
<td>Phragmites australis</td>
<td></td>
</tr>
<tr>
<td>Dog's tooth lichen</td>
<td>Peltigera canina</td>
<td></td>
</tr>
<tr>
<td>Horsetail - field</td>
<td>Equisetum arvense</td>
<td></td>
</tr>
<tr>
<td>Horsetail - swamp</td>
<td>Equisetum fluviatile</td>
<td></td>
</tr>
<tr>
<td>Horsetail - woodland</td>
<td>Equisetum sylvaticum</td>
<td></td>
</tr>
<tr>
<td>Lady fern</td>
<td>Athyrium filix-femina</td>
<td></td>
</tr>
<tr>
<td>Oak fern</td>
<td>Gymnocarpium dryopteris</td>
<td></td>
</tr>
<tr>
<td>Plume moss</td>
<td>Ptilium crista-castrensis</td>
<td></td>
</tr>
<tr>
<td>Sedge spp.</td>
<td>Carex spp.</td>
<td></td>
</tr>
<tr>
<td>Sphagnum spp.</td>
<td>Sphagnum spp.</td>
<td></td>
</tr>
<tr>
<td><strong>Aquatic Plants</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common cattail</td>
<td>Typha latifolia</td>
<td></td>
</tr>
</tbody>
</table>
## Fauna

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific (Latin) Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fish</strong></td>
<td></td>
</tr>
<tr>
<td>Smallmouth bass</td>
<td><em>Micropterus dolomieu</em></td>
</tr>
<tr>
<td>Emerald Shiner</td>
<td><em>Notropis atherinoides</em></td>
</tr>
<tr>
<td>Shiner spp.</td>
<td><em>Notropis spp.</em></td>
</tr>
<tr>
<td><strong>Invertebrates</strong></td>
<td></td>
</tr>
<tr>
<td>Black flies</td>
<td><em>Simuliidae spp.</em></td>
</tr>
<tr>
<td>Eastern tiger swallowtail</td>
<td><em>Papilio glaucus</em></td>
</tr>
<tr>
<td>Midges</td>
<td><em>Pseudochironomus spp.</em></td>
</tr>
<tr>
<td>Mosquitoes</td>
<td><em>Culicidae spp.</em></td>
</tr>
<tr>
<td>Red ants</td>
<td><em>Solenopsis spp.</em></td>
</tr>
<tr>
<td>Spring azure</td>
<td><em>Celastrina ladon</em></td>
</tr>
<tr>
<td>Water spider</td>
<td><em>Papilio glaucus</em></td>
</tr>
<tr>
<td>Water strider</td>
<td><em>Gerridae spp.</em></td>
</tr>
<tr>
<td><strong>Aves</strong></td>
<td></td>
</tr>
<tr>
<td>Canada goose</td>
<td><em>Branta canadensis</em></td>
</tr>
<tr>
<td>Ruffed grouse</td>
<td><em>Bonasa umbellus</em></td>
</tr>
<tr>
<td>Common merganser</td>
<td><em>Mergus merganser</em></td>
</tr>
<tr>
<td><strong>Mammals</strong></td>
<td></td>
</tr>
<tr>
<td>White tail deer</td>
<td><em>Odocoileus virginianus</em></td>
</tr>
</tbody>
</table>
Appendix C:
Techniques for Data Collection
Appendix C: Techniques for Data Collection

Air Temperature
The air temperature was measured with a basic mercury thermometer.

Channel Width & Depth
The width of the stream was measured using a nylon measuring-tape reel. Channel depth was measured by using a stainless steel meter stick.

Conductivity
Conductivity was measured with the YSI Pro DSS. The accuracy of the reading was ±0.001 mS/cm or ±1.0%; whichever was greater. The readings were recorded once the probe was completely submerged and all readings stabilized. In addition to conductivity readings taken in the field, laboratory analysis of the samples provided a second reading of conductivity which is included within the results.

Dissolved Oxygen
The YSI Pro DSS measured dissolved oxygen for the samples. The readings were recorded once the probe was submerged in the water and all variables were stabilized.

Flora and Fauna Identification
Identification was made in the vicinity of the sample sites, no transects were made. Observations were made approximately 50 metres from either stream edge. Field guides were used to accurately identify species.

Flow
The velocity of river flow at sites was measured using a stick and nylon measuring-tape reel. Distances measured varied depending upon stream obstructions and variable depth. The flow was then calculated using the equation \( Q = V \times A \), where \( Q \) is flow/discharge, \( V \) is velocity (distance divided by time), and \( A \) is the cross sectional area of the stream.

Latitude, Longitude, and Elevation
The Universal Transverse Mercator (UTM) coordinates for each site were measured with a Trimble Geo XH 2008 hand held GPS unit.

Location
The sample sites were chosen using a 1:50,000 scale topographic map. The sample sites were also described in terms of road access and road crossings.
pH
The YSI Pro DSS measured pH for the water sample sites. The readings were recorded once the probe was submerged in the water and all the variables were stabilized. A pH reading was also taken during the analysis at the laboratory.

Photographs
Photographs were taken at each site using the Stylus 1030SW shock and water proof camera. Upstream and downstream photographs as well as culvert, bridge, and outstanding litter or erosion photographs were all taken at each site. Substrate photographs were attempted at each site with the waterproof camera.

Surface Water Sampling
Samples were taken at the same position at each site wherever possible. Grab sampling technique was used when conducting surface water sampling. Sample bottles were pre-charged with preservatives, so this did not have to be done in the field. Sample bottles were submerged 15 to 30 centimetres below the surface of the water body and positioned towards the flow of the water source. Samples were kept cool and delivered to ALS Laboratory for analyzing.

Total Dissolved Solids
The total dissolved solids (TDS) were measured in laboratory.

Turbidity
Turbidity of the water was measured with the YSI Pro DSS. The readings were taken after the probe was submerged and all variables on the meter were stabilized.

Water Temperature
Water temperature was measured with the YSI Pro DSS. The readings were taken after the probe was submerged and all variables on the meter were stabilized.

OBBN In-Stream Materials Key

Soil Type
Like stream bed description, soil type on land will impact vegetation and erosion potential. Soil type was categorized based on its grain size using the FEC Manual for North Western Ontario.

Stream Bed Description
The bed description was described by means of a visual scan of the sample site area, with percentages assigned to the appropriate categories of varying grain sizes:
### Grain Size

<table>
<thead>
<tr>
<th>Description</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulder</td>
<td>&gt; 25.6 cm in diameter</td>
</tr>
<tr>
<td>Cobble</td>
<td>6.4 - 25.6 cm in diameter</td>
</tr>
<tr>
<td>Gravel</td>
<td>0.2 – 6.4 cm in diameter</td>
</tr>
<tr>
<td>Sand</td>
<td>&lt; 0.2 cm in diameter</td>
</tr>
<tr>
<td>Silt</td>
<td>Finer inorganic material than sand</td>
</tr>
<tr>
<td>Organic</td>
<td>Mainly organic combination of silt and clay</td>
</tr>
<tr>
<td>Clay</td>
<td>Inorganic origin with no apparent structure</td>
</tr>
</tbody>
</table>

### Stream Cover

Stream cover describes the vegetation density along the river bank no more than 5 metres from the water’s edge. Stream cover was divided into three categories of density:

<table>
<thead>
<tr>
<th>Description</th>
<th>% Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense</td>
<td>75-100% shaded by canopy</td>
</tr>
<tr>
<td>Partly Open</td>
<td>25-75% shaded by canopy</td>
</tr>
<tr>
<td>Open</td>
<td>0-25% shaded by canopy</td>
</tr>
</tbody>
</table>
Appendix D:
Summary of Water Quality Parameters
Appendix D: Summary of Water Quality Parameters

Physical Properties

The abiotic factors of water quality are very influential on aquatic plants and animals and can have a significant impact on the ecosystem. The following physical parameters were measured either in the field or in the laboratory.

Conductivity
Conductivity is the measure of the ability of water to carry an electrical current expressed in microseimens per centimetre. The reading is used to determine the total dissolved solids (TDS) in the water sample. There is no PWQO for conductivity.

Dissolved Oxygen
Like terrestrial animals, fish and other aquatic species require oxygen to breathe. It is not the mere presence of dissolved oxygen that is important; the gas has to be above a certain concentration in order to sustain life. As well, oxygen is required to decompose organic matter in the stream. Dissolved oxygen levels will be highest if the water is colder, turbulent (a lot of mixing at the air-water interface) and during the day when aquatic plants have had time to produce oxygen during photosynthesis. PWQO's have an acceptable range for dissolved oxygen in water dependent upon temperature. At 20 degrees Celsius the minimum amount of dissolved oxygen is 5 milligrams per litre.

pH
The pH measures the concentration of hydrogen ions in the water based on a logarithmic scale of 0 to 14. Lower pH is acidic (many free hydrogen ions) and higher pH is alkaline (few free hydrogen ions). The pH of water determines the solubility and biological availability of chemicals constituents such as nutrients (eg. nitrogen, phosphorus) and heavy metals (eg. lead, copper). Geology of the watershed can give the river some buffering capacity to resist changes in pH but overall the range has to stay between 6.5 and 8.5 to protect aquatic life.

Temperature
Water temperature is important because it dictates the kind of aquatic life that can live in a stream. Fish, insects, plankton and other aquatic species all have a preferred temperature range. If the temperature goes too far above or below their preferred range, then the number of species will decrease until there is none. Temperature also influences water chemistry which in turn affects biological activity. Chemical reactions generally speed up with warmer temperatures. Temperature is important, as warmer water holds less dissolved oxygen and warmer water will allow bacteria to reproduce and grow more quickly. Temperature can vary depending on the source of the water,
depth and velocity of the stream, sunlight intensity and the amount of shade by the shoreline vegetation.

**Total Dissolved Solids**
Total dissolved solids (TDS) measure the amount of inorganic salts and small amounts of organic matter that is dissolved in water. The principal constituents are usually calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chloride, sulphate, and nitrate (from agricultural use). Most of these originate from natural geological sources yet high levels may indicate runoff from of road salts, runoff from agricultural and erosion from exposed soil/no stream bank vegetation. There is no PWQO for TDS.

**Turbidity**
Turbidity is the measure of the relative clarity of water. Turbidity in water is caused by suspended matter such as silt, clay and algae that scatter the sunlight. The diversity of species will be affected by how far the sunlight can penetrate the water column. Fish gills will become clogged with a lot of suspended material, as well the material can settle on top of fish spawning grounds (and their eggs). Highly turbid water will appear murky or dirty. Turbidity will be higher after heavy rainfall, but high levels may also indicate soil erosion.

**Nutrients**
Like terrestrial plants, aquatic plants and algae require nutrients for growth and productivity. The main nutrients of concern are nitrogen and phosphorus.

**Nitrogen**
Nitrogen (N) is one of the most common gases in our atmosphere. It makes up approximately 78% of the earth’s atmosphere. Like phosphorus, these nutrients are often applied to agricultural crops as fertilizers and having too much in the river can increase plant growth and productivity to unhealthy levels. Nitrogen is constantly being recycled through the environment through decomposition, etc. The most important forms that plants can readily use are ammonia, nitrate (NO₃⁻) and nitrite (NO₂⁻). There are many different ways to report nitrogen so it is necessary to note that the results from ALS Laboratory Group were given in Total ammonia-nitrogen (mg/L), Nitrate-nitrogen (NO₃⁻N mg/L), and Nitrite-nitrogen (NO₂⁻N mg/L).

**Phosphorus**
Total phosphorus gives a measurement of all forms of phosphorus in the water, but the most important form within this measurement is soluble inorganic phosphate (PO₄³⁻) or orthophosphate ion (PO₄³⁻) because it is the fraction utilized by aquatic plants. While phosphorus is essential to life, too much of it will increase algae growth attached to rocks in the river. Excessive growths of attached algae can use up all the dissolved
oxygen leaving other species, like fish, with anoxic (no oxygen) conditions. Nutrient loading may cause a decrease in biodiversity and a decrease in the most ecologically sensitive species. Natural decomposition of organic matter such as leaves, twigs, grass that is washed into the stream during the winter does constitute an important source of nutrients. However, high levels of phosphorus may indicate unnatural sources such as detergent, pesticide and fertilizer runoff from developed watersheds. Milk house waste from dairy farms is also a large source of phosphorus and has become one of the main environmental issues surrounding dairy farming.

**Bacteria**

**Escherichia coli**

*Escherichia coli* (*E. coli*) are naturally found in the intestines of humans and warm-blooded animals. Unlike other bacteria in this family, *E. coli* does not usually occur naturally on plants or in soil and water. The inability of *E. coli* to grow in water combined with its short survival time in water environments means that the detection of *E. coli* in a water system is a good indicator of recent fecal contamination. Potential sources of *E. coli* include: leaking septic systems, runoff from manure storage facilities or wild animal waste (i.e. beavers and Canadian Geese). These bacteria can cause irritation of the skin and eyes when contact is made and can cause gastro-intestinal disorders.

**Total Coliforms**

Total coliforms are a group of bacteria that are naturally found on plants and in soils, water, and in the intestines of humans and warm-blooded animals. Because total coliforms are widespread in the environment, they can be used as one of the many operational tools to determine the efficacy of a drinking water treatment system. The total coliform group contains various species of the genera *Escherichia*, *Klebsiella*, *Enterobacte*, *Citrobacter*, *Serratia*, and many others. There is no current PWQO for total coliforms; however, the previous guideline was 1000 MPN per 100 mL.

**Metals**

Most of the metals listed below are found naturally within the earth’s crust and weathering of rock can transport them into surface water. The following is a complete list of the metals analysis performed on the water samples and their qualities.

**Aluminum**

Aluminum is the most abundant metal on Earth, comprising about 8% of the Earth's crust. It is found in a variety of minerals, such as feldspars and micas, which, with time, weather to clays and exposure is inevitable. High levels of aluminum will put strain on the kidneys of animals when they attempt to excrete it but it is not normally fatal. Aluminum and its compounds are often used in food as additives, in drugs, in consumer
products and in the treatment of drinking water. Aluminum poisoning has been linked to neurological dementia in kidney dialysis patients and, in recent years, its role in Alzheimer’s disease, Parkinson’s disease and Lou Gehrig’s disease. The intake of large amounts of aluminum can also cause anaemia, osteomalacia (brittle or soft bones), glucose intolerance, and cardiac arrest in humans. The PWQO guideline for aluminum varies with pH, the maximum concentration being 75 μg/L.

**Antimony**
Antimony is a metallic element that is a blue-white colour in its stable form. Acute intoxication is characterized by abdominal pain, vomiting, diarrhea, dehydration, muscular pain, shock, haemoglobinuria, anuria and uraemia. In addition, severe myocardial symptoms and convulsions have been observed with acute doses of antimonials, as well some deaths were attributed to liver necrosis. The maximum concentration of antimony under PWQO guidelines is 20 μg/L.

