MOSQUITO CREEK WATERSHED

Assessment Report




LAKEHEAD REGION
CONSERVATION AUTHORITY

Mosquito Creek Watershed Assessment Report

2015

Written and Published by:

Acknowledgements

The Lakehead Region Conservation Authority would like to acknowledge the residents of the Mosquito 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 Mosquito Creek.

The 2015 Mosquito Creek Watershed Assessment was prepared by Jennifer Harnden, Assistant Water Resource Technologist. Scott Drebit, GIS Technician/Planner of the Lakehead Region Conservation Authority, produced the maps for this report and provided input and revisions towards the final copy. Tammy Cook, 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 Mosquito Creek watershed in 2015.

Executive Summary

The Mosquito Creek watershed is located within the City of Thunder Bay, Municipality of Oliver Paipoonge, Municipality of Neebing and the Fort William First Nation. The watershed covers a drainage area of approximately 31.8 square kilometres. Mosquito Creek is approximately 15.6 kilometres in length and is a meandering creek which confluences with the Kaministiquia River into Lake Superior. The gradient of the watershed forms an area of low slope within a 2.5 kilometre valley. The valley is contained between mountains to the southeast (Logan Diabase Sills) and smaller outcrops of diabase, or glacial ground Moraine, to the west. The general slope of the watershed is 1.66 percent.

The majority of the Mosquito Creek watershed is privately owned land (81.97 percent) and the remainder is federally owned Indian reserve land (18.03 percent). Land uses in the watershed include: private residences, Loch Lomond Ski Area, Thunder Bay Correctional Centre, the Tournament Centre, Nor'Wester View Public School, and the South Neebing Community Centre. The area in the City of Thunder Bay is serviced by municipal water; however private individual septic systems.

The surficial geology of the Mosquito Creek watershed is mainly low relief glaciolacustrine lake plains (53.28 percent) although alluvial, slope/talus pile, bedrock and moraine plains are also present. The bedrock formation is mostly composed of sedimentary rocks (62.09 percent), but there are also Mafic and related intrusive rocks (37.91 percent). The Mosquito Creek watershed is composed of eight different soil types. The most abundant soil type is silt loam, which covers 14.84 square kilometres (46.67 percent) of the watershed. Rock is the second most abundant, covering 10.96 square kilometres (34.46 percent) of the watershed. The remaining soil is made up of clay, clay loam, fine sandy loam, gravel, medium to moderately fine loam, and moderately coarse sandy loam, which together cover 6.0 square kilometres (18.87 percent).

The Mosquito 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 Mosquito 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 Mosquito Creek and Kaministiquia River. Site 3 was the midpoint on the main

channel before it broke off into different tributaries, which Sites 2, 4, 5, 6 and 7 were located on. Site 8 was the closest location to the head waters of the watershed.

At each of the eight sample locations, surface water samples and field measurements were collected on June 9 - 10 and July 7 - 8, 2015. 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 with an YSI Multi-Parameter Probe included: water temperature, pH, conductivity, salinity, oxidation-reduction potential and dissolved oxygen. Field and laboratory results were compared to the Ministry of Environment'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 coliform, aluminum, iron, copper and cobalt.

Phosphorus exceeded the PWQO criterion (0.03 mg/L) at Sites 3, 4, 5, and 7. Phosphorus ranged from 0.0071 mg/L at Site 6 on June 9, 2015 to 0.2100 mg/L at Site 7 on July 7, 2015. The high levels of phosphorous are likely due to high clay content in the water column.

PWQO criterion for *E. coli* bacteria is that levels be below 100 counts per 100 mL of water for safe swimming and bathing. During the June sampling period, Site 3 (102 counts/100 mL) exceeded the criterion. During the July sampling, all sample sites were below the PWQO criterion.

As there is no current PWQO for total coliform, results were compared to the pre-1994 PWQO criterion (1,000 MPN/100 mL). Every site in 2015 for both sampling periods exceeded the criterion with the exception of Site 7. During the July sampling period, Site 7 had a count of 435 MPN/100 mL. The total coliform concentrations in 2015 ranged from 435 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 5, 6, and 7. During the July sampling period, all sites were above except for Sites 2, 5, 6 and 7. Aluminum concentrations ranged from 0.0146 mg/L (Site 5) to 0.7300 mg/L (Site 1). 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 6. Iron concentrations ranged from 0.161 mg/L (Site 6) to 3.770 mg/L (Site 5) for the watershed. Iron exceedances are common in the Region, due to natural sources.

Copper was below the criterion (0.005 mg/L) during both sampling periods for all sites except for Site 1 during the June sampling period. Copper concentrations ranged from 0.00060 mg/L (Site 7) to 0.00507 mg/L (Site 1) for the watershed.

Cobalt was below the PWQO criterion (0.0009 mg/L) at all sites except for Site 7 during the July sampling period. Cobalt concentration ranged from 0.00016 (Site 5) to 0.00159 mg/L (Site 7).

The flora and fauna inventory indicated that the Mosquito 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 was in good and stable condition and the culverts were also in good condition. The culverts at Site 8 (C7) should be monitored in the future as they appear to be deteriorating.

The Mosquito 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 Mosquito Creek watershed were used to determine a grade for the watershed. Surface water quality maintained a good rating with exceedances of phosphorus and *E. coli* present within the Mosquito 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 Mosquito Creek watershed in 2015 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 2015 the Mosquito Creek watershed was considered to be in good health.

Upon completion of the 2015 Mosquito Creek Watershed Assessment, the following recommendations have been made for consideration:

- Staff and funding permitting it is recommended that an update to the 2015 Mosquito 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.
- If the Provincial Water Quality Monitoring Network program was ever expanded, a monitoring location within the Mosquito Creek watershed should be considered.
- A copy of this report should be provided to the City of Thunder Bay, Municipality of Neebing and the Municipality of Oliver Paipoonge 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 Mosquito Creek watershed is located within the City of Thunder Bay, the Municipality of Neebing, the Municipality of Oliver Paipoonge, and the Fort William First Nation 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 Mosquito 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 drainage network of tributaries comprising the headwaters of Mosquito Creek generally originate within the low, flat plain basin at the base of the Nor'Westers Mountains from mountain runoff and seepage (LRCA, 2008). The watershed covers a drainage area of approximately 31.81 square kilometres. The prevailing soil type throughout the watershed is silt loam over bedrock. Most of the watershed is dominated by white spruce, jack pine, black spruce, balsam poplar and trembling aspen. Mosquito Creek is bounded by the bedrock ridges of Mount McKay and Mount McRae. It is 15.55 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 2015. 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 Mosquito Creek water crossings (bridges/culverts)
- Interpret results to record the health status of the watershed

2 Background

2.1 Physical Attributes

2.1.1 Topography

Mosquito Creek originates in the area between Loch Lomond and McQuaig Lake, south of Highway 61. It flows in a north easterly direction, joining with the Kaministiquia River approximately nine kilometers upstream from Lake Superior. The highest point in the watershed is approximately 460.5 meters above sea level bordering the south-western boundary of the watershed near Sawdust Lake (326616 N, 5352329 E). The lowest point in elevation can be found near the confluence of Kaministiquia River and Mosquito Creek, at 184.8 meters above sea level (328685 N, 5356900 E). The general slope of the watershed is 1.66 percent. Although the Nor'Wester Mountains form the height of land along the east and south limits of the watershed, the majority of Mosquito Creek consists of a low relief glaciolacustrine lake plain composed of silt and clay deposits (LRCA, 2008). Map M-3 illustrates the Mosquito Creek watershed topography.

2.1.2 Geology & Soils

2.1.2.1 Bedrock

The Mosquito Creek Watershed is in an area of low elevation bounded by the bedrock ridges of Mount McKay and Mount McRae to the east. The southeast edge of the watershed has steep gradients and is bounded by mountains. The watershed area is underlain by Paleo-Proterozoic rocks of the Lower Animikie Group consisting of mudstone, greywacke, argillite and siltstone. These rocks are about 1,600 to 2,200 million years in age. All of these sedimentary rocks are soft and permeable and have been deeply eroded and covered by thick deposits of lacustrine (lake) and riverine (river) sediments.

Logan Diabase Sills outcrop on the southeast and northwest sides 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. They have survived as large flat topped mesas such as Mount McKay. The diabase rock which forms the mesas was intruded as a flat lying sill or cap rock on the surrounding mesas. The diabase sills are underlain by Animikie Group shales which combine with the diabase to form steep talus on the edge of the mountains. A broken area of shale regolith can be seen on the edges of the mountains; 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 3: 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.

2.1.2.2 Surficial Geology & Soils

Much of the underlying bedrock in the Mosquito Creek Watershed is deeply eroded; the visible geology consists of Holocene Age sediments except along the margins, which are bedrock. The substrates or sediments were laid down as glacial outwash and lake bottom deposits called glaciolacustrine horizons. The gradient of the Mosquito Creek Watershed forms an area of low slope within a 2.5 kilometre wide valley. The valley is contained between mountains to the southeast (Logan Diabase Sills) and smaller outcrops of diabase, or glacial ground Moraine to the west. The Northern Ontario Engineering Geology Terrain Study (NOEGTS) map details the main types overburden as well as their glacial origins. The layer files derived from this map are illustrated on Map M-6: Soils.

The majority of the sediments and soils have been deposited by Mosquito Creek and by historical flooding of the area by Glacial Lake Minong. During the time period 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 Mosquito Creek Watershed. A gradient of 1.66 percent rise occurs over the length of Mosquito Creek. The soil horizons created by the erosion of the fine grained sedimentary rocks and the glacial deposits has formed fine silty and sand rich soils in the floodplain of Mosquito Creek.

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 Mosquito Creek as well as at an additional six sites chosen to represent the main landform types and NOEGTS soil types. Map M-6: Soils illustrates the location of the fourteen soil sampling sites. The majority of soils consist of silty loam with areas of moderately fine loam and sandy loam deposited along the creek bed.

The results of the soil testing are shown in Appendix J: Soils Summary and Borehole Logs, along with photographs of each soil profile. The soils usually have a thin organic layer in the Mosquito Creek Watershed. The organic horizon averages 10.0 to 15.0 centimetres in thickness along the creek bed and is 5.0 to10.0 centimetres thick in the rest of the watershed. 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. The soil testing program indicates that the clay loam layer

shown under the creek bed is actually silty clay loam and sandy clay loam (sites 2 to 8). There were no clay soils encountered in the watershed; a silty clay soil was found at site 11 where the NOEGTS layer indicates clay. The silty loam on the NOEGTS layer which underlies the majority of the watershed is a fair characterization of much of the watershed and has been confirmed by the sampling program.

The rock layers shown on the map were sampled at sites 12 and 13. Site 12 near the former Big Thunder Ski Area has very shallow sand and gravel soil horizons overlaying shale regolith. Site 13 near Mount Forest Boulevard is in an area laid out for future housing development. Thin sandy, gravel and boulder soils overlay a bedrock interface which dips to the southeast.

Quaternary mapping and geotechnical boreholes, located near the intersection of Chippewa Road and Highway 61, indicate that clay layers and sand and gravel deposits lie below the loams and have thicknesses of 7.0 metres near the mouth of Mosquito Creek. Numerous Boreholes were completed along Chippewa Road near the mouth of Mosquito Creek. These holes include Boreholes 618973 and 618974 which encountered shale bedrock at 7.0 to 9.0 metres depth. The substrates in this area are sand and silt with some gravel near the bedrock interface.

Geotechnical Boreholes completed near the intersection of Highway 61 and the 20th Sideroad (Boreholes 618962 and 618963) show multiple layers of silty clay, sand and gravel extending down to 9.1 metres. No bedrock was encountered in these drill holes indicating that the substrates are 10.0 metres or more in thickness in much of the Mosquito Creek Watershed. Information about the Borehole Logs is listed in Appendix J: Soils Summary and Borehole Logs.

2.1.3 Climate

The climate of the Mosquito 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, 2011) 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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature												
Daily (degrees Celsius)	-14.8	-12	-5.5	2.9	9.5	14	17.6	16.6	11	5	-3	-11.6
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
Date (yyyy /dd)	1956 /20	1951 /26	1957 /14	1954 /30	1971 /24	1947 /04	1973 /27	1973 /19	1977 /08	1968 /09	1973 /21	1948 /05

The average monthly temperatures (degrees Celsius) and precipitation levels (millimeters) were recorded at the Thunder Bay Airport for 2015 (Environment Canada, 2015), as shown below.

Table 2.1-2: Average Monthly Temperature and Precipitation for Thunder Bay, January-July 2015

	Jan	Feb	Mar	Apr	May	June	July
Average Temperature							
Daily (degrees Celsius)	-14.7	-19.6	-4.9	2.6	9.1	14.1	18.2
Precipitation							
Total Precipitation (millimetres)	17.7	22.9	21.7	39.6	101.6	83.5	39.8

The average monthly temperature for the June and July sampling periods was 16.1 degrees Celsius and the average monthly precipitation was 61.7 millimetres. In comparison with the historical data, the 2015 temperature was within 0.3 degrees Celsius of the average for June and July. The 2015 precipitation for June was within 2.2 millimetres of the historical average precipitation. The precipitation for July 2015 was 49.2 millimetres less than recorded historical average precipitation. In general temperatures in June and July, and precipitation in June, were very near normal while received precipitation for July was below average.

2.1.4 Hydrology

2.1.4.1 Watershed Characteristics

Mosquito Creek covers an area of approximately 31.81 square kilometres, and flows in a general northeasterly direction from the slopes of the Nor'Westers Mountain Range to its confluence with the Kaministiquia River, approximately nine kilometres upstream from Lake Superior. The surface water drainage area has been estimated at 0.19 square kilometres and a wetland area of 1.52 square kilometres. There are no provincially significant wetlands within the watershed. Mosquito Creek is primarily a runoff dominated system, therefore making high flow conditions closely linked to precipitation events (LRCA, 2008).

2.1.4.2 Hydrogeology

The Thunder Bay Area Regional Aquifer Characterization, Groundwater Management and Protection Report July 2005, illustrated that the Mosquito Creek watershed is in a zone with medium to high intrinsic susceptibility to contamination, in which the groundwater within these zones are more likely to become contaminated. The increased groundwater contamination susceptibility is due to the relatively thin overburden and the proximity of the water table to the ground surface. Site specific contamination controls for this watershed area should be determined as urban development persists.

2.1.4.3 Stormwater Management

At present there is minimal formal stormwater management within the Mosquito Creek Watershed. The area is serviced by municipal water; however, individual septic systems.

Recommendations from the 1996 Mosquito Creek Post Development Study regarding stormwater included:

- Completing "stormwater management studies to determine the effects of the individual developments;
- surface water management best management practices (BMPs) should be assessed for each area to maintain current (pre-development) runoff quality and quantity."

Stormwater Best Management Practices and Low Impact Development (LID) can reduce the effects and likelihood of flood events and groundwater contamination. General techniques recommended for consideration for the Mosquito Creek

Watershed include: evaluation of existing identified, unevaluated wetlands; maintaining riparian buffers; utilizing grassed swales and infiltration trenches as opposed to piped systems; use of permeable pavement to promote infiltration and other LID techniques as warranted.

2.1.4.4 Flood and Fill Line Mapping

Floodplain mapping was completed in 1984 on Mosquito Creek by The Lathem Group, on behalf of the LRCA. The report contained information about the watershed hydrology, the calculation of channel and valley hydraulics, the identification of flood profiles, and the location of Regional Storm flood and fill lines. The study concluded that flooding on Mosquito Creek occurs due to rapid runoff of both rainfall and snowmelt flows, and that peak discharges are affected by the Nor'Westers Mountain Range. In addition, the effect of increased development is not likely to substantially increase regional flood flows. The study also found that the Mosquito Creek valley below Mountain Road is capable of containing the Regional Flood and that the private domestic or commercial structures do not experience flooding in that area. It also concluded that road crossings in the watershed are generally incapable of passing the Regional Flood without road overtopping, but the road overtopping is not usually damaging to watershed access because alternate routes exist to all inhabited areas. Furthermore, that study found that the influence of increased low flows represent a greater potential hazard to the development of the watershed, than do increases in high flows. The more frequent occurrence of flows lower than regional can pose significant threat to the stability of the Mosquito Creek valley. The study suggested that the best way to reduce the impacts of future development on the persistence of low flows is to initiate stormwater management. Within the watershed the Regional floodplain is estimated to be 0.82 square kilometres. The Floodplain Mapping is tentatively scheduled to be updated by the LRCA in 2024, subject to funding.