**Arsenic**
Arsenic is a natural element abundantly found within the earth's crust. It may be found in some drinking water supplies, including wells. Long-term exposure (over many years or decades) to high levels of arsenic in drinking water may cause thickening and discoloration of the skin; nausea and diarrhea; decreased production of blood cells; abnormal heart rhythm and blood vessel damage, or numbness in the hands and feet. Short term exposure (days/weeks) to very high levels of arsenic can result in abdominal pain, vomiting and diarrhea, muscular cramping or pain, weakness and flushing of skin, skin rash, numbness, burning or tingling sensation on the palms of the hands and soles of the feet, or loss of movement and sensory response. The maximum concentration of arsenic under PWQO guidelines is 5 μg/L.

**Barium**
Barium is present as a trace element in both igneous and sedimentary rocks. Although it is not found free in nature, barium occurs in a number of compounds. Barium compounds have a wide variety of industrial applications. They are used in the plastics, rubber, electronics and textiles industries. At high concentrations, barium causes strong vasoconstriction by its direct stimulation of arterial muscle, peristalsis due to the violent stimulation of smooth muscle, and convulsions and paralysis following stimulation of the central nervous system. Depending on the dose and solubility of the barium salt, death may occur in a few hours or a few days. There are currently no PWQO guidelines for barium.

**Beryllium**
Beryllium is a hard grey metal that is extracted from the earth, refined and reduced to a very fine powder. It occurs as a chemical component of certain rocks, coal and oil, soil, and volcanic dust. People exposed to beryllium are at risk of developing serious
debilitating diseases. Chronic beryllium disease (CBD or berylliosis) is a painful scarring of the lung tissue. Less common than CBD, acute (short—term) beryllium disease, causes lung inflammation resembling pneumonia. In severe cases, both diseases may be fatal. The maximum concentration of beryllium under PWQO guidelines depends on hardness. If CaCO$_3$ is >75 mg/L the maximum concentration of beryllium is 1100 µg/L and if the CaCO$_3$ is <75 mg/L the maximum concentration of Beryllium is 11 µg/L.

**Bismuth**
Bismuth is a brittle metal with a pinkish colour, often found in its native form. Exposure to bismuth at low doses may cause gastrointestinal disorders, low stomach acid, heartburn, bloating, calcification, warts, diarrhea, and gastric ulcers. At large doses it may cause mental confusion, memory problems, tremors, staggering gait, muscle twitching, slurring speech, joint problems, hypoadrenalism, hearing and visual disturbances, hallucinations and coma. There are currently no PWQO guidelines limiting the intake of bismuth.

**Boron**
Boron is a non-metallic element that is not found in nature in its elemental form but can be found in a number of compounds. Exposure to boron in small doses may cause irritation to the nose, throat and eyes. In larger doses, boron can affect the stomach, liver, kidneys and brain, and may eventually lead to death. The maximum level of boron under PWQO guidelines is 200 µg/L.

**Cadmium**
Cadmium is an extremely toxic metal even in low concentrations. It is used commercially as a stabilizer in plastic, fungicides for golf courses, television picture tube phosphors, nickel–cadmium batteries, motor oils, and curing agents for rubber. Cadmium poisoning can lead to itai-itai disease, which initiates bone softening, joint pain and kidney failure. The maximum concentration of cadmium under PWQO guidelines is 0.2 µg/L. The interim PWQO guideline states if hardness as CaCO$_3$ is 0-100 the maximum cadmium concentration is 0.1 µg/L and if hardness is >100, the maximum cadmium concentration is 0.5 µg/L.

**Calcium**
Calcium is the third most abundant metal in the Earth’s crust. Calcium is also the most abundant metal in the human body and is the main constituent of bones. Calcium is a dietary requirement and there are no adverse health effects from intake of large doses of calcium. There are currently no PWQO guidelines for calcium.

**Chromium**
Chromium is a lustrous, hard metal. Chromium (III) is an essential nutrient, but higher intake may cause skin rashes. Chromium (VI) is known to cause various health effects
such as skin rashes, upset stomachs and ulcers, respiratory problems, weakened immune systems, kidney and liver damage, alteration of genetic material, lung cancer and death. The maximum concentration of chromium under PWQO guidelines is 1 µg/L for Chromium (VI) and 8.9 µg/L for Chromium (III).

**Cobalt**
Cobalt is a hard, lustrous, silver-grey metal and is found in various ores. Health effects resulting from exposure to high concentrations include vomiting and nausea, vision problems, heart problems and thyroid damage. The maximum concentration of cobalt under PWQO guidelines is 0.9 µg/L.

**Copper**
Copper occurs in nature as a metal and in minerals. Copper is an essential element to human metabolism, although intake at higher doses can cause adverse health effects. Acute copper poisoning health effects include vomiting, diarrhea, jaundice, haemolysis, haemoglobinuria, haematuria, and oliguria. In severe cases, the stool and saliva may appear green or blue. In the terminal phases, anuria, hypotension, and coma precede death. The maximum concentration of copper under PWQO guidelines is 5 µg/L.

**Iron**
Iron is also an abundant metal found in rock. The precipitation of excessive iron creates an objectionable reddish-brown colour to water. Iron may also stain laundry and plumbing fixtures, produce undesirable tastes in beverages, and promote the growth of certain iron-bacteria, leading to the deposition of a slimy coating in water distribution pipes. The PWQO guideline stipulates that the levels of iron in the water must be below 300 µg/L.

**Lead**
Lead is a very toxic metal to all forms of life, causing neurological damage and even death. Although natural occurrences can occur from precipitation and the weathering of ores, the majority of lead in watercourses comes from anthropogenic sources. The PWQO requirement for lead varies with different alkalinity as CaCO₃ (mg/L). The maximum lead concentration is 25 µg/L.

**Lithium**
Lithium is a soft, silver-white metal belonging to the alkali metal group of chemical elements. Under standard conditions, it is the lightest metal and the least dense solid element. Like all alkali metals, lithium is highly reactive and flammable. Lithium forms a minor part of igneous rocks, with the largest concentrations in granites. Lithium and its compounds have a range of effects on the human body. For instance, compounds of lithium tend to harm the kidneys and lithium carbonate can affect a person's mental health. There are no current PWQO guidelines for lithium.
Magnesium
Magnesium is very abundant in nature and is found in many minerals. It is a dietary requirement, but too much can lead to muscle weakness, lethargy and confusion. There are no current PWQO guidelines for magnesium.

Manganese
Manganese is a very common compound that can be found everywhere on earth. It is essential for humans to survive, but toxic when concentrations in the body are too high. Manganese can cause Parkinson, lung embolism and bronchitis. There are currently no PWQO guidelines for manganese.

Molybdenum
Molybdenum is a by-product of copper and tungsten mining. It is used as an alloy for various metals and occurs naturally in soil and rock. Potential health impacts associated with molybdenum include neurotoxicity and reproductive toxicity. The maximum concentration of molybdenum under PWQO guidelines is 40 $\mu$g/L.

Nickel
Nickel is a compound that occurs in the environment only at very low levels. An uptake of large quantities of nickel may cause higher risks of cancer, respiratory failure, birth defects and heart disorders. The maximum concentration of nickel under PWQO guidelines is 25 $\mu$g/L.

Potassium:
Potassium is a soft silvery white metal, which is a key plant element and is found in most fertilizers. Potassium is also a dietary requirement, but many potassium compounds may cause adverse health effects. Such compounds include potassium alum or potassium cyanide. There are currently no PWQO guidelines for potassium.

Selenium
Selenium is one of the rarer elements on the surface of the earth. It occurs naturally in the environment and is also released by human activities. The health effects of various forms of selenium can vary from brittle hair and deformed nails, to rashes, heat, swelling of the skin and severe pains. Selenium poisoning may become so severe in some cases that it can even cause death. The maximum concentration of selenium under PWQO guidelines is 100 $\mu$g/L.

Silver
Silver does not react with pure water. It is stable in both water and air. Moreover, it is acid and base resistant, but it corrodes when it comes in contact with sulphur compounds. Silver oxide is harmful upon swallowing, because it irritates the eyes, respiratory tract and skin. Silver nitrate is much more harmful, because it is a strong
oxidant. It causes corrosion, and an oral uptake can lead to vomiting, dizziness and diarrhea. The maximum concentration of silver under PWQO guidelines is 0.1 µg/L.

**Sodium**
Sodium is a soft, silvery-white, highly reactive metal. It is the sixth most abundant element in the Earth's crust, and exists in numerous minerals such as feldspars, sodalite and rock salt. Sodium has a number of important functions in plants, humans, and animals. In humans, it is involved in controlling the amount of fluid present in cells. An excess or lack of sodium can cause cells to gain or lose water. Either of these changes can prevent cells from carrying out their normal functions. There are currently no PWQO guidelines for sodium.

**Strontium**
Strontium is a bright silvery metal that is softer than calcium and even more reactive in water. Acute effects of strontium include vomiting and diarrhea if ingested, and may also cause irritation to the skin. Chronic skin contact may cause dermatitis. There are currently no PWQO guidelines for strontium.

**Tellurium**
Tellurium is a brittle, mildly toxic, rare, silver-white metalloid. It is chemically related to selenium and sulfur. It is occasionally found in native form as elemental crystals. Tellurium is far more common in the universe as a whole than on Earth. When taken internally, tellurium can have harmful effects. It may cause nausea, vomiting, and damage to the central nervous system. One interesting side effect is that it gives a garlicky-odor to the breath. There are currently no PWQO guidelines for tellurium.

**Thallium**
Thallium is a silvery-grey metal that is very toxic by inhalation, ingestion and skin absorption. It may act as a systemic poison, neurotoxin, and may cause birth abnormalities. It is also a respiratory and eye irritant. The maximum concentration of thallium under PWQO guidelines is 0.3 µg/L.

**Tin**
Tin is a soft, pliable, silvery-white metal. Acute effects of tin include skin or eye irritation, headaches, stomach aches, dizziness, and breathlessness. Long-term effects include liver damage, malfunctioning of immune systems, chromosomal damage, shortage of red blood cells, and brain damage. There are currently no PWQO guidelines limiting the intake of tin.

**Titanium**
Titanium is a white-silvery metallic colour and is always found bound to other elements in nature. There are no known health hazards of titanium in water, but it is known to
have adverse health effects in powder form. There are currently no PWQO guidelines for titanium.

**Tungsten**  
Tungsten is a lustrous, silvery-white metal. Acute health effects include irritation to the skin and eyes causing watering and redness. There are no known long-term health effects. The maximum concentration of tungsten under PWQO guidelines is 30 μg/L.

**Uranium**  
Uranium is a hard, dense, malleable, ductile, silver-white, radioactive metal. No harmful radiation effects of natural levels of uranium have been found. However, chemical effects may occur after the uptake of large amounts of uranium, which can cause health effects such as kidney disease. Exposure to uranium radionuclides that form during radioactive decay may cause cancer. The maximum concentration of uranium under PWQO guidelines is 5 μg/L.

**Vanadium**  
Vanadium is a rare, soft, ductile grey-white element found combined in certain minerals and used mainly to produce certain alloys. The uptake of vanadium by humans mainly takes place through foodstuffs, such as buckwheat, soy beans, olive oil, sunflower oil, apples and eggs. Some acute health effects associated with the high intake of vanadium include inflammation of stomach and intestines, sickness and headaches, dizziness, skin rashes, nosebleeds and throat pain. Chronic exposure may cause eye, skin and respiratory problems. The maximum concentration of vanadium under PWQO guidelines is 6 μg/L.

**Zinc**  
Zinc is a lustrous bluish-white metal. Overdoses do not occur very often. Symptoms include nausea, vomiting, dizziness, fevers and diarrhea. The maximum concentration of zinc under PWQO guidelines is 20 μg/L.

**Zirconium**  
Zirconium is a very strong, malleable, ductile, lustrous silver-grey metal. Zirconium and its salts generally have low systemic toxicity. The maximum concentration of Zinc under PWQO guidelines is 4 μg/L.
Appendix E:
Water Quality Guidelines
Appendix E: Water Quality Guidelines

The following are taken from the Ministry of the Environment, Provincial Water Quality Objectives (PWQO), July 1994.

**Physical**

**Alkalinity:**
Alkalinity should not be decreased by more than 25% of the natural concentration.

**Dissolved Oxygen:**
Dissolved oxygen concentrations should not be less than the values specified below for cold water biota (e.g. salmonid fish communities) and warm water biota (e.g. centrarchid fish communities):

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Cold Water Biota</th>
<th>Warm Water Biota</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Saturation</td>
<td>mg/L</td>
</tr>
<tr>
<td>0</td>
<td>54</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>54</td>
<td>7</td>
</tr>
<tr>
<td>10</td>
<td>54</td>
<td>6</td>
</tr>
<tr>
<td>15</td>
<td>54</td>
<td>6</td>
</tr>
<tr>
<td>20</td>
<td>57</td>
<td>5</td>
</tr>
<tr>
<td>25</td>
<td>63</td>
<td>5</td>
</tr>
</tbody>
</table>

In waters inhabited by sensitive biological communities, or in situations where additional physical or chemical stressors are operating, more stringent criteria may be required. For example, a sensitive species such as lake trout may require more specific water quality objectives.

In some hypolimnetic waters, dissolved oxygen is naturally lower than the concentrations specified in the above table. Such a condition should not be altered by adding oxygen-demanding materials causing a depletion of oxygen.

**pH:**
The pH should be maintained in the range of 6.5 – 8.5:
- to protect aquatic life
- both alkaline and acidic waters may cause irritation to anyone using the water for recreational purposes
Temperature:
The natural thermal regime of any body of water shall not be altered so as to impair the quality of the natural environment. In particular, the diversity, distribution and abundance of plant and animal life shall not be significantly changed.

Waste Heat Discharge

1. Ambient Temperature Changes

The temperature at the edge of a mixing zone shall not exceed the natural ambient water temperature at a representative control location by more than 10°C (18°F). However, in special circumstances, local conditions may require a significantly lower temperature difference than 10°C (18°F). Potential dischargers are to apply to the MOEE for guidance as to the allowable temperature rise for each thermal discharge. This ministry will also specify the nature of the mixing zone and the procedure for the establishment of a representative control location for temperature recording on a case-by-case basis.

2. Discharge Temperature Permitted

The maximum temperature of the receiving body of water, at any point in the thermal plume outside a mixing zone, shall not exceed 30°C (86°F) or the temperature of a representative control location plus 10°C (18°F) or the allowed temperature difference, whichever is the lesser temperature. These maximum temperatures are to be measured on a mean daily basis from continuous records.

3. Taking and Discharging of Cooling Water

Users of cooling water shall meet both the Objectives for temperature outlined above and the "Procedures for the Taking and Discharge of Cooling Water" as outlined in the MOEE publication Deriving Receiving-Water Based, Point-Source Effluent Requirements for Ontario Waters (1994).

Nutrients

Ammonia (un-ionized):
The amount of un-ionized ammonia should not exceed 20 µg/L.
The percentages of un-ionized ammonia (NH$_3$) in aqueous ammonia solution for different temperature and pH conditions are listed in the table below. For example, at 20°C and pH of 8.0, a total ammonia concentration of 500 µg/L would give an un-ionized ammonia concentration of $500 \times \frac{3.8}{100} = 19$ µg/L which is less than the un-ionized ammonia Objective of 20 µg/L.