2.2 Biological Attributes

2.2.1 Flora

The Mosquito 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 1). 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 which 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 Mosquito Creek watershed including ferns, shrubs, herbs, mosses and lichens. Plant species identified at the sample sites are listed in Appendix D: Common and Scientific Names of Identified Flora and Fauna. There is also a list of identified Flora and Fauna from the Mosquito Creek Post Development Study (1996) in Appendix E.

2.2.2 Fauna

The Mosquito 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 D: Common and Scientific Names of Identified Flora and Fauna. The Mosquito Creek watershed is part of the Ontario Ministry of Natural Resources and Forestry (OMNRF) Wildlife Management Unit 13 and Fisheries Management Zone 6.

Table 2.2-1 : Common Reptiles, Amphibians, and Butterflies

Species Name	
Common Name	**Scientific Name**
Amphibians and Reptiles	
Blue-Spotted Salamander	*Ambystoma laterale*
Jefferson Salamander	*Ambystoma jeffersonianum*
Snapping Turtle	*Chelydra serpentine*
Western Painted Turtle	*Chrysemys picta bellii*
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*
Eastern Newt	*Notophthalmus viridescens viridescens*
Mudpuppy	*Necturus maculosus*
American Toad	*Anaxyrus americanus*
Boreal Chorus Frog	*Pseudacris maculata*
Gray Tree Frog	*Hyla versicolor*
Green Frog	*Lithobates clamitans*
Mink Frog	*Lithobates septentrionalis*
Northern Leopard Frog	*Lithobates pipiens*
Spring Peeper	*Pseudacris crucifer*
Wood Frog	*Lithobates sylvaticus*
Butterflies	
Juvenal's Duskywing	*Erynnis juvenalis*
European Skipper	*Thymelicus lineola*
Common Branded Skipper	*Hesperia comma*
Long Dash Skipper	*Polites mystic*
Canadian Tiger Swallowtail	*Papilio Canadensis*

Mustard White	*Pieris oleracea*
Cabbage White	*Pieris oleracea*
Clouded Sulphur	*Colias philodice*
Atlantis Fritillary	*Speyeria atlantis*
Northern Crescent	*Phyciodes cocyta*
Satyr Comma	*Polygonia satyrus*
Mourning Cloak	*Nymphalis antiopa*
Milbert's Tortoiseshell	*Algais milberti*
American Lady	*Vanessa virginiensis*
Painted Lady	*Vanessa cardui*
Red Admiral	*Vanessa atalanta*
White Admiral	*Limenitis arthemis*
Northern Pearly-Eye	*Lethe anthedon*
Common Wood-Nymph	*Cercyonis pegala*
Monarch	*Danaus plexippus*

Source: Ontario Butterfly Atlas & Reptile and Amphibian Atlas, 2015

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 16 species at risk in the Thunder Bay area that have potential to exist within the Mosquito 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, with documented sightings in the Mosquito Creek watershed and immediate surrounding area.

Table 2.2-2: Species at Risk

Species Name		Status of Risk
Common Name	**Scientific Name**	
Coralloid Foam Lichen	*Stereocaulon subcoralloides*	Very Rare/Rare to Uncommon
Lake Sturgeon	*Acipenser fulvescens*	Very Rare
Large Marble	*Euchloe ausonides*	Rare to Uncommon
Leiberg's Panicgrass	*Dichanthelium leibergii*	Very Rare
Limestone Oak Fern	*Gymnocarpium robertianum*	Very Rare
Liverwort (No common name)	*Mannia sibirica*	Extremely Rare
Macoun's Arctic	*Oeneis macounii*	Rare to Uncommon
Missouri Goldenrod	*Solidago missouriensis*	Very Rare
Northern Long-Eared Myotis	*Myotis septentrionalis*	Rare to Uncommon
Oeder's Map Lichen	*Rhizocarpon oederi*	Very Rare/Rare to Uncommon
Peregrine Falcon	*Falco peregrinus*	Rare to Uncommon (for a migratory species, rank applies to breeding population)
Purple Reedgrass	*Calamagrostis purpurascens*	Very Rare
Ram's-Head Lady's-Slipper	*Cypripedium arietinum*	Rare to Uncommon
Red-Disked Alpine	*Erebia discoidalis*	Rare to Uncommon
Small Macewort	*Mannia pilosa*	Extremely Rare

Thin Starwort	*Asterella gracilis*	Extremely Rare

Source: Ontario Ministry of Natural Resources and Forestry - Species at Risk in Thunder Bay Region, 2015

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 Kaministiquia River, Lake Superior or the District of Thunder Bay, Ontario may be present in the Mosquito 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 2.2-3 : Invasive Species

Species Name	
Common Name	**Scientific Name**
Chinese Mitten Crab	*Eriocheir sinensis*
Common Reed	*Phragmites australis*
Eurasian Ruffe	*Gymnocephalus cernua*
European Common Reed	*Phragmites australis ssp. australis*
European Flounder	*Platichthys flesus*
Flowering-Rush	*Butomus umbellatus*
Goldfish	*Carassius auratus*
Himalayan Balsam	*Impatiens glandulifera*
Japanese Knotweed	*Reynoutria japonica*
New Zealand Mud Snail	*Potamopyrgus antipodarum*
Purple Loosestrife	*Lythrum salicaria*
Rainbow Smelt	*Osmerus mordax*
Round Goby	*Neogobius melanostomus*
Rusty Crayfish	*Orconectes rusticus*
Spiny Water Flea	*Bythotrephes longimanus*

Three Spine Stickleback	*Gasterosteus aculeatus*
Tubenose Goby	*Proterorhinus marmoratus*
White Perch	*Morone Americana*
Yellow Sweet-Clover	*Melilotus officinalis*
Zebra Mussel	*Dreissena polymorpha*

Source: Early Detection & Distribution Mapping System for Ontario, 2015

2.3 Socio-Economic Attributes

2.3.1 Planning & Development Controls

Land Tenure

The majority of the Mosquito Creek watershed is privately owned land (81.97%). Federally owned Indian reserve land constitutes 18.03%. Land ownership in the watershed is illustrated on Map 7: Land Ownership.

Areas of Jurisdiction

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

Table 2.3-1: Areas of Jurisdiction within the Mosquito Creek Watershed

Geographic Boundaries	Total Municipal Area (km^2)	Municipal Area within Mosquito Creek Watershed (km^2)	Municipal Area within Mosquito Creek Watershed (%)
City of Thunder Bay	334.17	21.28	66.90
Municipality of Neebing	877.60	4.52	14.21
Municipality of Oliver Paipoonge	350.76	0.27	0.85
Fort William First Nation	58.31	5.74	18.04
Total	**1620.84**	**31.81**	**100**

Within the boundaries of the Mosquito Creek watershed the LRCA area of jurisdiction extends within the City of Thunder Bay, the Municipality of Neebing and the Municipality of Oliver Paipoonge. Of the total Mosquito Creek watershed area, 26.07 square kilometers are within the LRCA area of jurisdiction. The remaining 5.74 square kilometres of the watershed is within the Fort William First Nation.

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 Mosquito Creek watershed is affected by the City of Thunder Bay, the Municipality of Oliver Paipoonge, and the Municipality of Neebing Official Plan and Zoning by-laws. Part of the land is also owned by Fort William First Nation. Land use designations within the Mosquito Creek watershed can be found on Map 9: 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 City of Thunder Bay, the Mosquito Creek watershed has been zoned as:

- Rural Zone (RU1)
- Residential One Zone (R1)
- Residential Future Zone (R5)
- Neighborhood Centre Two Zone (NC2)
- Highway Commercial Zone (C3)
- Open Space Zone (OS)
- Environmental Protection Zone (EP)
- Major Institutional Zone (MI)
- Environmental Overlay

The following definitions are taken from the City of Thunder Bay zoning by-law No. 100 – 2010, dated January 2011.

Rural Zone (RU1)

No person shall, within any "Rural Zone", use any land, or erect or use any building or structure for any purpose or use other than the following: agricultural use; animal boarding facility; animal care facility; emergency services facility; kennel; nursery; park; recreation facility; residential care facility one; residential care facility two; riding and/or boarding stables; or single detached dwelling which may include a personal farm.

Residential One Zone (R1)

No person shall within any "Residential One Zone", use any land or erect or use any building or structure for any purpose or use other than the following: park; residential care facility one; single detached dwelling; duplex dwelling legally existing on January 1, 2011; or semi-detached dwelling legally existing on January 1, 2011.

Residential Future Zone (R5)

No person shall within any "Residential Future Zone" use any land or erect or use any building or structure for any purpose or use other than the following: single detached dwelling; or park.

Neighborhood Centre Two Zone (NC2)

No person shall use any land or erect or use any building or structure within any "Neighborhood Centre Two Zone" for any purpose or use other than the following: park; residential care facility one; or single detached dwelling. The following additional uses are permitted on a corner lot, where a minimum of one of the defining streets of the corner lot is classified as a collector or higher: day care facility; dwelling unit for owner or caretaker of a permitted use in this section; educational institution; food store; media store; medical office; or personal services establishment. In addition, the following additional uses are permitted on a lot fronting on a street which is classified as an arterial or higher: cultural facility; community centre; community health and resource centre; emergency services facility; fuel bar; drive service units associated with permitted uses; recreation facility; religious institution; or restaurant.

Highway Commercial Zone (C3)

No person shall use any land or erect or use any building or structure within any "Highway Commercial Zone" for any purpose or use other than the following: bait store; financial office; car wash; drive service units associated with permitted uses; fuel bar; home improvement store; hotel; food store; media store; motel; motor vehicle sales or rental establishment; motor vehicle service station; pet store; restaurant; personal services establishment; recreation facility; or shopping centre. In addition, the following uses are permitted on lots with full municipal services: car wash; or dry-cleaning plant.

Open Space Zone (OS)

No person shall within any "Open Space Zone" use any land or erect or use any building or structure for any purpose or use other than the following: community

centre; cultural facility; golf course; marina; nursery; park; recreation facility; ski resort; or zoo.

Environmental Protection Zone (EP)

No person shall use any land or erect or use any building or structure within any "Environmental Protection Zone" for any purpose or use other than the following: docks; boat launches; flood control; erosion control; marina; or park exclusive of buildings or structures.

Major Institutional Zone (MI)

No person shall use any land or erect or use any building or structure within any "Major Institutional Zone" for any purpose or use other than the following: cemetery; community centre; crematorium; cultural facility; correctional centre; day care facility; dwelling unit accessory to a permitted use; educational institution; emergency services facility; medical office; open market; park; penitentiary; recreation facility; religious institution; research and development centre; residential care facility one; residential care facility two; or residential care facility three. In addition, the following uses are permitted on lots with municipal services: long term care facility; retirement residence; or hospital

Environmental Overlay

The "Environmental Overlay" is shown as grey shading on the zoning maps. It applies to lands including those adjacent to natural corridors, wetlands, and provincially significant wetlands as designated in the official plan. It is designed and intended to alert readers of this by-law to areas of Thunder Bay where the LRCA may have legislative requirements that are pre-requisites to land development.

Within the Municipality of Oliver Paipoonge the Mosquito Creek watershed has been zoned as:

- Paipoonge General Agricultural Zone (PAG)
- Paipoonge Rural (PRU)

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

Paipoonge General Agricultural Zone (PAG)

No person shall within and PAG Zone use any lot or erect, alter or use any building or structure for any purpose except in accordance with the following: agriculture;

forestry; stables, riding academies, animal kennels – boarding and breeding; single detached dwellings; a greenhouse operation; a bee-keeping operation; a market garden; an accessory single detached dwelling, except accessory buildings on new lots created for a forestry use and not more than two additional farm related dwelling units; accessory buildings, structures and uses; home occupation or home industry; watershed management and conservation rules.

Paipoonge Rural Zone (PRU)

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

Within the Municipality of Neebing the Mosquito Creek watershed has been zoned as:

- Recreation Commercial Zone (C2)
- Rural Zone (R)
- Watershed Reserve Zone (WR)

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

Recreation Commercial Zone (C2)

No person shall within any Recreation Commercial (C2) Zone use any lot or erect, alter or use any building or structure for any purpose except in accordance with the following: a tourist camp or tourist park and cabins; a tourist commercial resort; a tourist outfitters establishment; a campground, trailer park; a hunting and fishing camp; a marina; an arena; a curling rink; a golf course and driving range; a ski facility; a restaurant; a hotel, motel, cabins; a convention centre; an accessory dwelling to the uses listed above; or buildings, structures and uses accessory to the uses in accordance with Section 2.1.

Rural Zone (R)

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: a single dwelling; a modular dwelling; agricultural use; forestry use; stables, riding academies; watershed management and conservation uses; a home occupation; a home industry; a guest cottage; a bed and breakfast; mineral exploration; wind farms; buildings, structures and uses accessory to the above uses in accordance with Section 2.1.

Watershed Reserve Zone (WR)

No person shall within any Watershed Reserve (WR) Zone use any lot or erect, alter or use any building or structure for any use or purpose except in accordance with the following: watershed protection; Notwithstanding the previous permitted uses in 3.18.1, no building or structures shall be permitted in the Watershed Reserve (WR) Zone except where such are intended for: management and protection of watershed area.

2.3.2 Existing Land Uses

Thunder Bay Correctional Centre

Thunder Bay Correctional Centre, located at 2351 Highway 61, is a Provincial correctional facility for male offenders sentenced to less than two years and a female offender unit for adult females. It serves the Thunder Bay District. The Correctional Centre sewage system uses seasonal lagoons located south of the main facility across Highway 61.

Loch Lomond Ski Area

Loch Lomond Ski Area is located at 1800 Loch Lomond Road and offers skiing, snowboarding, snowshoeing and tubing in the winter and mountain biking and hiking in the summer. There are seventeen ski runs and three chair lifts.

Fort William Country Club

The Fort William Country Club is an 18 championship hole golf course located at 1350 Mountain Road. Construction of the course, including an irrigation system for the greens, and grow-in occurred during 1924 and 1925. The course first opened for play in the spring of 1926.

Nor'wester View Public School

Nor'wester View Public School is located at 1946 Mountain Road, just past the Thunder Bay Tournament Centre. There are approximately 330 students registered from Junior Kindergarten through to Grade 8. Opened in September 1996, the semi-rural school area encompasses the South Neebing area, Riverdale area, Vickers Heights area, the Fort William Band Reserve, Totem Trailer Court, Loch Lomond area and the Mount Forest area.

South Neebing Community Centre

South Neebing Community Centre is located at 1841 Mountain Road. It is owned by the City of Thunder Bay and run by volunteers. The Centre offers an array of programs including: Tennis Courts, Basketball Court, Baseball Field, Fitness Classes, Outdoor Skating Rink, Skateboard Park and a Play Group.

Thunder Bay Tournament Centre

The Thunder Bay Tournament Centre is a multi-purpose facility with two ice sheets, lounge and entertainment centre. The Centre can host all levels of hockey, figure skating, ringette and curling. The facility can host trade shows and hockey tournaments. The Thunder Bay Tournament Centre is home to the Northern Hawks. Owned by the City of Thunder Bay but operated by a management team.

2.4 Past Reports

Mosquito Creek Post Development Study

In 1996, the LRCA commissioned the "Mosquito Creek Post Development Study", which was to assess potential watershed impacts associated with the rapid urbanization and continuing development in the watershed. The Study was to assist in minimizing the impacts of future development.