The table below is taken from the PWQO, percentages are rounded to two significant figures. The equations given by may be used to interpolate values between those given in the table:

$$f = \frac{1}{10^{pK_a-pH} + 1}, \text{ where } f \text{ is the fraction of NH}_3$$

$$pK_a = 0.09018 + \frac{2729.92}{T}, \text{ where } T = \text{ambient water temperature in Kelvin (K = °C + 273.16)}$$

Results should be converted to percent and rounded to two significant figures. Extrapolations should not be made beyond the ranges of the table.

Note: Under certain temperature and pH conditions, the total ammonia criteria for the protection of aquatic life may be less stringent than the criteria for other beneficial uses (e.g. public water supply).

**Percent NH$_3$ in aqueous ammonia solutions for 0-30 °C and pH 6-10**

<table>
<thead>
<tr>
<th>Temp. °C</th>
<th>pH 6.0</th>
<th>pH 6.5</th>
<th>pH 7.0</th>
<th>pH 7.5</th>
<th>pH 8.0</th>
<th>pH 8.5</th>
<th>pH 9.0</th>
<th>pH 9.5</th>
<th>pH 10.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>.0083</td>
<td>.026</td>
<td>.083</td>
<td>.26</td>
<td>.82</td>
<td>2.6</td>
<td>7.6</td>
<td>21.</td>
<td>45.</td>
</tr>
<tr>
<td>1</td>
<td>.0090</td>
<td>.028</td>
<td>.090</td>
<td>.28</td>
<td>.89</td>
<td>2.8</td>
<td>8.3</td>
<td>22.</td>
<td>47.</td>
</tr>
<tr>
<td>2</td>
<td>.0098</td>
<td>.031</td>
<td>.098</td>
<td>.31</td>
<td>.97</td>
<td>3.0</td>
<td>8.9</td>
<td>24.</td>
<td>49.</td>
</tr>
<tr>
<td>3</td>
<td>.011</td>
<td>.034</td>
<td>.11</td>
<td>.34</td>
<td>1.1</td>
<td>3.3</td>
<td>9.6</td>
<td>25.</td>
<td>52.</td>
</tr>
<tr>
<td>4</td>
<td>.012</td>
<td>.036</td>
<td>.12</td>
<td>.36</td>
<td>1.1</td>
<td>3.5</td>
<td>10.</td>
<td>27.</td>
<td>54.</td>
</tr>
<tr>
<td>5</td>
<td>.013</td>
<td>.040</td>
<td>.13</td>
<td>.39</td>
<td>1.2</td>
<td>3.8</td>
<td>11.</td>
<td>28.</td>
<td>56.</td>
</tr>
<tr>
<td>6</td>
<td>.014</td>
<td>.043</td>
<td>.14</td>
<td>.43</td>
<td>1.3</td>
<td>4.1</td>
<td>12.</td>
<td>30.</td>
<td>58.</td>
</tr>
<tr>
<td>7</td>
<td>.015</td>
<td>.046</td>
<td>.15</td>
<td>.46</td>
<td>1.5</td>
<td>4.4</td>
<td>13.</td>
<td>32.</td>
<td>60.</td>
</tr>
<tr>
<td>8</td>
<td>.016</td>
<td>.050</td>
<td>.16</td>
<td>.50</td>
<td>1.6</td>
<td>4.8</td>
<td>14.</td>
<td>34.</td>
<td>61.</td>
</tr>
<tr>
<td>9</td>
<td>.017</td>
<td>.054</td>
<td>.17</td>
<td>.54</td>
<td>1.7</td>
<td>5.2</td>
<td>15.</td>
<td>35.</td>
<td>63.</td>
</tr>
<tr>
<td>10</td>
<td>.019</td>
<td>.059</td>
<td>.19</td>
<td>.59</td>
<td>1.8</td>
<td>5.6</td>
<td>16.</td>
<td>37.</td>
<td>65.</td>
</tr>
<tr>
<td>11</td>
<td>.020</td>
<td>.064</td>
<td>.20</td>
<td>.63</td>
<td>2.0</td>
<td>6.0</td>
<td>17.</td>
<td>39.</td>
<td>67.</td>
</tr>
<tr>
<td>12</td>
<td>.022</td>
<td>.069</td>
<td>.22</td>
<td>.68</td>
<td>2.1</td>
<td>6.4</td>
<td>18.</td>
<td>41.</td>
<td>69.</td>
</tr>
<tr>
<td>13</td>
<td>.024</td>
<td>.074</td>
<td>.24</td>
<td>.74</td>
<td>2.3</td>
<td>6.9</td>
<td>19.</td>
<td>43.</td>
<td>70.</td>
</tr>
<tr>
<td>14</td>
<td>.025</td>
<td>.080</td>
<td>.25</td>
<td>.80</td>
<td>2.5</td>
<td>7.4</td>
<td>20.</td>
<td>45.</td>
<td>72.</td>
</tr>
<tr>
<td>15</td>
<td>.027</td>
<td>.087</td>
<td>.27</td>
<td>.86</td>
<td>2.7</td>
<td>8.0</td>
<td>22.</td>
<td>46.</td>
<td>73.</td>
</tr>
</tbody>
</table>
The following nitrate and nitrite guidelines are taken from the Canadian Council of Resource and Environment Ministers (CCREM) Canadian water quality guidelines for the protection of aquatic life. Summary table, updated 2012. The information in these guidelines and supporting text is used to complement the Provincial Water Quality Objectives and Interim Objectives.

**Phosphorus:**
Current scientific evidence is insufficient to develop a firm objective at this time. Accordingly, the following phosphorus concentrations should be considered as general guidelines, which should be supplemented by site-specific studies:

- To avoid nuisance concentrations of algae in lakes, average total phosphorus concentrations for the ice-free period should not exceed 20 µg/L;
- A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration for the ice-free period of 10 µg/L or less. This should apply to all lakes naturally below this value;
- Excessive plant growth in rivers and streams should be eliminated at a total phosphorus concentration below 30 µg/L.

**Bacteriological**

**Escherichia coli:**
The amount of *Escherichia coli* should not exceed 100 counts per 100 mL of water (based on a geometric mean of at least 5 samples).

Based on a recreational water quality guideline published by the Ontario Ministry of Health in 1992, this Ministry of Health guideline was specifically intended for application by the local Medical Officer of Health to swimming and bathing beaches. It is based upon a geometric mean of levels of *E. coli* determined from a minimum of 5 samples per site taken within a given swimming area and collected within a one month period. If the geometric mean *E. coli* level for the sample series at a given site exceeds 100 per 100 mL, the site should be considered unsuitable for swimming and bathing. *E. coli* was selected for the guideline because studies have determined that, among bacteria of the coliform group, *E. coli* is the most suitable and specific indicator of fecal contamination.

An analytical test with a high degree of specificity for *E. coli* regardless of water sample source, requiring no confirmation procedures, and which produces results in 21 hours has been developed and adopted by both the Ministry of Health, and Ministry of Environment and Energy laboratories.

Where testing indicates sewage or fecal contamination, a site-specific judgment must be made as to the severity of the problem and the appropriate course of action.

As of May 1, 1994, MOEE staff has been advised to base all new compliance, enforcement and monitoring activities on the *E. coli* test. Some water managers may find it necessary to continue testing for fecal coliforms or total coliforms. For example, where testing at a long term water quality monitoring station requires a continuous record of results using either the fecal or total coliform test to monitor trends in water quality. As a benchmark for the long term monitoring results, the former objectives for fecal coliforms and total coliforms are referenced for your information. For fecal coliforms the objective was 100 counts per 100 ml (based on a geometric mean density for a series of water samples). For total coliforms the objective was 1000 counts per 100 ml (based on a geometric mean density for a series of water samples).

### Metals

#### Aluminum:
Aluminum amounts should not exceed the following:

<table>
<thead>
<tr>
<th>PH values</th>
<th>Interim PWQO (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5 to 5.5</td>
<td>15</td>
</tr>
<tr>
<td>&gt;5.5 to 6.5</td>
<td>No more than 10 % of natural background</td>
</tr>
<tr>
<td>&gt; 6.5 to 9.0</td>
<td>75</td>
</tr>
</tbody>
</table>

#### Antimony:
The amount of Antimony should not exceed 20 µg/L.
Arsenic:
The amount of Arsenic should not exceed 5 μg/L.

Barium:
There are currently no PWQO guidelines for Barium.

Beryllium:
Beryllium amounts should not exceed the following:

<table>
<thead>
<tr>
<th>Hardness as CaCO₃ (mg/L)</th>
<th>Interim PWQO (μg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 75</td>
<td>11</td>
</tr>
<tr>
<td>&gt;75</td>
<td>1100</td>
</tr>
</tbody>
</table>

Bismuth:
There are currently no PWQO guidelines for Bismuth.

Boron:
The amount of Boron should not exceed 200 μg/L.

Cadmium:
Cadmium amounts should not exceed 0.2 μg/L.

<table>
<thead>
<tr>
<th>Hardness as CaCO₃ (mg/L)</th>
<th>Interim PWQO (μg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 100</td>
<td>0.1</td>
</tr>
<tr>
<td>&gt;100</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Calcium:
There are currently no PWQO guidelines for Calcium.

Chromium:
Chromium amounts should not exceed the following:

<table>
<thead>
<tr>
<th></th>
<th>Interim PWQO (μg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hexavalent Chromium</td>
<td>1</td>
</tr>
<tr>
<td>Trivalent Chromium</td>
<td>8.9</td>
</tr>
</tbody>
</table>

Cobalt:
The amount of Cobalt should not exceed 0.9 μg/L.

Copper:
The amount of Copper should not exceed 5 μg/L.

<table>
<thead>
<tr>
<th>Hardness as CaCO₃ (mg/L)</th>
<th>Interim PWQO (μg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>1</td>
</tr>
<tr>
<td>&gt;20</td>
<td>5</td>
</tr>
</tbody>
</table>
Iron:
The amount of Iron should not exceed 300µg/L.

Lead:
Lead amounts should not exceed the following:

<table>
<thead>
<tr>
<th>Hardness as CaCO₃ (mg/L)</th>
<th>Interim PWQO (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 30</td>
<td>1</td>
</tr>
<tr>
<td>30 to 80</td>
<td>3</td>
</tr>
<tr>
<td>&gt; 80</td>
<td>5</td>
</tr>
</tbody>
</table>

Lithium:
There are currently no PWQO guidelines for Lithium.

Magnesium:
There are currently no PWQO guidelines limiting the intake of Magnesium.

Manganese:
There are currently no PWQO guidelines for Manganese.

Molybdenum:
The amount of Molybdenum should not exceed 40 µg/L.

Nickel:
The amount of Nickel should not exceed 25 µg/L.

Potassium:
There are currently no PWQO guidelines for Potassium.

Selenium:
The amount of Selenium should not exceed 100 µg/L.

Silicon:
There are currently no PWQO guidelines for Silicon.

Silver:
The amount of Silver should not exceed 0.1 µg/L.

Sodium:
There are currently no PWQO guidelines for Sodium.

Strontium:
There are currently no PWQO guidelines for Strontium.
Tellurium:
There are currently no PWQO guidelines for Tellurium.

Thallium:
The amount of Thallium should not exceed 0.3 µg/L.

Tin:
There are currently no PWQO guidelines for Tin.

Titanium:
There are currently no PWQO guidelines for Titanium.

Tungsten:
The amount of Tungsten should not exceed 30 µg/L.

Uranium:
The amount of Uranium should not exceed 5 µg/L.

Vanadium:
The amount of Vanadium should not exceed 6 µg/L.

Zinc:
The amount of Zinc should not exceed 20 µg/L.

Zirconium:
The amount of Zirconium should not exceed 4 µg/L.
Appendix F: 
Forest Ecosystem Classification
Appendix F: Forest Ecosystem Classification

Site 1: V14 Balsam Fir Mixedwood

**Description:** An extremely variable mixedwood type. The canopy, comprising mainly balsam fir, may contain a mixture of several species. The understory varies from shrub rich to moderately herb and shrub poor. Usually on deep, fresh to moist, mineral soils but encompassing a wide range of soil and site conditions.

![River scene]

**Common Overstory Species (in descending order):**
* balsam fir, trembling aspen, white birch, white spruce, black spruce, jack pine, balsam poplar, white cedar

**Common Understory Species:**

<table>
<thead>
<tr>
<th>Shrub species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abies balsamea, Acer spicatum, Rubus pubescens, Linnaea borealis, Diervilla</td>
</tr>
<tr>
<td>lonicera, Sorbus decora, Populus tremuloides, Corylus cornuta, Amelanchier</td>
</tr>
<tr>
<td>spp., Rosa acicularis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Herb species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maianthemum canadense, Aralia nudicaulis, Clintonia borealis, Streptopus</td>
</tr>
<tr>
<td>roseus, Cornus canadensis, Trientalis borealis, Viola renifolia, Mitella</td>
</tr>
<tr>
<td>nuda, Aster macrophyllus, Galium triflorum, Coptis trifolia, Petasites</td>
</tr>
<tr>
<td>palmatus</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Moss species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleurozium schreberi, Ptilium crista-castrensis, Hylocomium splendens,</td>
</tr>
<tr>
<td>Plagiommium cuspidatum</td>
</tr>
</tbody>
</table>

**Forest Floor Cover:**

<table>
<thead>
<tr>
<th>Species</th>
<th>Broadleaf Litter</th>
<th>Moss</th>
<th>Conifer Litter</th>
<th>Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Floor Cover (%)</td>
<td>66</td>
<td>12</td>
<td>14</td>
<td>6</td>
</tr>
</tbody>
</table>
Site 2, Site 5, Site 7 and Site 8: V15 White Spruce Mixedwood

**Description:** A variable mixedwood type with white spruce as the main canopy species. The understory ranges from herb and shrub rich to poor, with balsam fir commonly abundant in the shrub layer. Occurring over a broad range of soil and site conditions but primarily on deep, fresh to moist, mineral soils.

**Site 2**

**Site 5**

**Site 7**

**Site 8**

**Common Overstory Species (in descending order):**
White spruce, balsam fir, trembling aspen, white birch, black spruce, balsam poplar, red maple, jack pine

**Common Understory Species:**

<table>
<thead>
<tr>
<th>Shrub varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abies balsamea, Acer spicatum, Rubus pubescens, Corylus cornuta, Sorbus decora, Linnaea borealis, Diervilla lonicera, Rosa acicularis, Amelanchier spp., Populus tremuloides</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Herb varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aralia nudicaulis, Cornus canadensis, Clintonia borealis, Maianthemum canadense, Streptopus roseus, Trientalis borealis, Galium triflorum, Aster macrophyllus, Mitella nuda, Viola renifolia, Anemone quinquefolia, Petasites palmatus</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Moss varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleurozium schreberi, Ptilium crista-castrensis, Rhytidiadelphus triquetrus, Plagiommium, cuspidatum</td>
</tr>
</tbody>
</table>

**Forest Floor Cover:**

<table>
<thead>
<tr>
<th>Cover Type</th>
<th>Broadleaf Litter</th>
<th>Moss</th>
<th>Conifer Litter</th>
<th>Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Floor Cover (%)</td>
<td>61</td>
<td>16</td>
<td>13</td>
<td>5</td>
</tr>
</tbody>
</table>

F-2
Site 6: V2 Black Ash Hardwood and Mixedwood

**Description:** Hardwood and mixedwood stands containing black ash in the overstory. The understory is typically dense and floristically diverse. Of limited areal extent; occurring in low-lying locations on deep, moist to wet, usually non-calcareous substrates.