Main conclusions in the report included: groundwater quality was naturally poor; a groundwater supply in the watershed with a sustained yield would be difficult to obtain due to low permeability; the natural setting was not highly suitable for disposal of sewage in septic tile fields because of the low permeability of the overburden deposits, and occasionally shallow bedrock. The study did recognize that within the watershed, piped municipal water was provided, but not sewage collection and treatment; as a result, a substantial amount of water from outside the watershed is added to the area.

The report provided water quality data from July 24, 1995 that was collected as part of the study. Exceedance of the PWQO at the time of the study included: Phosphorous 0.06 mg/L and 0.07 mg/L (PWQO criterion 0.03 mg/L); Iron 0.500 mg/L (PWQO criterion 0.3 mg/L); Zinc 0.038 mg/L (PWQO criterion 0.02 mg/L); and aluminum 0.17 mg/L (PWQO criterion 0.075 mg/L.

The study recommended that future developments consider stormwater management and to maintain current (pre-development) runoff quality and quantity. The study recommended a septic system inspection program and a public education program on septic system function and maintenance. The study did conclude that the Thunder Bay Correctional Centre seasonal lagoon discharges were a major source of

sediment, nutrient and bacteriological contamination to the watershed during discharge periods. Road salt was also noted as a concern. Long term water quality monitoring, flow monitoring, wetland assessments and sediment sampling were recommended.

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 Mosquito 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 8 was located on Trendiak Road as it was the closest location to the head waters of the watershed to obtain samples. Site 7 was located on Loch Lomond Road as it was the closest sampling point to the Thunder Bay Correctional Centre settling ponds. Site 6 was located on Highway 61 in order to obtain water samples downstream of the Mount Forest Estates subdivision. Site 5 was located on Mountain Road in order to obtain water samples downstream from the Nor'Wester View Public School. Site 4 was also located on Mountain Road beside the South Neebing Community Centre; it is downstream of the Broad Oaks subdivision. Site 3 was located on 15th Side Road; it is the "midpoint" of the main channel before it breaks off into different tributaries. Site 2 was located on Mountain Road in order to collect base data prior to the Whiskey Jack Estates subdivision being completed. It is also beside the Fort William Country Club. Site 1 was located on Chippewa Road and was meant to be a representation of the entire watershed upstream of the confluence. The UTM coordinates and elevation of each site were marked using the Trimble Geo XH GPS unit as shown on Map M-8: Site Plan.

3.2 Quantitative Assessment

Several parameters were measured to assess surface water quality of Mosquito 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 9 and 10, 2015. The second set was collected on July 7 and 8, 2015.

Methodology for water sample collection was based on the Provincial Water Quality Monitoring Network (PWQMN), Ministry of the Environment, 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 four 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 6000 QS 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, stop watch 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 A: Water Quality Parameters.

3.3 Applicable Criteria

Surface water quality results from the Mosquito Creek watershed were compared to applicable criteria published in the *Provincial Water Quality Objectives* (PWQO) by the Ontario Ministry of Environment and Energy (MOEE), 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". Applicable criteria published in the *Canadian Water Quality Guidelines for the Protection of Aquatic Life: Summary Table* by the Canadian Council of Resource and Environment Ministers (CCREM), September 2012 were also used for comparison to surface water quality results for the Mosquito Creek watershed. The information in these guidelines and supporting text is used to complement the PWQO and Interim Objectives.

The applicable criteria published in the PWQO and CCREM water quality guidelines are attached in Appendix B: 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 and in Appendix E: Common and Scientific Names of Mosquito Creek Post Development Study Identified Flora and Fauna. Fauna was assessed by identifying the species and number of individuals observed at each site.

An inventory of Mosquito 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 H: Bridge Assessments and Appendix G: Culvert 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 Mosquito 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

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

Table 3.5-2: 2011 Forest Conditions Indicator Guidelines

					Overall Forest Conditions	
% Forest Cover	**% Forest Interior**	**% Riparian Zone Forested**	**Point Score**	**Grade**	**Final Points**	**Final Grade**
>35.0	>11.5	>57.5	5	A	>4.4	A
25.1 - 35.0	8.6 - 11.5	42.6- 57.5	4	B	3.5 - 4.4	B
15.1 - 25.0	5.6 - 8.5	27.6 - 42.5	3	C	2.5 - 3.4	C
5.0 – 15.0	2.5 - 5.5	12.5 - 27.5	2	D	1.5 - 2.4	D
<5.0	<2.5	<12.5	1	F	<1.5	F

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)
- Stopwatch
- Trimble Geo XH GPS
- YSI 556 MPS 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 K: Laboratory Water Quality Results Summary Tables. The original Laboratory Certificates of Analysis and Analytical Reports have been attached in Appendix L: Laboratory Certificates of Analysis and Test Results.

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

4.1 Site 1

Site 1 was located near the confluence of Mosquito Creek at the Kaministiquia River and was accessed from Chippewa Road. The substrate at this site included muck, boulders and cobbles. The banks of the shoreline were stable with abundant vegetation in the riparian zone including balsam fir, trembling aspen, white birch, mountain ash, speckled alder, chokecherry and willow. 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 sandy-loam. Animal tracks were observed during the July sampling period which were assumed to be a bear, deer, raccoon, and either a wolf or coyote (Figure 17: Animal Tracks).

The laboratory results from the June 10, 2015 sampling period showed that copper exceeded the PWQO criterion of 0.005 mg/L (interim) with a value of 0.00507 mg/L. Total coliforms, aluminum and iron all exceeded the PWQO guidelines on both June 10, 2015 and July 8, 2015 sampling periods. Total coliforms were above the pre-1994 PWQO criterion of 1,000 MPN/100mL with a value of 1,300 MPN/100mL on June 10, 2015 and >2,420 MPN/100mL on July 8, 2015. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.7300 mg/L on June 10, 2015 and 0.4350 mg/L on July 8, 2015. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 1.210 mg/L on June 10, 2015 and 0.959 mg/L on July 8, 2015.

Table 4.1-1: Location References for Site 1	
Location Description	Chippewa Road, Mosquito Creek confluence at Kaministiquia River
UTM Coordinates	Northing 5356893 Easting 328696
Altitude/Elevation	187.1 metres above sea level

Table 4.1-2: Field Measurements for Site 1			
Parameter	**Unit**	**Date:** 10-JUN-15	**Date**: 08-JUL-15
		Time: 10:55	**Time**: 13:15
Water Temperature	ºC	15.54	21.18
Conductivity	uS/cm	419	578
Dissolved Oxygen	mg/L	11.13	8.13
Dissolved Oxygen	%	111.3	92.0
pH		8.17	8.60
Turbidity	NTU	14.7	10.9
Air Temperature	ºC	17.0	23.0
Channel Width	m	7.1	7.1
Channel Depth	m	0.20	0.30
Velocity	m/s	0.26	0.03
Salinity		0.20	0.28
Oxygen Reduction Potential	ORP	99.3	84.2

Table 4.1-3: Laboratory Water Quality Results for Site 1				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 10-JUN-15	**Date:** 08-JUL-15
			Time: 11:00	**Time:** 13:15
Bacteriological				
Escherichia Coli	MPN/100mL	100	27	39
Total Coliforms	MPN/100mL	1,000 (prior to 1994)	**1,300**	**>2,420**
Physical				
Conductivity (EC)	uS/cm	N/A	412	557
pH		6.5-8.5	8.21	8.33
Total Dissolved Solids	mg/L	N/A	237	315
Turbidity	NTU	<10% of natural	24.60	14.00
Nutrients and Anions				
Ammonia-N, Total	mg/L	N/A	<0.020	0.056
Chloride (Cl)	mg/L	N/A	51.7	76.3
Nitrate-N (NO3-N)	mg/L	N/A	0.070	0.072
Nitrite-N (NO2-N)	mg/L	N/A	<0.010	<0.010
Phosphorus (P)-Total	mg/L	0.030	0.0283	0.0266
Sulfate (SO4)	mg/L	N/A	9.41	9.57
Metals				
Aluminum (Al)	mg/L	0.075	**0.7300**	**0.4350**
Cadmium (Cd)	mg/L	0.0002 (interim)	0.0000329	0.0000425
Cobalt (Co)	mg/L	0.0009	0.00057	0.00051
Copper (Cu)	mg/L	0.005 (interim)	**0.00507**	0.00490
Iron (Fe)	mg/L	0.300	**1.210**	**0.959**
Lead (Pb)	mg/L	0.001 (interim)	0.000311	0.000241
Sodium (Na)	mg/L	N/A	28.70	42.60

Bold indicates exceedance above PWQO guidelines

Table 4.1-4: Flora Observed at Site 1			
FEC V-Type: V14 Balsam Fir Mixedwood			
Forest Density / Stream Cover	20% stream cover		
Terrestrial Species			
Trees	**Shrubs**	**Herbs**	**Ferns / Horsetails / Mosses / Grasses**
Balsam Poplar Trembling Aspen White Birch White Spruce Balsam Fir	Chokecherry Willow spp. Speckled Alder Mountain Ash	Dandelion	Meadow Horsetail
Aquatic Macrophytes and Algae			
Emergent	-	**Floating Algae**	-
Rooted Floating	-	**Filaments**	-
Submergent	-	**Attached Algae**	-
Free Floating	-	**Slimes or Crusts**	-

Table 4.1-5: Fauna Observed at Site 1	
Fauna Species	
Amphibians	Tadpoles
Birds	Belted Kingfisher
Crustaceans	-
Fish	-
Insects	Black Flies Mosquitoes
Mammals	-
Mollusca	-
Reptiles	Garter Snake

Table 4.1-6: Physical Features Observed at Site 1							
FEC Soil Type: S8 – Moist / Coarse Loamy							
In-stream Substrate							
Bedrock	**Boulder**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Muck**	**Clay**
-	25%	25%	-	-	-	50%	-
Bank Stability/Erosion	Erosion downstream from the sampling site						

4.2 Site 2

Site 2 was located on north side of Mountain Road, near the White Fox Inn and across from the Fort William Country Club. The substrate at this site included muck, gravel and cobbles. The banks of the shoreline were stable with abundant vegetation in the riparian zone including white spruce, red pine, jack pine, speckled alder, swamp thistle and white clover. Broad-leaved arrowhead was also prevalent in the water at the sample site. The soil type present at this side in the "A" Horizon was sand, the "B" Horizon was sandy-clay loam, and the "C" Horizon was silty-clay.

The laboratory results from the June 10, 2015 sampling period showed that aluminum exceeded the PWQO criterion of 0.075 mg/L with a value of 0.1420 mg/L on June 10, 2015. Total coliforms and iron exceeded the PWQO guidelines on both June 10, 2015 and July 8, 2015 sampling periods. Total coliforms were above the pre-1994 PWQO criterion of 1,000 MPN/100mL with a value of 2,420 MPN/100mL on June 10, 2015 and 1,990 MPN/100mL on July 8, 2015. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 0.539 mg/L on June 10, 2015 and 0.657 mg/L on July 8, 2015.

Table 4.2-1: Location References for Site 2	
Location Description	North side of Mountain Road - Near White Fox Inn, across from the Fort William Country Club
UTM Coordinates	Northing 5355157 Easting 328148
Altitude/Elevation	205.02 metres above sea level

Table 4.2-2: Field Measurements for Site 2			
Parameter	**Unit**	**Date:** 10-JUN-15 **Time:** 10:20	**Date**: 08-JUL-15 **Time**: 12:40
Water Temperature	ºC	13.95	17.29
Conductivity	uS/cm	278	365
Dissolved Oxygen	mg/L	10.22	7.51
Dissolved Oxygen	%	99.6	78.6
pH		7.66	7.99
Turbidity	NTU	2.58	2.27
Air Temperature	ºC	16.0	25.0
Channel Width	m	0.65	0.8
Channel Depth	m	0.20	0.20
Velocity	m/s	0.38	0.20
Salinity		0.13	0.18
Oxygen Reduction Potential	ORP	50.0	56.5

Table 4.2-3: Laboratory Water Quality Results for Site 2				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 10-JUN-15 **Time:** 10:20	**Date:** 08-JUL-15 **Time:** 12:40
Bacteriological				
Escherichia Coli	MPN/100mL	100	9	25
Total Coliforms	MPN/100mL	1,000 (prior to 1994)	**2,420**	**1,990**
Physical				
Conductivity (EC)	uS/cm	N/A	264	337
pH		6.5-8.5	7.76	7.84
Total Dissolved Solids	mg/L	N/A	174	204
Turbidity	NTU	<10% of natural	3.69	2.33
Nutrients and Anions				
Ammonia-N, Total	mg/L	N/A	<0.020	0.074
Chloride (Cl)	mg/L	N/A	20.70	33.80
Nitrate-N (NO3-N)	mg/L	N/A	0.024	0.044
Nitrite-N (NO2-N)	mg/L	N/A	<0.010	<0.010
Phosphorus (P)-Total	mg/L	0.030	0.0145	0.0205
Sulfate (SO4)	mg/L	N/A	9.22	6.83
Metals				

Aluminum (Al)	mg/L	0.075	**0.1420**	0.0605
Cadmium (Cd)	mg/L	0.0002 (interim)	0.0000177	0.0000139
Cobalt (Co)	mg/L	0.0009	0.00023	0.00023
Copper (Cu)	mg/L	0.005 (interim)	0.00371	0.00285
Iron (Fe)	mg/L	0.300	**0.539**	**0.657**
Lead (Pb)	mg/L	0.001 (interim)	0.000072	0.000051
Sodium (Na)	mg/L	N/A	14.80	21.40

Bold indicates exceedance above PWQO guidelines

Table 4.2-4: Flora Observed at Site 2

FEC V-Type: V24 White Spruce – Balsam Fir / Shrub Rich			
Forest Density / Stream Cover	20% stream cover		
Terrestrial Species			
Trees	**Shrubs**	**Herbs**	**Ferns / Horsetails / Mosses / Grasses**
Balsam Poplar Jack Pine Red Pine White Spruce	Speckled Alder	Cow Vetch Dandelion White Clover Red Clover Swamp Thistle Tall Buttercup Ox-Eye Daisy	
Aquatic Macrophytes and Algae			
Emergent	Broad-Leaved-Arrowhead Small Yellow Water-Crowfoot	**Floating Algae**	-
Rooted Floating	-	**Filaments**	-
Submergent	-	**Attached Algae**	-
Free Floating	-	**Slimes or Crusts**	-

Table 4.2-5: Fauna Observed at Site 2

Fauna Species	
Amphibians	Tadpoles
Birds	-
Crustaceans	-
Fish	-
Insects	Black Flies Mosquitoes Water Striders Bumblebees
Mammals	-
Mollusca	-
Reptiles	-

Table 4.2-6: Physical Features Observed at Site 2							
FEC Soil Type: S10 – Moist / Fine Loamy - Clayey							
In-stream Substrate							
Bedrock	**Boulder**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Muck**	**Clay**
-	-	25%	25%	-	-	75%	-
Bank Stability/ Erosion	Stable / abundant vegetation						

4.3 Site 3

Site 3 was located on the east side of 15th Side Road, halfway between Highway 61 and Mountain Road. The substrate at this site included sand, gravel and boulders. The banks of the shoreline were stable with abundant vegetation in the riparian zone including white spruce, balsam poplar, slender willow, pincherry, serviceberry, sweet coltsfoot and rough-stemmed goldenrod. Broad-leaved arrowhead was also prevalent in the water at the sample site. The soil type present at this site in the "A" Horizon was loamy-sand; the "B" Horizon was silty-clay loam.

The laboratory results from the June 10, 2015 sampling period determined that *E. coli* exceeded the PWQO guidelines. *E. coli* exceeded the PWQO criterion of 100 MPN/100mL with a value of 102 MPN/100mL. Phosphorus exceeded the PWQO criterion of 0.030 mg/L with a value of 0.0330 mg/L on July 8, 2015. Total coliforms, aluminum, and iron all exceeded the PWQO guidelines for both the June 10, 2015 and July 8, 2015 sampling period. Total coliforms exceeded the PWQO criterion of 1,000 MPN/100mL with a value of 1,990 MPN/100mL on both June 10, 2015 and July 8, 2015. Aluminum exceeded the PWQO criterion of 0.075 mg/L with a value of 0.2070 mg/L on June 10, 2015 and 0.2850 on July 8, 2015. Iron was in exceedance of the PWQO criterion of 0.3 mg/L with values of 0.689 mg/L on June 10, 2015 and 0.912 mg/L on July 8, 2015.