![Image of forest](image_url)

**Common Overstory Species (in descending order):**
*black ash, balsam fir, trembling aspen, white birch, white spruce, cedar, red ash, American ash, balsam poplar*

**Common Understory Species:**

<table>
<thead>
<tr>
<th>Shrubs:</th>
<th>Rubus pubescens, Acer spicatum, balsam fir, Ribes triste, Prunus virginiana, Comus stolonifera, Alnus rugosa, Corylus cornuta, Rubus idaeus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbs:</td>
<td>Viola spp., Mitella nuda, Athyrium filix-femina, Galium trijorum, Maianthemum canadense, Dryopteris austriaca, Circeae alpina, Streptopus roseus, Aralia nudicaulis, Aster macrophyllus, Trientalis borealis, Equisetum sylvaticum</td>
</tr>
<tr>
<td>Marsises:</td>
<td>Plagiomnium cuspidatum, Climacium dendroides</td>
</tr>
</tbody>
</table>

**Forest Floor Cover:**

<table>
<thead>
<tr>
<th>Species</th>
<th>Broadleaf Litter</th>
<th>Moss</th>
<th>Humus</th>
<th>Water</th>
<th>Graminoid Litter</th>
<th>Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Floor Cover (%)</td>
<td>39</td>
<td>20</td>
<td>12</td>
<td>11</td>
<td>11</td>
<td>6</td>
</tr>
</tbody>
</table>
Appendix G:
Culvert Assessments
Appendix G: Culvert Assessments
### Oliver Creek 2016 Culvert Assessments

<table>
<thead>
<tr>
<th>Culvert Number/ Site Number</th>
<th>J-K Road Surface Width (m)</th>
<th>H-I Length of Covered Stream (m)</th>
<th>N-O Fill Height Upstream (m)</th>
<th>L-M Fill Height Downstream (m)</th>
<th>A-D Width of Opening (m)</th>
<th>A-B Inside Top to Rust Line (m)</th>
<th>A-C Inside Top to Water Surface (m)</th>
<th>A-E Height Above Outlet Pool (m)</th>
<th>E-G Water Surface to High Water Mark (m)</th>
<th>A-F Inside Top to Bottom of Stream (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1/Site 1</td>
<td>11.3</td>
<td>21.1</td>
<td>1.05</td>
<td>1.25</td>
<td>Upstream 7.1</td>
<td>2.85</td>
<td>3.35</td>
<td>3.35</td>
<td>0.5</td>
<td>3.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Downstream 7.1</td>
<td>2.87</td>
<td>3.24</td>
<td>3.24</td>
<td>0.37</td>
<td>3.75</td>
</tr>
<tr>
<td>C2/Site 2</td>
<td>6.8</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Upstream 0.8</td>
<td>0.58</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Downstream 0.8</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>C3/Site 3</td>
<td>7.0</td>
<td>12.5</td>
<td>0.75</td>
<td>N/A</td>
<td>Upstream 1.3</td>
<td>0.77</td>
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<td>1.21</td>
<td>0.44</td>
<td>1.38</td>
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<td></td>
<td></td>
<td>Downstream 1.3</td>
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<td>0.95</td>
<td>0.95</td>
<td>0.33</td>
<td>1.13</td>
</tr>
<tr>
<td>C4/Site 4</td>
<td>7.0</td>
<td>12.7</td>
<td>0.67</td>
<td>0.8</td>
<td>Upstream 1.7</td>
<td>0.69</td>
<td>1.46</td>
<td>1.46</td>
<td>0.77</td>
<td>1.61</td>
</tr>
<tr>
<td>Culvert A (East)</td>
<td>7.0</td>
<td>12.7</td>
<td>0.67</td>
<td>0.8</td>
<td>Downstream 1.7</td>
<td>0.65</td>
<td>1.52</td>
<td>1.52</td>
<td>0.87</td>
<td>1.56</td>
</tr>
<tr>
<td>Culvert B (West)</td>
<td>7.0</td>
<td>12.7</td>
<td>0.72</td>
<td>0.83</td>
<td>Upstream 1.7</td>
<td>0.50</td>
<td>1.41</td>
<td>1.41</td>
<td>0.91</td>
<td>1.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Downstream 1.7</td>
<td>0.56</td>
<td>1.39</td>
<td>1.39</td>
<td>0.83</td>
<td>1.52</td>
</tr>
<tr>
<td>Culvert Number/ Site Number</td>
<td>J-K Road Surface Width (m)</td>
<td>H-I Length of Covered Stream (m)</td>
<td>N-O Fill Height Upstream (m)</td>
<td>L-M Fill Height Downstream (m)</td>
<td>A-D Width of Opening (m)</td>
<td>A-B Inside Top to Rust Line (m)</td>
<td>A-C Inside Top to Water Surface (m)</td>
<td>A-E Height Above Outlet Pool (m)</td>
<td>E-G Water Surface to High Water Mark (m)</td>
<td>A-F Inside Top to Bottom of Stream (m)</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------</td>
<td>----------------------------------</td>
<td>-----------------------------</td>
<td>-----------------------------</td>
<td>-------------------------</td>
<td>-------------------------------</td>
<td>---------------------------------</td>
<td>---------------------------------</td>
<td>---------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td><strong>C5/Site 5</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Culvert</td>
<td>7.0</td>
<td>14.0</td>
<td>0.47</td>
<td>0.4</td>
<td>Upstream: 1.20</td>
<td>0.82</td>
<td>1.01</td>
<td>1.01</td>
<td>0.19</td>
<td>1.26</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Downstream: 1.20</td>
<td>0.85</td>
<td>1.02</td>
<td>1.02</td>
<td>0.17</td>
<td>1.25</td>
</tr>
<tr>
<td><strong>C6/Site 6</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Culvert A</td>
<td>7.5</td>
<td>15.6</td>
<td>0.90</td>
<td>0.92</td>
<td>Upstream: 0.8</td>
<td>0.77</td>
<td>1.19</td>
<td>1.19</td>
<td>0.42</td>
<td>1.89</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>Downstream: 0.8</td>
<td>0.65</td>
<td>1.10</td>
<td>1.10</td>
<td>0.45</td>
<td>1.51</td>
</tr>
<tr>
<td>Culvert B</td>
<td>7.5</td>
<td>15.6</td>
<td>0.85</td>
<td>0.86</td>
<td>Upstream: 0.8</td>
<td>0.78</td>
<td>1.25</td>
<td>1.25</td>
<td>0.47</td>
<td>1.81</td>
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<td>Downstream: 0.8</td>
<td>0.72</td>
<td>1.11</td>
<td>1.11</td>
<td>0.39</td>
<td>1.48</td>
</tr>
<tr>
<td><strong>C7/Site 7</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Culvert</td>
<td>9.0</td>
<td>19.0</td>
<td>0.48</td>
<td>0.79</td>
<td>Upstream: 2.1</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>Downstream: 2.1</td>
<td>0.97</td>
<td>1.37</td>
<td>1.37</td>
<td>0.4</td>
<td>2.05</td>
</tr>
</tbody>
</table>
Culvert 1 / Site 1

**Location:** River Road, near Oliver Creek confluence at Kaministiquia River.

**GPS Coordinates:** Northing 5359381 Easting 312614

**Description:** The large corrugated steel culvert is in excellent condition and seemed large enough to be able to support water flow during times of both high water level and low water level. The water level was relatively low compared to the size of the culvert opening. There is abundant vegetation surrounding the culvert and the banks appear to be stable.
Culvert 2 / Site 2

Location: North side of Barrie Drive – Across from 457 Barrie Drive.

GPS Coordinates: Northing 5357660 Easting 312283

Description: The corrugated steel culvert has abundant vegetation surrounding the culverts on both sides. There was no water flowing through the culvert during the site visit. The downstream side is perched and the bottom of the upstream side is starting to deteriorate.
Culvert 3 / Site 3

**Location:** South side of Barrie Drive, beside the driveway to 617 Barrie Drive.

**GPS Coordinates:** Northing 5357694 Easting 310732

**Description:** The corrugated steel culvert is in good condition except the bottom of the upstream side is starting to deteriorate. Vegetation completely covers the culvert on the downstream side

Upstream

Downstream
Culvert 4 / Site 4

**Location:** South side of Barrie Drive, approximately 105 metres from 741 Barrie Drive.

**GPS Coordinates:** Northing 5357730 Easting 309619

**Description:** The two corrugated steel culverts appear to be in excellent condition, except for one end of the culverts on the upstream side is bent inwards on the top. The culverts seemed large enough to be able to support water flow during times of both high water level and low water level. Rip rap was used to prevent erosion around the culverts. There is abundant vegetation surrounding the culverts and the banks appear to be stable.
Culvert 5 / Site 5

**Location:** West side of C-Line Road, approximately 130 metres from 19 C-Line Road.

**GPS Coordinates:** Northing 5355789 Easting 308729

**Description:** The corrugated steel culvert is in excellent condition and seemed large enough to be able to support water flow during times of both high water level and low water level. The water level was relatively low compared to the size of the culvert opening. There is abundant vegetation surrounding the culvert and the banks appear to be stable.
Culvert 6 / Site 6

Location: South side of Candy Mountain Road, approximately 65 metres from Oliver Creek Road.

GPS Coordinates: Northing 5355688 Easting 309852

Description: The two corrugated steel culverts are in excellent condition and seemed large enough to be able to support water flow during times of both high water level and low water level. There is abundant vegetation surrounding the culverts and the banks appear to be stable.

Upstream                                           Downstream
Culvert 7 / Site 7

Location: South side of Boundary Drive, approximately 60 metres from 1150 Boundary Drive.

GPS Coordinates: Northing 5351643 Easting 310097

Description: The corrugated steel culvert appeared to be in excellent condition and seemed large enough to be able to support water flow during times of both high water level and low water level. The water level was backing up on the upstream side due to a beaver dam.

Upstream

Downstream
Appendix H: Bridge Assessments
Appendix H: Bridge Assessments

Bridge Measurement Parameters
### Oliver Creek 2016 Bridge Measurements

<table>
<thead>
<tr>
<th>Site Number</th>
<th>Bridge Number</th>
<th>A-C Bottom of Bridge to Water Surface (m)</th>
<th>A-B Bottom of Bridge to Bottom of Stream (m)</th>
<th>D-E Outlet Pool Water Surface to Outlet Pool High Water Mark (m)</th>
<th>F-G Width of Stream (m)</th>
<th>H-I Length of Bridge (m)</th>
<th>J-K Width of Bridge (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>1</td>
<td>1.16</td>
<td>1.31</td>
<td>N/A</td>
<td>1.8</td>
<td>8.5</td>
<td>2.4</td>
</tr>
</tbody>
</table>
Bridge 1

Location: East Oliver Lake Road, at Oliver Lake.

GPS Coordinates: Northing 5349812 Easting 309530

Description: This bridge is a single-span structure made out of timber. It was completed in 2010 with a permit issued by the LRCA (33/10). Rip rap protection was placed for erosion control on the banks. The bridge was in very good condition, but regular maintenance should be conducted, as it is a high traffic area.
Appendix I:
Site Photography
Appendix I: Site Photography

<table>
<thead>
<tr>
<th>Site 1 – River Road, near Oliver Creek confluence at Kaministiquia River</th>
<th>A: Upstream</th>
<th>B: Downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.jpg" alt="Upstream Image" /></td>
<td><img src="image2.jpg" alt="Downstream Image" /></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>C: Vegetation</th>
<th>D: Substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3.jpg" alt="Vegetation Image" /></td>
<td><img src="image4.jpg" alt="Substrate Image" /></td>
<td></td>
</tr>
<tr>
<td>Site 2 – North side of Barrie Drive – Across from 457 Barrie Drive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>A: Upstream</strong></td>
<td><strong>B: Downstream</strong></td>
<td></td>
</tr>
<tr>
<td><img src="image1" alt="A: Upstream Image" /></td>
<td><img src="image2" alt="B: Downstream Image" /></td>
<td></td>
</tr>
<tr>
<td><strong>C: Vegetation</strong></td>
<td><strong>D: Substrate</strong></td>
<td></td>
</tr>
<tr>
<td><img src="image3" alt="C: Vegetation Image" /></td>
<td><img src="image4" alt="D: Substrate Image" /></td>
<td></td>
</tr>
</tbody>
</table>
Site 3 – South side of Barrie Drive, beside the driveway to 617 Barrie Drive

<table>
<thead>
<tr>
<th>A: Upstream</th>
<th>B: Downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="A: Upstream Image" /></td>
<td><img src="image2" alt="B: Downstream Image" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C: Vegetation</th>
<th>D: Substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="C: Vegetation Image" /></td>
<td><img src="image4" alt="D: Substrate Image" /></td>
</tr>
</tbody>
</table>
Site 4 - South side of Barrie Drive, approximately 105 metres from 741 Barrie Drive

<table>
<thead>
<tr>
<th>A: Upstream</th>
<th>B: Downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Upstream" /></td>
<td><img src="image2" alt="Downstream" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C: Vegetation</th>
<th>D: Substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Vegetation" /></td>
<td><img src="image4" alt="Substrate" /></td>
</tr>
</tbody>
</table>
Site 5 - West side of C-Line Road, approximately 130 metres from 19 C-Line Road

<table>
<thead>
<tr>
<th>A: Upstream</th>
<th>B: Downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Upstream Image" /></td>
<td><img src="image2" alt="Downstream Image" /></td>
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<table>
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<th>D: Substrate</th>
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<tr>
<td><img src="image3" alt="Vegetation Image" /></td>
<td><img src="image4" alt="Substrate Image" /></td>
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</table>
Site 6 - South side of Candy Mountain Road, approximately 65 metres from Oliver Creek Road

<table>
<thead>
<tr>
<th></th>
<th>A: Upstream</th>
<th>B: Downstream</th>
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<td><img src="image1" alt="Vegetation Image" /></td>
<td><img src="image2" alt="Vegetation Image" /></td>
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<tr>
<td>D: Substrate</td>
<td><img src="image3" alt="Substrate Image" /></td>
<td><img src="image4" alt="Substrate Image" /></td>
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</table>
Site 7 – South side of Boundary Drive, approximately 60 metres from 1150 Boundary Drive

<table>
<thead>
<tr>
<th>A: Upstream</th>
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<td>![Upstream Image]</td>
<td>![Downstream Image]</td>
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</table>