Table 4.3-1: Location References for Site 3	
Location Description	East side of 15th Side Road, between Highway 61 and Mountain Road
UTM Coordinates	Northing 5355175 Easting 327036
Altitude/Elevation	203.59 metres above sea level

Table 4.3-2: Field Measurements for Site 3			
Parameter	**Unit**	**Date:** 10-JUN-15 **Time:** 9:30	**Date**: 08-JUL-15 **Time**: 11:20
Water Temperature	ºC	16.37	17.39
Conductivity	uS/cm	414	614
Dissolved Oxygen	mg/L	9.75	7.78
Dissolved Oxygen	%	99.8	81.3
pH		7.80	8.24
Turbidity	NTU	3.23	6.58
Air Temperature	ºC	18.0	25.0
Channel Width	m	4.3	4.3

Sample Depth	m	0.29	0.28
Velocity	m/s	0.44	N/A
Salinity		0.20	0.30
Oxygen Reduction Potential	ORP	92.2	112.5

Table 4.3-3: Laboratory Water Quality Results for Site 3

Parameter	Unit	PWQO Guidelines	**Date:** 10-JUN-15 **Time:** 9:30	**Date:** 08-JUL-15 **Time:** 11:20
Bacteriological				
Escherichia Coli	MPN/100mL	100	**102**	50
Total Coliforms	MPN/100mL	1,000 (prior to 1994)	**1,990**	**1,990**
Physical				
Conductivity (EC)	uS/cm	N/A	408	590
pH		6.5-8.5	7.90	8.07
Total Dissolved Solids	mg/L	N/A	238	348
Turbidity	NTU	<10% of natural	4.65	7.13
Ammonia-N, Total	mg/L	N/A	<0.020	0.050
Chloride (Cl)	mg/L	N/A	46.2	83.9
Nitrate-N (NO3-N)	mg/L	N/A	0.051	0.043
Nitrite-N 2-N)	mg/L	N/A	<0.010	<0.010
Phosphorus (P)-Total	mg/L	0.030	0.0208	**0.0330**
Sulfate (SO4)	mg/L	N/A	6.15	6.30
Metals				
Aluminum (Al)	mg/L	0.075	**0.2070**	**0.2850**
Cadmium (Cd)	mg/L	0.0002 (interim)	0.0000182	0.0000241
Cobalt (Co)	mg/L	0.0009	0.00029	0.00045
Copper (Cu)	mg/L	0.005 (interim)	0.00327	0.00300
Iron (Fe)	mg/L	0.300	**0.689**	**0.912**
Lead (Pb)	mg/L	0.001 (interim)	0.000090	0.000158
Sodium (Na)	mg/L	N/A	30.20	48.90

Bold indicates exceedance above PWQO guidelines

Table 4.3-4: Flora Observed at Site 3

FEC V-Type: V15 White Spruce Mixedwood	
Forest Density / Stream Cover	5% stream cover

Terrestrial Species

Trees	Shrubs	Herbs	Ferns / Horsetails / Mosses / Grasses
Balsam Poplar Trembling Aspen White Pine White Spruce	Pincherry Serviceberry Slender Willow Speckled Alder	Cow Vetch Dandelion Rough-Stemmed-Goldenrod Swamp Thistle Sweet Coltsfoot	Meadow Horsetail Sphagnum Moss

Aquatic Macrophytes and Algae

Emergent	-	**Floating Algae**	-
Rooted Floating	-	**Filaments**	-
Submergent	-	**Attached Algae**	-
Free Floating	-	**Slimes or Crusts**	-

Table 4.3-5: Fauna Observed at Site 3	
Fauna Species	
Amphibians	Tadpoles
Birds	-
Crustaceans	-
Fish	-
Insects	Black Flies House Flies Mosquitoes
Mammals	-
Mollusca	-
Reptiles	-

Table 4.3-6: Physical Features Observed at Site 3							
FEC Soil Type: S10 – Moist / Fine Loamy - Clayey							
In-stream Substrate							
Bedrock	**Boulder**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Muck**	**Clay**
-	10%	-	40%	50%	-	-	-
Bank Stability/ Erosion	Stable/ abundant vegetation						

4.4 Site 4

Site 4 was located on the north side of Mountain Road beside the South Neebing Community Center. The substrate at this site was muck. The banks of the shoreline were stable with abundant vegetation in the riparian zone including balsam fir, jack pine, trembling aspen, common reed, Canada blue joint, common thistle and red clover. Aquatic vegetation was visible during both visits. There was a beaver dam observed further downstream, which could be causing the water to back up. The soil type present at this site in the "A" and "B" Horizon was sand; the "C" Horizon was silty-clay/clay.

The laboratory results from the July 8, 2015 sampling period showed that phosphorus exceeded the PWQO criterion of 0.030 mg/L with a value of 0.0449 mg/L on July 8, 2015. Total coliforms, aluminum and iron all exceeded the PWQO guidelines on both June 9, 2015 and July 8, 2015 sampling periods. Total coliforms were above the pre-1994 PWQO criterion of 1,000 MPN/100mL with a value of 1,300 MPN/100mL on June 9, 2015 and 1,990 MPN/100mL on July 8, 2015. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.1410 mg/L on June 9, 2015 and 0.1370 mg/L on July 8, 2015. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 0.663 mg/L on June 9, 2015 and 1.380 mg/L on July 8, 2015.

Table 4.4-1: Location References for Site 4	
Location Description	North side of Mountain Road beside the South Neebing Community Centre
UTM Coordinates	Northing 5354184 Easting 326100
Altitude/Elevation	212.74 metres above sea level

Table 4.4-2: Field Measurements for Site 4			
Parameter	**Unit**	**Date:** 09-JUN-15	**Date**: 08-JUL-15
		Time: 14:50	**Time**: 10:40
Water Temperature	ºC	19.02	17.28
Conductivity	uS/cm	223	291
Dissolved Oxygen	mg/L	10.0	5.56
Dissolved Oxygen	%	108.1	58.4
pH		7.64	7.90
Turbidity	NTU	2.36	3.29
Air Temperature	ºC	25.0	27.0
Channel Width	m	8.4	8.4
Sample Depth	m	0.70	0.70
Velocity	m/s	N/A	N/A
Salinity		0.11	0.14
Oxygen Reduction Potential	ORP	106.9	98.2

Table 4.4-3: Laboratory Water Quality Results for Site 4				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 09-JUN-15	**Date:** 08-JUL-15
			Time: 14:50	**Time:** 10:40
Bacteriological				
Escherichia Coli	MPN/100mL	100	88	40
Total Coliforms	MPN/100mL	1,000 (prior to 1994)	**1,300**	**1,990**
Physical				
Conductivity (EC)	uS/cm	N/A	217	281
pH		6.5-8.5	7.72	7.55
Total Dissolved Solids	mg/L	N/A	151	204
Turbidity	NTU	<10% of natural	2.83	3.85
Nutrients and Anions				
Ammonia-N, Total	mg/L	N/A	<0.020	0.068
Chloride (Cl)	mg/L	N/A	17.9	23.1
Nitrate-N (NO3-N)	mg/L	N/A	0.032	<0.020
Nitrite-N (NO2-N)	mg/L	N/A	<0.010	<0.010
Phosphorus (P)-Total	mg/L	0.030	0.0190	**0.0449**
Sulfate (SO4)	mg/L	N/A	2.60	0.77
Metals				
Aluminum (Al)	mg/L	0.075	**0.1410**	**0.1370**
Cadmium (Cd)	mg/L	0.0002 (interim)	0.0000167	0.0000115
Cobalt (Co)	mg/L	0.0009	0.00023	0.00038
Copper (Cu)	mg/L	0.005 (interim)	0.00314	0.00183
Iron (Fe)	mg/L	0.300	**0.663**	**1.380**
Lead (Pb)	mg/L	0.001 (interim)	0.000088	0.000146
Sodium (Na)	mg/L	N/A	11.60	15.30