<table>
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<th>C: Vegetation</th>
<th>D: Substrate</th>
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<tr>
<td>![Vegetation Image]</td>
<td>![Substrate Image]</td>
</tr>
<tr>
<td>Site 8 - East Oliver Lake Road, at Oliver Lake</td>
<td>A: Upstream</td>
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<tr>
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<td>C: Vegetation</td>
<td><img src="image1" alt="A: Upstream" /></td>
</tr>
<tr>
<td>D: Substrate</td>
<td><img src="image3" alt="C: Vegetation" /></td>
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I-8
Appendix J:
Laboratory Water Quality Results Summary Tables
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>PWQO Criterion</th>
<th>OC1 Oliver Creek - SITE#1</th>
<th>OC2 Oliver Creek - SITE#2</th>
<th>OC3 Oliver Creek - SITE#3</th>
<th>OC4 Oliver Creek - SITE#4</th>
<th>OC5 Oliver Creek - SITE#5</th>
<th>OC6 Oliver Creek - SITE#6</th>
<th>OC7 Oliver Creek - SITE#7</th>
<th>OC8 Oliver Creek - SITE#8</th>
<th>Average</th>
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<tr>
<td><strong>Physical Tests</strong></td>
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<tr>
<td>Conductivity (EC)</td>
<td>(uS/cm)</td>
<td>N/A</td>
<td>150</td>
<td>143</td>
<td>461</td>
<td>111</td>
<td>93.2</td>
<td>97.1</td>
<td>80.2</td>
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<tr>
<td>pH</td>
<td></td>
<td>6.5-8.5</td>
<td>7.84</td>
<td>7.70</td>
<td>7.33</td>
<td>7.64</td>
<td>7.42</td>
<td>7.59</td>
<td>7.34</td>
<td>7.46</td>
<td>7.62</td>
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<td>Total Dissolved Solids</td>
<td>(mg/L)</td>
<td>N/A</td>
<td>109</td>
<td>105</td>
<td>290</td>
<td>86</td>
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<td>81</td>
<td>55</td>
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<td>Turbidity</td>
<td>(NTU)</td>
<td>N/A</td>
<td>4.47</td>
<td>4.9</td>
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<td>5.02</td>
<td>2.59</td>
<td>5.84</td>
<td>1.46</td>
<td>0.46</td>
<td>3.48</td>
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<td><strong>Anions and Nutrients</strong></td>
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<tr>
<td>Alkalinity, Total (as CaCO₃)*</td>
<td>(mg/L)</td>
<td>20.3</td>
<td>62.3</td>
<td>58.3</td>
<td>221</td>
<td>44.9</td>
<td>46.7</td>
<td>36.7</td>
<td>31.6</td>
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<td>66.1</td>
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<tr>
<td>Ammonia-N, Total</td>
<td>(mg/L)</td>
<td>N/A</td>
<td>0.021</td>
<td>0.035</td>
<td>0.051</td>
<td>0.026</td>
<td>0.026</td>
<td>&lt;0.020</td>
<td>&lt;0.020</td>
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<tr>
<td>Un-ionized Ammonia (calculated)**</td>
<td>(mg/L)</td>
<td>0.02</td>
<td>0.0006</td>
<td>0.0010</td>
<td>0.0013</td>
<td>0.0002</td>
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<td>Chloride (Cl)</td>
<td>(mg/L)</td>
<td>N/A</td>
<td>5.62</td>
<td>5.19</td>
<td>13.9</td>
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<td>2.94</td>
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<td>4.49</td>
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<tr>
<td>Nitrate (NO₃-N)</td>
<td>(mg/L)</td>
<td>N/A</td>
<td>0.0020</td>
<td>0.0200</td>
<td>0.027</td>
<td>0.0312</td>
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<tr>
<td>Nitrite (NO₂-N)</td>
<td>(mg/L)</td>
<td>N/A</td>
<td>0.00010</td>
<td>0.0010</td>
<td>0.0010</td>
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<td>0.00010</td>
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<td>Total Kjedahl Nitrogen</td>
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<td>0.48</td>
<td>0.95</td>
<td>0.48</td>
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<td>Phosphorus (P)-Total</td>
<td>(mg/L)</td>
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<td>0.02</td>
<td>0.02</td>
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<td>0.02</td>
<td>0.02</td>
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<td>Sulfate (SO₄)</td>
<td>(mg/L)</td>
<td>N/A</td>
<td>8.34</td>
<td>8.44</td>
<td>233</td>
<td>8.17</td>
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<tr>
<td>Escherichia Coli</td>
<td>(MPN/100mL)</td>
<td>100</td>
<td>33</td>
<td>68</td>
<td>24</td>
<td>58</td>
<td>13</td>
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<td>Total Coliforms</td>
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<td>&gt;2420</td>
<td>2420</td>
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<td>Aluminum (Al)-Total***</td>
<td>(mg/L)</td>
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<td>0.195</td>
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<td>0.105</td>
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<td>Antimony (Sb)-Total</td>
<td>(mg/L)</td>
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<td>0.00012</td>
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<td>0.00011</td>
<td>0.00011</td>
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<td>0.00010</td>
<td>0.00010</td>
<td>0.00011</td>
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<td>Arsenic (As)-Total</td>
<td>(mg/L)</td>
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<td>0.00125</td>
<td>0.00120</td>
<td>0.00125</td>
<td>0.00121</td>
<td>0.00135</td>
<td>0.00099</td>
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<td>0.00022</td>
<td>0.00101</td>
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<tr>
<td>Barium (Ba)-Total</td>
<td>(mg/L)</td>
<td>N/A</td>
<td>0.0254</td>
<td>0.0226</td>
<td>0.043</td>
<td>0.0205</td>
<td>0.0132</td>
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<td>0.0202</td>
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<tr>
<td>Beryllium (Be)-Total****</td>
<td>(mg/L)</td>
<td>0.011 (&lt;75 mg/L CaCO₃)</td>
<td>&lt;0.000010</td>
<td>&lt;0.000010</td>
<td>&lt;0.000010</td>
<td>&lt;0.000010</td>
<td>&lt;0.000010</td>
<td>&lt;0.000010</td>
<td>&lt;0.000010</td>
<td>&lt;0.000010</td>
<td>&lt;0.000010</td>
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<tr>
<td>Bismuth (Bi)-Total</td>
<td>(mg/L)</td>
<td>N/A</td>
<td>&lt;0.000050</td>
<td>&lt;0.000005</td>
<td>&lt;0.000050</td>
<td>&lt;0.000050</td>
<td>&lt;0.000050</td>
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<td>&lt;0.000050</td>
<td>&lt;0.000050</td>
<td>&lt;0.000050</td>
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<tr>
<td>Boron (B)-Total</td>
<td>(mg/L)</td>
<td>0.2</td>
<td>0.010</td>
<td>0.010</td>
<td>0.014</td>
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<td>&lt;0.010</td>
<td>&lt;0.010</td>
<td>0.011</td>
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<tr>
<td>Cadmium (Cd)-Total***</td>
<td>(mg/L)</td>
<td>0.0001 (0-100 mg/L CaCO₃)</td>
<td>0.00046</td>
<td>0.00051</td>
<td>0.00057</td>
<td>0.00062</td>
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<td>&lt;0.000050</td>
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<tr>
<td>Calcium (Ca)-Total</td>
<td>(mg/L)</td>
<td>0.0005 (&gt;100 mg/L CaCO₃)</td>
<td>0.00073</td>
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<tr>
<td>Chloride (Cl)-Total</td>
<td>(mg/L)</td>
<td>N/A</td>
<td>18.2</td>
<td>17</td>
<td>68.8</td>
<td>125</td>
<td>12.5</td>
<td>11.3</td>
<td>8.56</td>
<td>7.49</td>
<td>18.3</td>
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<tr>
<td>Cobalt (Co)-Total</td>
<td>(mg/L)</td>
<td>0.0009</td>
<td>0.0002</td>
<td>0.0002</td>
<td>0.0006</td>
<td>0.00077</td>
<td>0.00061</td>
<td>0.0008</td>
<td>0.00026</td>
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<td>0.00058</td>
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<tr>
<td>Copper (Cu)-Total****</td>
<td>(mg/L)</td>
<td>0.005</td>
<td>0.0037</td>
<td>0.0038</td>
<td>0.0030</td>
<td>0.0040</td>
<td>0.0039</td>
<td>0.0036</td>
<td>0.0018</td>
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<td>Iron (Fe)-Total</td>
<td>(mg/L)</td>
<td>0.3</td>
<td>0.937</td>
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<td>0.963</td>
<td>1.040</td>
<td>0.925</td>
<td>0.343</td>
<td>0.028</td>
<td>0.739</td>
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</table>

**Notes:**

- PWQO - Provincial Water Quality Objectives. **Bold** indicates exceedance of PWQO criteria
- * - Alkalinity should not be decreased by more than 25% of the natural conditions (Site B)
- ** - indicates criterion is pH and temperature dependent
- *** - indicates criterion is pH dependent
- **** - indicates criteria are Alkalinity dependent
### Laboratory Water Quality Results for June 15, 2016

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>PWQO Criterion</th>
<th>OC1 Oliver Creek - SITE#1</th>
<th>OC2 Oliver Creek - SITE#2</th>
<th>OC3 Oliver Creek - SITE#3</th>
<th>OC4 Oliver Creek - SITE#4</th>
<th>OC5 Oliver Creek - SITE#5</th>
<th>OC6 Oliver Creek - SITE#6</th>
<th>OC7 Oliver Creek - SITE#7</th>
<th>OC8 Oliver Creek - SITE#8</th>
<th>Average</th>
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<tbody>
<tr>
<td><strong>Total Metals Continued</strong></td>
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<td></td>
</tr>
<tr>
<td>Lead (Pb)-Total****</td>
<td>(mg/L)</td>
<td>0.003</td>
<td>30-80 mg/L CaCO₃</td>
<td>0.00015</td>
<td>0.00016</td>
<td>0.00019</td>
<td>0.00011</td>
<td>0.00020</td>
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<td>0.00012</td>
</tr>
<tr>
<td></td>
<td>(mg/L)</td>
<td>0.005</td>
<td>(&gt;80 mg/L CaCO₃)</td>
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<tr>
<td>Lithium (Li)-Total</td>
<td>(mg/L)</td>
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<td>0.0015</td>
<td>0.0096</td>
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<td>&lt;0.0010</td>
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<td>Magnesium (Mg)-Total</td>
<td>(mg/L)</td>
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<td>7.23</td>
<td>6.72</td>
<td>24.80</td>
<td>5.58</td>
<td>4.95</td>
<td>5.09</td>
<td>3.94</td>
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<td>Manganese (Mn)-Total</td>
<td>(mg/L)</td>
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<td>0.0372</td>
<td>0.1410</td>
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<td>0.025</td>
<td>0.0616</td>
<td>0.0527</td>
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<tr>
<td>Molybdenum (Mo)-Total</td>
<td>(mg/L)</td>
<td>0.004</td>
<td>0.00836</td>
<td>0.000794</td>
<td>0.001390</td>
<td>0.000758</td>
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<td>Nickel (Ni)-Total</td>
<td>(mg/L)</td>
<td>0.025</td>
<td>0.00218</td>
<td>0.00239</td>
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<td>Potassium (K)-Total</td>
<td>(mg/L)</td>
<td>0.951</td>
<td>0.92</td>
<td>3.600</td>
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<td>Selenium (Se)-Total</td>
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<td>0.000175</td>
<td>0.000357</td>
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<td>Silver (Ag)-Total</td>
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<td>&lt;0.000010</td>
<td>0.000025</td>
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<tr>
<td>Sodium (Na)-Total</td>
<td>(mg/L)</td>
<td>3.76</td>
<td>3.63</td>
<td>3.136</td>
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<td>1.67</td>
<td>2.42</td>
<td>1.93</td>
<td>1.80</td>
<td>3.36</td>
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<td>Strontium (Sr)-Total</td>
<td>(mg/L)</td>
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<td>0.0398</td>
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<td>0.0194</td>
<td>0.0397</td>
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<td>Tellurium (Te)-Total</td>
<td>(mg/L)</td>
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<td>&lt;0.00020</td>
<td>&lt;0.00020</td>
<td>&lt;0.00020</td>
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<td>Thallium (Tl)-Total</td>
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<td>&lt;0.000010</td>
<td>0.000015</td>
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<tr>
<td>Tin (Sn)-Total</td>
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<td>&lt;0.00010</td>
<td>&lt;0.00010</td>
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<td>&lt;0.00010</td>
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<tr>
<td>Titanium (Ti)-Total</td>
<td>(mg/L)</td>
<td>0.00418</td>
<td>0.00459</td>
<td>0.00393</td>
<td>0.00517</td>
<td>0.00293</td>
<td>0.00617</td>
<td>0.00147</td>
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<tr>
<td>Tungsten (W)-Total</td>
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<tr>
<td>Uranium (U)-Total</td>
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<td>Vanadium (V)-Total</td>
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<td>0.00131</td>
<td>0.00293</td>
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<td>0.00109</td>
<td>0.00126</td>
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<td>&lt;0.00050</td>
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<td>Zinc (Zn)-Total</td>
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<td>0.02 (interim)</td>
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**Notes:**

PWQO - Provincial Water Quality Objectives. **Bold** indicates exceedance of PWQO criteria

* - Alkalinity should not be decreased by more than 25% of the natural conditions (Site 8)

** - indicates criterion is pH and temperature dependent

*** - indicates criterion is pH dependent

**** - indicates criteria are Alkalinity dependent
### Laboratory Water Quality Results for July 14, 2016

**Parameter** | Units | PWQO Criterion | OC1 Oliver Creek - SITE#2 | OC2 Oliver Creek - SITE#2 | OC3 Oliver Creek - SITE#3 | OC4 Oliver Creek - SITE#4 | OC5 Oliver Creek - SITE#5 | OC6 Oliver Creek - SITE#6 | OC7 Oliver Creek - SITE#7 | OC8 Oliver Creek - SITE#8 | Average |
---|---|---|---|---|---|---|---|---|---|---|---|
**Physical Tests** | | | 14-Jul-16 | 14-Jul-16 | 14-Jul-16 | 14-Jul-16 | 14-Jul-16 | 14-Jul-16 | 14-Jul-16 | 14-Jul-16 | July |
Conductivity (EC) | (uS/cm) | N/A | 170 | 162 | 552 | 121 | 102 | 101 | 83 | 76 | 171 |
pH | | | 6.5-8.5 | 8.13 | 7.89 | 7.96 | 7.64 | 7.55 | 7.71 | 7.50 | 7.75 | 7.77 |
Total Dissolved Solids | (mg/L) | N/A | 127 | 122 | 356 | 107 | 92 | 78 | 61 | 48 | 124 |
Turbidity | (NTU) | N/A | 5.44 | 5.69 | 3.71 | 5.67 | 2.77 | 6.40 | 2.74 | 0.53 | 4.12 |
**Anions and Nutrients** | | | | | | | | | | | |
Alkalinity, Total (as CaCO$_3$)*** | (mg/L) | 20.6 | 74.3 | 71.4 | 267 | 51.3 | 50.0 | 38.4 | 30.8 | 27.5 | 76.3 |
Ammonia-N, Total | (mg/L) | N/A | <0.0020 | <0.0020 | 0.037 | <0.0020 | <0.0020 | <0.0020 | 0.175 | 0.190 | 0.106 |
Un-ionized Ammonia (calculated)**** | | | 0.02 | <0.00068 | <0.0007 | 0.0012 | <0.0002 | <0.0002 | <0.0002 | 0.0021 | 0.0040 | 0.0012 |
Chloride (Cl) | (mg/L) | N/A | 5.16 | 4.57 | 13.70 | 2.51 | 0.15 | 0.015 | 0.032 | 1.91 | 4.06 |
Nitrate-N (NO$_3$-N) | (mg/L) | N/A | 0.072 | 0.087 | 0.137 | 0.072 | <0.020 | 0.030 | 0.023 | <0.020 | 0.070 |
Nitrite-N (NO$_2$-N) | (mg/L) | N/A | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
Total Kjeldahl Nitrogen | (mg/L) | N/A | 0.65 | 0.62 | 1.07 | 0.57 | 0.68 | 0.46 | 0.41 | 0.25 | 0.59 |
Phosphorus (P) - Total | (mg/L) | <0.03 | 0.03 | 0.03 | 0.24 | 0.02 | 0.03 | 0.02 | 0.01 | <0.003 | 0.05 |
Sulphate (SO$_4$) | (mg/L) | N/A | 6.65 | 6.62 | 19.40 | 6.69 | 1.45 | 7.07 | 5.82 | 8.36 | 7.76 |
**Bacteriological Tests** | | | | | | | | | | | |
Escherichia Coli | (MPN/100mL) | 100 | 37 | 77 | 687 | 56 | 33 | 50 | 99 | 2 | 130 |
Total Coliforms | (MPN/100mL) | 1000 (prior to 1994) | >2420 | >2420 | >2420 | >2420 | >2420 | >2420 | >2420 | >2420 | >2420 |
**Total Metals** | | | | | | | | | | | |
Aluminum (Al)-Total*** | (mg/L) | 0.075 | 0.201 | 0.200 | 0.110 | 0.226 | 0.101 | 0.262 | 0.080 | 0.022 | 0.150 |
Antimony (Sb)-Total | (mg/L) | 0.02 | 0.00019 | 0.00014 | 0.000017 | 0.00014 | 0.00013 | 0.00013 | -0.00010 | -0.00010 | 0.00011 |
Arsenic (As)-Total | (mg/L) | 0.005 (Interim) | 0.0019 | 0.00181 | 0.00161 | 0.00181 | 0.00208 | 0.00134 | 0.00096 | 0.00027 | 0.0015 |
Barium (Ba) - Total | (mg/L) | N/A | 0.0124 | 0.0126 | 0.0524 | 0.0323 | 0.0140 | 0.0163 | 0.0127 | 0.0393 | 0.0234 |
Beryllium (Be)-Total**** | | | 0.0010 | <0.00010 | <0.00010 | <0.00010 | <0.00010 | <0.00010 | <0.00010 | <0.00010 | <0.00010 |
Bismuth (Bi)-Total | (mg/L) | 1.10 (>75 mg/L CaCO$_3$) | <0.00010 | <0.00010 | <0.00010 | <0.00010 | <0.00010 | <0.00010 | <0.00010 | <0.00010 | <0.00010 |
Boron (B)-Total | (mg/L) | N/A | <0.000050 | <0.000050 | <0.000050 | <0.000050 | <0.000050 | <0.000050 | <0.000050 | <0.000050 | <0.000050 |
Cadmium (Cd)-Total**** | | | 0.2 | 0.013 | 0.012 | 0.012 | 0.011 | <0.010 | 0.012 | <0.010 | 0.0132 |
Copper (Cu)-Total**** | | | 0.005 | 0.00044 | 0.00040 | 0.00029 | 0.00040 | 0.0030 | 0.0036 | 0.0018 | 0.0010 | 0.0031 |
Iron (Fe)-Total | (mg/L) | 0.3 | 1.290 | 1.260 | 0.912 | 1.200 | 1.510 | 1.160 | 0.585 | 0.043 | 0.995 |
**Notes:**
- PWQO - Provincial Water Quality Objectives. Bold indicates exceedance of PWQO criteria.
- * - Alkalinity should not be decreased by more than 25% of the natural conditions (Site 8)
- ** - indicates criterion is pH and temperature dependent
- *** - indicates criteria are pH dependent
- **** - indicates criteria are Alkalinity dependent
# Laboratory Water Quality Results for July 14, 2016

<table>
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<tr>
<th>Parameter</th>
<th>Units</th>
<th>PWQO Criterion</th>
<th>OC1 Oliver Creek - SITE#1</th>
<th>OC2 Oliver Creek - SITE#2</th>
<th>OC3 Oliver Creek - SITE#3</th>
<th>OC4 Oliver Creek - SITE#4</th>
<th>OC5 Oliver Creek - SITE#5</th>
<th>OC6 Oliver Creek - SITE#6</th>
<th>OC7 Oliver Creek - SITE#7</th>
<th>OC8 Oliver Creek - SITE#8</th>
<th>Average</th>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lead (Pb)-Total****</td>
<td>(mg/L)</td>
<td>0.003 (30-80 mg/L CaCO₃)</td>
<td>0.002214</td>
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<td>0.000233</td>
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<tr>
<td>Lithium (Li)-Total</td>
<td>(mg/L)</td>
<td>N/A</td>
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<td>0.0019</td>
<td>0.0096</td>
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<td>&lt;0.0010</td>
<td>0.0033</td>
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<td>Magnesium (Mg)-Total</td>
<td>(mg/L)</td>
<td>N/A</td>
<td>8.42</td>
<td>7.72</td>
<td>29.30</td>
<td>5.93</td>
<td>5.37</td>
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<td>Molybdenum (Mo)-Total</td>
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<td>Nickel (Ni)-Total</td>
<td>(mg/L)</td>
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<td>Potassium (K)-Total</td>
<td>(mg/L)</td>
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<td>Selenium (Se)-Total</td>
<td>(mg/L)</td>
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<td>Silver (Ag)-Total</td>
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<td>Sodium (Na)-Total</td>
<td>(mg/L)</td>
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<td>1.59</td>
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<td>Strontium (Sr)-Total</td>
<td>(mg/L)</td>
<td>N/A</td>
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<td>0.1260</td>
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<td>Tellurium (Te)-Total</td>
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<td>&lt;0.00020</td>
<td>&lt;0.00020</td>
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<td>(mg/L)</td>
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<tr>
<td>Tin (Sn)-Total</td>
<td>(mg/L)</td>
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<tr>
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<td>Tungsten (W)-Total</td>
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<tr>
<td>Uranium (U)-Total</td>
<td>(mg/L)</td>
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<tr>
<td>Vanadium (V)-Total</td>
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<td>Zinc (Zn)-Total</td>
<td>(mg/L)</td>
<td>0.02 (interim)</td>
<td>0.0039</td>
<td>0.0040</td>
<td>&lt;0.0030</td>
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</table>
| Zirconium (Zr)-Total     | (mg/L)         | 0.004 | 0.00034 | 0.000032 | 0.000033 | 0.000036 | <0.00030 | <0.00030 | <0.00030 | <0.00030 | <0.00030 | 0.0003 |     “PWQO - Provincial Water Quality Objectives. Bold indicates exceedance of PWQO criteria
* - Alkalinity should not be decreased by more than 25% of the natural conditions (Site 8)
** - indicates criterion is pH and temperature dependent
*** - indicates criterion is pH dependent
**** - indicates criteria are Alkalinity dependent

Notes:
Appendix K:
Laboratory Certificates of Analysis and Test Results
Certificate of Analysis

Lab Work Order #: L1783692
Project P.O. #: NOT SUBMITTED
Job Reference: OLIVER CREEK
C of C Numbers: 
Legal Site Desc:

Brandon Trudell
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]
**ALS ENVIRONMENTAL ANALYTICAL REPORT**

**Sample ID**

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<th>Description</th>
<th>Sampled Date</th>
<th>Sampled Time</th>
<th>Client ID</th>
<th>Sampled Date</th>
<th>Sampled Time</th>
<th>Client ID</th>
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<td>OC8 - OLIVER CREEK - SITE #8</td>
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<td>Grab</td>
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<td>Grab</td>
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**Grouping**

**WATER**

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<td>Total Dissolved Solids (mg/L)</td>
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<td>1.46</td>
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<td>Turbidity (NTU)</td>
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<td>31.6</td>
<td>36.7</td>
<td>46.7</td>
<td>44.9</td>
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<tr>
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<td>&lt;0.020</td>
<td>&lt;0.020</td>
<td>0.026</td>
<td>0.026</td>
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<tr>
<td>Ammonia, Total (as N) (mg/L)</td>
<td>2.23</td>
<td>2.94</td>
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<td>Chloride (Cl) (mg/L)</td>
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<td>&lt;0.020</td>
<td>&lt;0.020</td>
<td>&lt;0.020</td>
<td>&lt;0.020</td>
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<tr>
<td>Nitrate (as N) (mg/L)</td>
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<td>&lt;0.010</td>
<td>&lt;0.010</td>
<td>&lt;0.010</td>
<td>&lt;0.010</td>
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<tr>
<td>Nitrite (as N) (mg/L)</td>
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<td>Total Kjeldahl Nitrogen (mg/L)</td>
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<td>Phosphorus (P)-Total (mg/L)</td>
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<td>1730</td>
<td>2420</td>
<td>2420</td>
<td>&gt;2420</td>
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<td>Total Metals</td>
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<td>6.07</td>
<td>8.35</td>
<td>2.74</td>
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<td>Aluminum (Al)-Total (mg/L)</td>
<td>0.0163</td>
<td>0.0639</td>
<td>0.331</td>
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<td>Antimony (Sb)-Total (mg/L)</td>
<td>0.00016</td>
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<td>0.00011</td>
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<td>Arsenic (As)-Total (mg/L)</td>
<td>0.00022</td>
<td>0.00060</td>
<td>0.00099</td>
<td>0.00135</td>
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<tr>
<td>Barium (Ba)-Total (mg/L)</td>
<td>0.0102</td>
<td>0.0116</td>
<td>0.0154</td>
<td>0.0132</td>
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<td>Beryllium (Be)-Total (mg/L)</td>
<td>&lt;0.00010</td>
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<td>Bismuth (Bi)-Total (mg/L)</td>
<td>&lt;0.000050</td>
<td>&lt;0.000050</td>
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<td>Boron (B)-Total (mg/L)</td>
<td>&lt;0.010</td>
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<td>Cadmium (Cd)-Total (mg/L)</td>
<td>&lt;0.000050</td>
<td>0.0000232</td>
<td>0.0000563</td>
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<td>Calcium (Ca)-Total (mg/L)</td>
<td>7.49</td>
<td>8.56</td>
<td>11.3</td>
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<td>Chromium (Cr)-Total (mg/L)</td>
<td>0.00018</td>
<td>0.00026</td>
<td>0.00080</td>
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<td>Cobalt (Co)-Total (mg/L)</td>
<td>&lt;0.00010</td>
<td>&lt;0.00010</td>
<td>0.00018</td>
<td>0.00019</td>
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<td>Copper (Cu)-Total (mg/L)</td>
<td>0.00115</td>
<td>0.00178</td>
<td>0.00362</td>
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<td>Iron (Fe)-Total (mg/L)</td>
<td>0.028</td>
<td>0.343</td>
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<td>Lead (Pb)-Total (mg/L)</td>
<td>&lt;0.000050</td>
<td>0.000052</td>
<td>0.000203</td>
<td>0.000106</td>
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<td>Lithium (Li)-Total (mg/L)</td>
<td>&lt;0.0010</td>
<td>&lt;0.0010</td>
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<td>Magnesium (Mg)-Total (mg/L)</td>
<td>3.40</td>
<td>3.94</td>
<td>5.09</td>
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<td>Manganese (Mn)-Total (mg/L)</td>
<td>0.00161</td>
<td>0.0249</td>
<td>0.0189</td>
<td>0.119</td>
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<td>Molybdenum (Mo)-Total (mg/L)</td>
<td>0.000167</td>
<td>0.000350</td>
<td>0.000552</td>
<td>0.00109</td>
<td>0.000758</td>
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<td>Nickel (Ni)-Total (mg/L)</td>
<td>&lt;0.00050</td>
<td>0.00086</td>
<td>0.00223</td>
<td>0.00203</td>
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<td>Phosphorus (P)-Total (mg/L)</td>
<td>&lt;0.050</td>
<td>&lt;0.050</td>
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</tbody>
</table>

* Please refer to the Reference Information section for an explanation of any qualifiers detected.
### Grouping Analyte

#### Physical Tests
- Conductivity (EC) (uS/cm)
  - Sampled Date: 14-JUN-16
  - Sampled Time: 14:05

- Hardness (as CaCO3) (mg/L)
  - Sampled Date: 14-JUN-16
  - Sampled Time: 14:25

- pH (pH)
  - Sampled Date: 15-JUN-16

- Total Dissolved Solids (mg/L)
  - Sampled Date: 15-JUN-16

- Turbidity (NTU)
  - Sampled Date: 15-JUN-16

#### Anions and Nutrients
- Alkalinity, Total (as CaCO3) (mg/L)
  - Sampled Date: 15-JUN-16
  - Sampled Time: 15:00

- Ammonia, Total (as N) (mg/L)
  - Sampled Date: 15-JUN-16

- Chloride (Cl) (mg/L)
  - Sampled Date: 15-JUN-16

- Nitrate (as N) (mg/L)
  - Sampled Date: 15-JUN-16

- Nitrite (as N) (mg/L)
  - Sampled Date: 15-JUN-16

- Total Kjeldahl Nitrogen (mg/L)
  - Sampled Date: 15-JUN-16

- Phosphorus (P)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Sulfate (SO4) (mg/L)
  - Sampled Date: 15-JUN-16

#### Bacteriological Tests
- Escherichia Coli (MPN/100mL)
  - Sampled Date: 15-JUN-16

- Total Coliforms (MPN/100mL)
  - Sampled Date: 15-JUN-16

#### Total Metals
- Aluminum (Al)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Antimony (Sb)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Arsenic (As)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Barium (Ba)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Beryllium (Be)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Bismuth (Bi)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Boron (B)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Cadmium (Cd)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Calcium (Ca)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Cesium (Cs)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Chromium (Cr)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Cobalt (Co)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Copper (Cu)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Iron (Fe)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Lead (Pb)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Lithium (Li)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Magnesium (Mg)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Manganese (Mn)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Molybdenum (Mo)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Nickel (Ni)-Total (mg/L)
  - Sampled Date: 15-JUN-16

- Phosphorus (P)-Total (mg/L)
  - Sampled Date: 15-JUN-16

*Please refer to the Reference Information section for an explanation of any qualifiers detected.
<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Description</th>
<th>Sampled Date</th>
<th>Sampled Time</th>
<th>Grouping</th>
<th>Analyte</th>
<th>Concentration</th>
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<td>L1783692-1</td>
<td>Grab</td>
<td>14-JUN-16</td>
<td>11:10</td>
<td>OC8 - OLIVER CREEK - SITE #8</td>
<td>Potassium (K)-Total (mg/L)</td>
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<td>Rubidium (Rb)-Total (mg/L)</td>
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<td>12:30</td>
<td>OC6 - OLIVER CREEK - SITE #6</td>
<td>Selenium (Se)-Total (mg/L)</td>
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<td>Grab</td>
<td>14-JUN-16</td>
<td>13:00</td>
<td>OC5 - OLIVER CREEK - SITE #5</td>
<td>Silicon (Si)-Total (mg/L)</td>
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<td>Silver (Ag)-Total (mg/L)</td>
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<td>Sodium (Na)-Total (mg/L)</td>
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<td>Strontium (Sr)-Total (mg/L)</td>
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<td>Sulfur (S)-Total (mg/L)</td>
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<td>Tellurium (Te)-Total (mg/L)</td>
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<td>Thorium (Th)-Total (mg/L)</td>
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<td>Tin (Sn)-Total (mg/L)</td>
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<td>Titanium (Ti)-Total (mg/L)</td>
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<td>Tungsten (W)-Total (mg/L)</td>
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<td>Uranium (U)-Total (mg/L)</td>
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<td>Vanadium (V)-Total (mg/L)</td>
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<td>Zinc (Zn)-Total (mg/L)</td>
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<td>Zirconium (Zr)-Total (mg/L)</td>
<td>&lt;0.00030</td>
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</tbody>
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* Please refer to the Reference Information section for an explanation of any qualifiers detected.
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<th>Grouping</th>
<th>Analyte</th>
<th>OC3 - OLIVER CREEK - SITE #3</th>
<th>OC2 - OLIVER CREEK - SITE #2</th>
<th>OC1 - OLIVER CREEK - SITE #1</th>
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<tr>
<td>Total Metals</td>
<td>Potassium (K)-Total (mg/L)</td>
<td>3.60</td>
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<td>Rubidium (Rb)-Total (mg/L)</td>
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<td>Selenium (Se)-Total (mg/L)</td>
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<td>Silicon (Si)-Total (mg/L)</td>
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<td>3.66</td>
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<td>Silver (Ag)-Total (mg/L)</td>
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<td>Sodium (Na)-Total (mg/L)</td>
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<td>Strontium (Sr)-Total (mg/L)</td>
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<td>Sulfur (S)-Total (mg/L)</td>
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<td>Tellurium (Te)-Total (mg/L)</td>
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<tr>
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<td>Thallium (Tl)-Total (mg/L)</td>
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<td>Thorium (Th)-Total (mg/L)</td>
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<td>Tin (Sn)-Total (mg/L)</td>
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<td>Titanium (Ti)-Total (mg/L)</td>
<td>0.00393</td>
<td>0.00459</td>
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<td>Tungsten (W)-Total (mg/L)</td>
<td>&lt;0.00010</td>
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<tr>
<td></td>
<td>Uranium (U)-Total (mg/L)</td>
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<td>0.000248</td>
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<td>Vanadium (V)-Total (mg/L)</td>
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<tr>
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<td>Zinc (Zn)-Total (mg/L)</td>
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<td>Zirconium (Zr)-Total (mg/L)</td>
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<td>&lt;0.00030</td>
<td>&lt;0.00030</td>
</tr>
</tbody>
</table>

* Please refer to the Reference Information section for an explanation of any qualifiers detected.
Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.

Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Qualifier</th>
<th>Applies to Sample Number(s)</th>
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</thead>
<tbody>
<tr>
<td>Chloride (Cl)</td>
<td>B</td>
<td>L1783692-1, -2, -3, -5, -6, -7, -8</td>
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<tr>
<td>Calcium (Ca)-Total</td>
<td>MS-B</td>
<td>L1783692-1, -2, -3, -4, -5, -6, -7, -8</td>
</tr>
<tr>
<td>Magnesium (Mg)-Total</td>
<td>MS-B</td>
<td>L1783692-1, -2, -3, -4, -5, -6, -7, -8</td>
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<tr>
<td>Sulfate (SO4)</td>
<td>MS-B</td>
<td>L1783692-1, -2, -3, -4, -5, -6, -7, -8</td>
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<tr>
<td>Calcium (Ca)-Total</td>
<td>MS-B</td>
<td>L1783692-1, -2, -3, -4, -5, -6, -7, -8</td>
</tr>
<tr>
<td>Magnesium (Mg)-Total</td>
<td>MS-B</td>
<td>L1783692-1, -2, -3, -4, -5, -6, -7, -8</td>
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<tr>
<td>Sodium (Na)-Total</td>
<td>MS-B</td>
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<tr>
<td>Strontium (Sr)-Total</td>
<td>MS-B</td>
<td>L1783692-1, -2, -3, -4, -5, -6, -7, -8</td>
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<tr>
<td>Sulfur (S)-Total</td>
<td>MS-B</td>
<td>L1783692-1, -2, -3, -4, -5, -6, -7, -8</td>
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<tr>
<td>Total Kjeldahl Nitrogen</td>
<td>MS-B</td>
<td>L1783692-1, -2, -3, -4, -5, -6, -7, -8</td>
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<td>Total Kjeldahl Nitrogen</td>
<td>MS-B</td>
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**Qualifiers for Individual Parameters Listed:**

<table>
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<tr>
<th>Qualifier</th>
<th>Description</th>
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<tbody>
<tr>
<td>B</td>
<td>Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.</td>
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<tr>
<td>MS-B</td>
<td>Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.</td>
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**Test Method References:**

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<th>ALS Test Code</th>
<th>Matrix</th>
<th>Test Description</th>
<th>Method Reference**</th>
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<tbody>
<tr>
<td>ALK-TITR-TB</td>
<td>Water</td>
<td>Alkalinity</td>
<td>APHA 2320</td>
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<td>CL-L-IC-N-TB</td>
<td>Water</td>
<td>Chloride in Water by IC (Low Level)</td>
<td>EPA 300.1 (mod)</td>
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<tr>
<td>EC-TITR-TB</td>
<td>Water</td>
<td>Conductivity</td>
<td>APHA 2510 B</td>
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<tr>
<td>HARDNESS-CALC-TB</td>
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<td>Hardness (as CaCO3)</td>
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<td>MET-T-CCMS-TB</td>
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<td>Total Metals in Water by CRC ICPMS</td>
<td>EPA 200.2/6020A (mod)</td>
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<tr>
<td>NH3-COL-TB</td>
<td>Water</td>
<td>Ammonia by Discrete Analyzer</td>
<td>APHA 4500-NH3 G. (modified)</td>
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<tr>
<td>NO2-IC-N-TB</td>
<td>Water</td>
<td>Nitrate in Water by IC</td>
<td>EPA 300.1 (mod)</td>
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<tr>
<td>NO3-IC-N-TB</td>
<td>Water</td>
<td>Nitrate in Water by IC</td>
<td>EPA 300.1 (mod)</td>
</tr>
<tr>
<td>P-T-COL-TB</td>
<td>Water</td>
<td>Total Phosphorus by Discrete Analyzer</td>
<td>APHA 4500-P B, F, G (modified)</td>
</tr>
<tr>
<td>PH-TITR-TB</td>
<td>Water</td>
<td>pH</td>
<td>APHA 4500-H</td>
</tr>
<tr>
<td>S04-IC-N-TB</td>
<td>Water</td>
<td>Sulfate in Water by IC</td>
<td>EPA 300.1 (mod)</td>
</tr>
<tr>
<td>TC.EC-QT97-TB</td>
<td>Water</td>
<td>Total Coliform and E.coli</td>
<td>APHA 9223 B</td>
</tr>
</tbody>
</table>

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Ammonia in aqueous matrices is analyzed using discrete analyzer with colourimetric detection.

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Phosphorus in aqueous matrices is analyzed using discrete Analyzer with colourimetric detection.

This analysis is carried out using procedures adapted from APHA Method 9223 "Enzyme Substrate Coliform Test". E. coli and Total Coliform are determined simultaneously. The sample is mixed with a mixture of hydrolyzable substrates and then sealed in a multi-well packet. The packet is incubated for 18 or 24 hours and then the number of wells exhibiting a positive response are counted. The final result is obtained by comparing the
positive responses to a probability table.

<table>
<thead>
<tr>
<th>Test Code</th>
<th>Category</th>
<th>Description</th>
<th>Method</th>
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<tr>
<td>TDS-TB</td>
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<td>Total Dissolved Solids</td>
<td>APHA 2540 C (modified)</td>
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<tr>
<td>TKN-COL-TB</td>
<td>Water</td>
<td>Total Kjeldahl Nitrogen</td>
<td>APHA 4500-Norg (modified)</td>
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<tr>
<td>TURBIDITY-TB</td>
<td>Water</td>
<td>Turbidity</td>
<td>APHA 2130 B-Nephelometer</td>
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</table>

Aqueous matrices are analyzed using gravimetry and evaporation.

Total Kjeldahl Nitrogen in aqueous matrices is analyzed using a discrete analyzer with colourimetric detection.

Aqueous matrices are analyzed using nephelometry with the light scatter measured at a 90º angle.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

<table>
<thead>
<tr>
<th>Laboratory Definition Code</th>
<th>Laboratory Location</th>
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</thead>
<tbody>
<tr>
<td>TB</td>
<td>ALS ENVIRONMENTAL - THUNDER BAY, ONTARIO, CANADA</td>
</tr>
</tbody>
</table>

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

mg/kg - milligrams per kilogram.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.

< - Less than.

D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.
Chain of Custody (COC) / Analytical Request Form

Report To
Company: Lakehead Region Conservation Authority
Contact: 
Address: 130 Conservation Road
PO Box 10427
Phone: 807-344-5887
Email 1 or Fax: tammym@lakeheadka.com
Email 2: 

Invoice To
Same as Report To

Copy of Invoice with Report

Select Invoice Distribution:

Company:

Project Information
ALS Quote #: Q56900
Job #: GL Account:
PO / AFE:
LSD:

ALS Lab Work Order # (lab use only) [L783692]

ALS Contact: SD

Sample Identification and/or Coordinates
(As description will appear on the report)

<table>
<thead>
<tr>
<th>ALS Sample #</th>
<th>Sample Description</th>
<th>Date (dd-mm-yyyy)</th>
<th>Time (hh:mm)</th>
<th>Sample Type</th>
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</thead>
<tbody>
<tr>
<td>OC8 - Oliver Creek - Site #8</td>
<td>14-Jun-16 11:10</td>
<td>grab</td>
<td>x x x x x x x x</td>
<td>5</td>
</tr>
<tr>
<td>OC7 - Oliver Creek - Site #7</td>
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<tr>
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<tr>
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<td>grab</td>
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<tr>
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</tr>
<tr>
<td>OC3 - Oliver Creek - Site #3</td>
<td>14-Jun-16 14:05</td>
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</tr>
<tr>
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<tr>
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<td>5</td>
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</tbody>
</table>

Drinking Water (DW) Samples (client use)
Special Instructions / Specify Criteria to add on report (client Use)

SAMPLE CONDITION AS RECEIVED (lab use only)

Are samples taken from a Regulated DW System?
Yes ☒ No ☐

Are samples for human drinking water use?
Yes ☒ No ☐

SHIPPMENT RELEASE (client use)

Released by: Date: June 15/16

INITIAL SHIPMENT RECEPTION (lab use only)

Received By: Date: June 15/16

FINAL SHIPMENT RECEPTION (lab use only)

Received By: Date: June 15/16

Failure to complete all ports 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.
Certificate of Analysis

Lab Work Order #: L1798433
Project P.O. #: NOT SUBMITTED
Job Reference: OLIVER CREEK
C of C Numbers:
Legal Site Desc: 

Christina Shepherd
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]
## ALS ENVIRONMENTAL ANALYTICAL REPORT

### Grouping Analyte

#### WATER

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<tr>
<th>Physical Tests</th>
<th>Analyte</th>
<th>L1798433-1</th>
<th>L1798433-2</th>
<th>L1798433-3</th>
<th>L1798433-4</th>
<th>L1798433-5</th>
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<td></td>
<td>Conductivity (uS/cm)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conductivity (EC) (uS/cm)</td>
<td>76.2</td>
<td>83.4</td>
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<td>Hardness (as CaCO3) (mg/L)</td>
<td>32.5</td>
<td>48.8</td>
<td>56.7</td>
<td>60.7</td>
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<tr>
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<td>pH (pH)</td>
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<td>7.50</td>
<td>7.71</td>
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<td>Total Dissolved Solids (mg/L)</td>
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<td>61</td>
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<td>Turbidity (NTU)</td>
<td>0.53</td>
<td>2.74</td>
<td>6.40</td>
<td>2.77</td>
<td>5.67</td>
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<td>Anions and Nutrients</td>
<td>Alkalinity, Total (as CaCO3) (mg/L)</td>
<td>27.5</td>
<td>30.8</td>
<td>38.4</td>
<td>50.0</td>
<td>51.3</td>
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<td>Ammonia, Total (as N) (mg/L)</td>
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<td>0.175</td>
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<td>&lt;0.020</td>
<td>&lt;0.020</td>
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<td>Chloride (Cl) (mg/L)</td>
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<td>Nitrate (as N) (mg/L)</td>
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<td>0.030</td>
<td>&lt;0.020</td>
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<td></td>
<td>Total Kjeldahl Nitrogen (mg/L)</td>
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<td>0.41</td>
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<td>0.68</td>
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<td>Phosphorus (P)-Total (mg/L)</td>
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<td>0.0090</td>
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<td>Sulfate (SO4) (mg/L)</td>
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<td>Bacteriological Tests</td>
<td>Escherichia Coli (MPN/100mL)</td>
<td>2</td>
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<td>50</td>
<td>33</td>
<td>56</td>
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<td>Total Coliforms (MPN/100mL)</td>
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<td>1730</td>
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<td>Total Metals</td>
<td>Aluminum (Al)-Total (mg/L)</td>
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<td>&lt;0.00010</td>
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<td>0.00013</td>
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<td>Arsenic (As)-Total (mg/L)</td>
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<td>0.00096</td>
<td>0.00144</td>
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<td>Barium (Ba)-Total (mg/L)</td>
<td>0.00932</td>
<td>0.0127</td>
<td>0.0163</td>
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<td>Beryllium (Be)-Total (mg/L)</td>
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<td>&lt;0.00010</td>
<td>&lt;0.00010</td>
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<td>Bismuth (Bi)-Total (mg/L)</td>
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<td>&lt;0.000050</td>
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<td>Boron (B)-Total (mg/L)</td>
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<td>&lt;0.010</td>
<td>0.012</td>
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<td>Cadmium (Cd)-Total (mg/L)</td>
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<td>Calcium (Ca)-Total (mg/L)</td>
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<td>9.02</td>
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<td>14.5</td>
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<td>Cesium (Cs)-Total (mg/L)</td>
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<td>Chromium (Cr)-Total (mg/L)</td>
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<td>Cobalt (Co)-Total (mg/L)</td>
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<td>Copper (Cu)-Total (mg/L)</td>
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<td>Iron (Fe)-Total (mg/L)</td>
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<td>Lead (Pb)-Total (mg/L)</td>
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<td>Lithium (Li)-Total (mg/L)</td>
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<td>&lt;0.0010</td>
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<td>Magnesium (Mg)-Total (mg/L)</td>
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<td>Manganese (Mn)-Total (mg/L)</td>
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<td>Molybdenum (Mo)-Total (mg/L)</td>
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<td>0.000441</td>
<td>0.000775</td>
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* Please refer to the Reference Information section for an explanation of any qualifiers detected.
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<th>Grouping</th>
<th>Analyte</th>
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<td>Description</td>
<td>11:35</td>
<td>11:50</td>
<td>12:05</td>
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<td>Sampled Date</td>
<td>OC3 - OLIVER CREEK - SITE #3</td>
<td>OC2 - OLIVER CREEK - SITE #2</td>
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<td>12:05</td>
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<tr>
<td>WATER</td>
<td>Conductivity (uS/cm)</td>
<td>552</td>
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<td>Conductivity (EC) (uS/cm)</td>
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<tr>
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<td>Hardness (as CaCO3) (mg/L)</td>
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<td>Hardness (as CaCO3)</td>
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<td>pH (pH)</td>
<td>7.96</td>
<td>7.89</td>
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<td></td>
<td>Total Dissolved Solids (mg/L)</td>
<td>356</td>
<td>122</td>
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<td>Turbidity (NTU)</td>
<td>3.71</td>
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<tr>
<td></td>
<td>Anions and Nutrients</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>Alkalinity, Total (as CaCO3) (mg/L)</td>
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<td>71.4</td>
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<td>Ammonia, Total (as N) (mg/L)</td>
<td>0.037</td>
<td>&lt;0.020</td>
<td>&lt;0.020</td>
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<tr>
<td></td>
<td>Chloride (Cl) (mg/L)</td>
<td>13.7</td>
<td>4.57</td>
<td>5.10</td>
</tr>
<tr>
<td></td>
<td>Nitrate (as N) (mg/L)</td>
<td>0.137</td>
<td>0.087</td>
<td>0.072</td>
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<tr>
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<td>Nitrite (as N) (mg/L)</td>
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<td>&lt;0.010</td>
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<tr>
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<td>Total Kjeldahl Nitrogen (mg/L)</td>
<td>1.07</td>
<td>0.62</td>
<td>0.65</td>
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<tr>
<td></td>
<td>Phosphorus (P)-Total (mg/L)</td>
<td>0.235</td>
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<tr>
<td></td>
<td>Sulfate (SO4) (mg/L)</td>
<td>19.4</td>
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<td>6.65</td>
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<tr>
<td></td>
<td>Bacteriological Tests</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Escherichia Coli (MPN/100mL)</td>
<td>687</td>
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<td>37</td>
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<tr>
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<td>Total Coliforms (MPN/100mL)</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>&gt;2420</td>
<td>&gt;2420</td>
<td>&gt;2420</td>
</tr>
<tr>
<td></td>
<td>Total Metals</td>
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<tr>
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<td>Aluminum (Al)-Total (mg/L)</td>
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<td>0.200</td>
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<td>Antimony (Sb)-Total (mg/L)</td>
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<td>Boron (B)-Total (mg/L)</td>
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<td>Copper (Cu)-Total (mg/L)</td>
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<td>Molybdenum (Mo)-Total (mg/L)</td>
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* Please refer to the Reference Information section for an explanation of any qualifiers detected.
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<td>&lt;0.050</td>
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<td>0.679</td>
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<td>Silicon (Si)-Total (mg/L)</td>
<td>1.76</td>
<td>2.66</td>
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<td>Sodium (Na)-Total (mg/L)</td>
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<td>Strontium (Sr)-Total (mg/L)</td>
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<td>0.0229</td>
<td>0.0302</td>
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<td>Sulfur (S)-Total (mg/L)</td>
<td>2.74</td>
<td>2.02</td>
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<td>Tin (Sn)-Total (mg/L)</td>
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<td>Titanium (Ti)-Total (mg/L)</td>
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<td>0.0163</td>
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<td>Tungsten (W)-Total (mg/L)</td>
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<td></td>
<td>Uranium (U)-Total (mg/L)</td>
<td>0.000011</td>
<td>0.000049</td>
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<td>Vanadium (V)-Total (mg/L)</td>
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<td>Zinc (Zn)-Total (mg/L)</td>
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<td>&lt;0.0030</td>
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<td>&lt;0.0030</td>
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<td>Zirconium (Zr)-Total (mg/L)</td>
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<td>&lt;0.0030</td>
<td>&lt;0.0030</td>
<td>&lt;0.0030</td>
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* Please refer to the Reference Information section for an explanation of any qualifiers detected.
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<th>Analyte</th>
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<th>L1798433-7</th>
<th>L1798433-8</th>
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<td>WATER</td>
<td>Nickel (Ni)-Total (mg/L)</td>
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<td>Phosphorus (P)-Total (mg/L)</td>
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<td>Rubidium (Rb)-Total (mg/L)</td>
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<td>Selenium (Se)-Total (mg/L)</td>
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<td>Silicon (Si)-Total (mg/L)</td>
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<td>Silver (Ag)-Total (mg/L)</td>
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<td>Sodium (Na)-Total (mg/L)</td>
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<td>Strontium (Sr)-Total (mg/L)</td>
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<td>Sulfur (S)-Total (mg/L)</td>
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<tr>
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<td>Tin (Sn)-Total (mg/L)</td>
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<td>Titanium (Ti)-Total (mg/L)</td>
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<td>Tungsten (W)-Total (mg/L)</td>
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<td>Uranium (U)-Total (mg/L)</td>
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<td>Vanadium (V)-Total (mg/L)</td>
<td>0.00371</td>
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<td>Zinc (Zn)-Total (mg/L)</td>
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<td>Zirconium (Zr)-Total (mg/L)</td>
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* Please refer to the Reference Information section for an explanation of any qualifiers detected.
**Reference Information**

**QC Samples with Qualifiers & Comments:**

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<th>Parameter</th>
<th>Qualifier</th>
<th>Applies to Sample Number(s)</th>
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<td>Method Blank</td>
<td>Iron (Fe)-Total</td>
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<td>L1798433-2, -3, -4, -5, -6, -7, -8</td>
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<tr>
<td>Method Blank</td>
<td>Manganese (Mn)-Total</td>
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<td>Duplicate</td>
<td>Aluminum (Al)-Total</td>
<td>DLHC</td>
<td>L1798433-1</td>
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<tr>
<td>Duplicate</td>
<td>Antimony (Sb)-Total</td>
<td>DLHC</td>
<td>L1798433-1</td>
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<td>Duplicate</td>
<td>Arsenic (As)-Total</td>
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<td>L1798433-1</td>
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<tr>
<td>Duplicate</td>
<td>Aluminum (Al)-Total</td>
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<td>Matrix Spike</td>
<td>Ammonia, Total (as N)</td>
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<td>Matrix Spike</td>
<td>Calcium (Ca)-Total</td>
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<td>Matrix Spike</td>
<td>Manganese (Mn)-Total</td>
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<td>Matrix Spike</td>
<td>Strontium (Sr)-Total</td>
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<td>Calcium (Ca)-Total</td>
<td>MS-B</td>
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<td>Manganese (Mn)-Total</td>
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<td>Sodium (Na)-Total</td>
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<td>Matrix Spike</td>
<td>Sulfur (S)-Total</td>
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**Qualifiers for Individual Parameters Listed:**

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<tr>
<td>B</td>
<td>Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.</td>
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<tr>
<td>DLHC</td>
<td>Detection Limit Raised: Dilution required due to high concentration of test analyte(s).</td>
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<tr>
<td>DUP-H</td>
<td>Duplicate results outside ALS DQO, due to sample heterogeneity.</td>
</tr>
<tr>
<td>MS-B</td>
<td>Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.</td>
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**Test Method References:**

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<th>Matrix</th>
<th>Test Description</th>
<th>Method Reference**</th>
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<tr>
<td>ALK-TITR-VA</td>
<td>Water</td>
<td>Alkalinity Species by Titration</td>
<td>APHA 2320 Alkalinity</td>
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<td>This analysis is carried out using procedures adapted from APHA Method 2320 &quot;Alkalinity&quot;. Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.</td>
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<tr>
<td>CL-L-IC-N-TB</td>
<td>Water</td>
<td>Chloride in Water by IC (Low Level)</td>
<td>EPA 300.1 (mod)</td>
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<td>Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.</td>
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<tr>
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<td>This analysis is carried out using procedures adapted from APHA Method 2510 &quot;Conductivity&quot;. Conductivity is determined using a conductivity electrode.</td>
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<td>EC-TITR-TB</td>
<td>Water</td>
<td>Conductivity</td>
<td>APHA 2510 B</td>
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<td>This analysis is carried out using procedures adapted from APHA Method 2510 &quot;Conductivity&quot;. Conductivity is determined using a conductivity electrode.</td>
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<td>HARDNESS-CALC-TB</td>
<td>Water</td>
<td>Hardness (as CaCO3)</td>
<td>CALCULATION</td>
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<tr>
<td>MET-T-CCMS-TB</td>
<td>Water</td>
<td>Total Metals in Water by CRC ICPMS</td>
<td>EPA 200.2/6020A (mod)</td>
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<td>Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.</td>
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<tr>
<td>NH3-COL-TB</td>
<td>Water</td>
<td>Ammonia by Discrete Analyzer</td>
<td>APHA 4500-NH3 G. (modified)</td>
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<td>Ammonia in aqueous matrices is analyzed using discrete analyzer with colourimetric detection.</td>
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<td>NO2-IC-N-TB</td>
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<td>Nitrite in Water by IC</td>
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<tr>
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<td>Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.</td>
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**Reference Information**

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<th>Method/Institution</th>
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<td>Total Phosphorus by Discrete Analyzer APHA 4500-P B, F, G (modified)</td>
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<td>PH-METER-TB</td>
<td>Water</td>
<td>pH APHA 4500-H-ELECTRODE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>This analysis is carried out using procedures adapted from APHA Method 4500-H &quot;pH Value&quot;. The pH is determined in the laboratory using pH electrode.</td>
</tr>
<tr>
<td>SO4-IC-N-TB</td>
<td>Water</td>
<td>Sulfate in Water by IC EPA 300.1 (mod)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.</td>
</tr>
<tr>
<td>TC,EC-QT97-TB</td>
<td>Water</td>
<td>Total Coliform and E.coli APHA 9223 B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>This analysis is carried out using procedures adapted from APHA Method 9223 &quot;Enzyme Substrate Coliform Test&quot;. E. coli and Total Coliform are determined simultaneously. The sample is mixed with a mixture of hydrolyzable substrates and then sealed in a multi-well packet. The packet is incubated for 18 or 24 hours and then the number of wells exhibiting a positive response are counted. The final result is obtained by comparing the positive responses to a probability table.</td>
</tr>
<tr>
<td>TDS-TB</td>
<td>Water</td>
<td>Total Dissolved Solids APHA 2540 C (modified)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aqueous matrices are analyzed using gravimetry and evaporation.</td>
</tr>
<tr>
<td>TKN-COL-TB</td>
<td>Water</td>
<td>Total Kjeldahl Nitrogen APHA 4500-Norg (modified)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Kjeldahl Nitrogen in aqueous matrices is analyzed using a discrete analyzer with colourimetric detection.</td>
</tr>
<tr>
<td>TURBIDITY-TB</td>
<td>Water</td>
<td>Turbidity APHA 2130 B-Nephelometer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aqueous matrices are analyzed using nephelometry with the light scatter measured at a 90° angle.</td>
</tr>
</tbody>
</table>

**ALS test methods may incorporate modifications from specified reference methods to improve performance.**

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

<table>
<thead>
<tr>
<th>Laboratory Definition Code</th>
<th>Laboratory Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB</td>
<td>ALS ENVIRONMENTAL - THUNDER BAY, ONTARIO, CANADA</td>
</tr>
<tr>
<td>VA</td>
<td>ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA</td>
</tr>
</tbody>
</table>

**GLOSSARY OF REPORT TERMS**

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

- mg/kg - milligrams per kilogram based on dry weight of sample.
- mg/kg wwt - milligrams per kilogram based on wet weight of sample.
- mg/kg lwL - milligrams per kilogram based on lipid-adjusted weight of sample.
- mg/L - milligrams per litre.
- < - Less than.
- D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
- N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.
**Chain of Custody (COC) / Analytical Request Form**

**Company:** Lakehead Region Conservation Authority

**Contact:**

**Address:** 130 Conservation Road PO Box 10427

**Phone:** 807-344-5857

**Email:** tammy@lakeheadco.com

**Report Format / Distribution**

- Select Report Format: None Excel XDDO DIGITAL DIGITAL
- Quality Control (QC) Report with Report: Yes No
- Criteria on Report - provide details if box checked
- Select Distribution: Email Email Fax
- Email 1 or Fax: tammy@lakeheadco.com
- Email 2: Scott@bluepalette.com

**Invoice Distribution**

- Invoice To: Same as Report To
- Copy of Invoice with Report: Yes No
- Select Invoice Distribution: Email Email Fax
- Email 1 or Fax: scott@bluepalette.com

**Project Information**

- ALS Quote #: Q69600
- Job #: Oliver Creek
- PO / AFE: Activity Code:
- Location:

**Oil and Gas Required Fields (client use)**

**ALS Lab Work Order # (lab use only):** L798543

**ALS Contact:**

**ALS Sample # (lab use only):**

<table>
<thead>
<tr>
<th>Sample Identification and/or Coordinates</th>
<th>Date</th>
<th>Time</th>
<th>Sample Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>OC8 - Oliv Creek - Site # 8</td>
<td>14-JUL-16</td>
<td>10:05</td>
<td>GB1</td>
</tr>
<tr>
<td>OC7 - Oliv Creek - Site # 7</td>
<td>14-JUL-16</td>
<td>10:25</td>
<td>GB2</td>
</tr>
<tr>
<td>OC6 - Oliv Creek - Site # 6</td>
<td>14-JUL-16</td>
<td>10:10</td>
<td>GB3</td>
</tr>
<tr>
<td>OC5 - Oliv Creek - Site # 5</td>
<td>14-JUL-16</td>
<td>11:00</td>
<td>GB4</td>
</tr>
<tr>
<td>OC4 - Oliv Creek - Site # 4</td>
<td>14-JUL-16</td>
<td>11:20</td>
<td>GB5</td>
</tr>
<tr>
<td>OC3 - Oliv Creek - Site # 3</td>
<td>14-JUL-16</td>
<td>11:35</td>
<td>GB6</td>
</tr>
<tr>
<td>OC2 - Oliv Creek - Site # 2</td>
<td>14-JUL-16</td>
<td>11:50</td>
<td>GB7</td>
</tr>
<tr>
<td>OC1 - Oliv Creek - Site # 1</td>
<td>14-JUL-16</td>
<td>12:05</td>
<td>GB8</td>
</tr>
</tbody>
</table>

**Drinking Water (DW) Samples** (client use)

- Special Instructions / Specify Criteria to add on report (client use)

**SAMPLE CONDITION AS RECEIVED** (lab use only)

- Frozen: Yes No
- Ice packs: Yes No
- Cooling initiated: Yes No
- Custody seal intact: Yes No

**SHIPPING RELEASE** (client use)

- Released by: JRF
- Time: 14:16
- Received by: S.D.
- Date: 14:16
- Time: 2:20

**INITIAL SHIPMENT RECEIPT** (lab use only)

- Released by: JRF
- Date: 14-JUL-16
- Time: 1:46

**FINAL SHIPMENT RECEIPT** (lab use only)

- Released by: S.D.
- Date: 14-JUL-16
- Time: 2:20