Bold indicates exceedance above PWQO guidelines

Table 4.4-4: Flora Observed at Site 4			
FEC V-Type: V14 Balsam Fir Mixedwood			
Forest Density / Stream Cover	10% stream cover		
Terrestrial Species			
Trees	**Shrubs**	**Herbs**	**Ferns / Horsetails / Mosses / Grasses**
Balsam Fir Trembling Aspen Jack Pine Red Pine Balsam Poplar	Willow spp. Chokecherry	Tall Buttercup Red Clover White Clover Dandelion Swamp Thistle Cow Vetch Ox-Eye Daisy	Common Reed Canada Blue Joint
Aquatic Macrophytes and Algae			
Emergent	Broad-Leaved Arrowhead	**Floating Algae**	-
Rooted Floating	Waterlily	**Filaments**	-
Submergent	-	**Attached Algae**	-
Free Floating	-	**Slimes or Crusts**	-

Table 4.4-5: Fauna Observed at Site 4	
Fauna Species	
Amphibians	-
Birds	-
Crustaceans	-
Fish	Minnows
Insects	Black Flies Dragonflies Mosquitoes Red Ants
Mammals	
Mollusca	-
Reptiles	-

Table 4.4-6: Physical Features Observed at Site 4							
FEC Soil Type: S10 – Moist / Fine Loamy - Clayey							
In-stream Substrate							
Bedrock	**Boulder**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Muck**	**Clay**
-	-	-	-	-	-	100%	-
Bank Stability/ Erosion	Stable/ abundant vegetation						

4.5 Site 5

Site 5 was located on the north side of Mountain Road, between 1947 and 1953 Mountain Road, across from Nor'Wester View Public School. The substrate was composed of muck. The banks of the shoreline were stable with abundant vegetation

in the riparian zone including balsam poplar, trembling aspen, white spruce, pincherry, lupines and swamp thistle. Aquatic vegetation was visible during both visits including broad-leaved arrowhead and common cattail. The soil type present at this site was silty-clay in exclusively an "A" Horizon.

The laboratory results from the July 8, 2015 sampling period showed that phosphorus exceeded the PWQO criterion of 0.030 mg/L with a value of 0.0504 mg/L on July 8, 2015. Total coliforms and iron exceeded the PWQO guidelines on both June 9, 2015 and July 8, 2015 sampling periods. Total coliforms were above the pre-1994 PWQO criterion of 1,000 MPN/100mL with a value of 1,050 MPN/100mL on June 9, 2015 and 2,420 MPN/100mL on July 8, 2015. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 0.377 mg/L on June 9, 2015 and 0.961 mg/L on July 8, 2015.

Table 4.5-1: Location References for Site 5

Location Description	North side of Mountain Road, between 1947 and 1953 Mountain Road, across from Nor'Wester View Public School
UTM Coordinates	Northing 5354188 Easting 325570
Altitude/Elevation	219.41 metres above sea level

Table 4.5-2: Field Measurements for Site 5

Parameter	**Unit**	**Date:** 09-JUN-15 **Time:** 14:20	**Date**: 08-JUL-15 **Time**: 10:10
Water Temperature	ºC	18.58	15.77
Conductivity	uS/cm	476	533
Dissolved Oxygen	mg/L	8.51	3.57
Dissolved Oxygen	%	91.6	37.2
pH		7.58	7.84
Turbidity	NTU	0.58	1.35
Air Temperature	ºC	26.0	23.0
Channel Width	m	1.25	1.10
Sample Depth	m	0.30	0.39
Velocity	m/s	0.45	0.009
Salinity		0.23	0.26
Oxygen Reduction Potential	ORP	95.4	58.5

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

Parameter	**Unit**	**PWQO Guidelines**	**Date:** 09-JUN-15 **Time:** 14:20	**Date:** 08-JUL-15 **Time:** 10:10
Bacteriological				
Escherichia Coli	MPN/100mL	100	10	11
Total Coliforms	MPN/100mL	1,000 (prior to 1994)	**1,050**	**2,420**
Physical				
Conductivity (EC)	uS/cm	N/A	469	529
pH		6.5-8.5	7.73	7.61
Total Dissolved	mg/L	N/A	278	302
Turbidity	NTU	<10% of natural	0.96	1.52
Nutrients and Anions				
Ammonia-N, Total	mg/L	N/A	0.032	0.031
Chloride (Cl)	mg/L	N/A	53.8	59.6

Nitrate-N (NO3-N)	mg/L	N/A	<0.020	<0.020
Nitrite-N (NO2-N)	mg/L	N/A	<0.010	<0.010
Phosphorus (P)-Total	mg/L	0.030	0.0261	**0.0504**
Sulfate (SO4)	mg/L	N/A	8.62	0.96
Metals				
Aluminum (Al)	mg/L	0.075	0.0204	0.0146
Cadmium (Cd)	mg/L	0.0002 (interim)	0.0000087	0.0000103
Cobalt (Co)	mg/L	0.0009	0.00016	0.00059
Copper (Cu)	mg/L	0.005 (interim)	0.00177	0.00075
Iron (Fe)	mg/L	0.300	**0.377**	**0.961**
Lead (Pb)	mg/L	0.001 (interim)	0.000088	<0.000050
Sodium (Na)	mg/L	N/A	30.80	32.50

Bold indicates exceedance above PWQO guidelines

Table 4.5-4: Flora Observed at Site 5

FEC V-Type: V14 Balsam Fir Mixedwood			
Forest Density / Stream Cover	75% stream cover		
Terrestrial Species			
Trees	**Shrubs**	**Herbs**	**Ferns / Horsetails / Mosses / Grasses**
Balsam Poplar Jack Pine Trembling Aspen White Spruce Balsam Fir	Pincherry Willow spp.	Common Cattail Swamp Thistle Lupine Wood Lily Dandelion	
Aquatic Macrophytes and Algae			
Emergent	Broad-Leaved Arrowhead	**Floating Algae**	-
Rooted Floating	-	**Filaments**	-
Submergent	-	**Attached Algae**	-
Free Floating	-	**Slimes or Crusts**	-

Table 4.5-5: Fauna Observed at Site 5

Fauna Species	
Amphibians	-
Birds	-
Crustaceans	-
Fish	-
Insects	Black Flies Bumblebee Water Striders
Mammals	-
Mollusca	-
Reptiles	-

Table 4.5-6: Physical Features Observed at Site 5							
FEC Soil Type: S10 – Moist / Fine Loamy - Clayey							
In-stream Substrate							
Bedrock	**Boulder**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Muck**	**Clay**
-	-	-	-	-	-	100%	-
Bank Stability/ Erosion	Stable/ abundant vegetation						

4.6 Site 6

Site 6 was located on the south side of Highway 61, adjacent to 1956 Highway 61, approximately 700 metres from Mountain Road. The substrate was composed of silt, sand and cobbles. The banks of the shoreline were stable with abundant vegetation in the riparian zone including white spruce, balsam poplar, trembling aspen, speckled alder, pincherry and willow. Aquatic vegetation was not present during both site visits. The soil type present at this site was sandy-clay loam in the "A" Horizon and loamy-sand in the "C" Horizon.

Total coliforms exceeded the PWQO guidelines on both June 9, 2015 and July 8, 2015 sampling periods. Total coliforms were above the pre-1994 PWQO criterion of 1,000 MPN/100mL with a value of 1,300 MPN/100mL on June 9, 2015 and >2,420 MPN/100mL on July 8, 2015.

Table 4.6-1: Location References for Site 6	
Location Description	South side of Highway 61, adjacent to 1956 Highway 61, approximately 700 metres from Mountain Road
UTM Coordinates	Northing 5354748 Easting 325572
Altitude/Elevation	216.01 metres above sea level

Table 4.6-2: Field Measurements for Site 6			
Parameter	**Unit**	**Date:** 09-JUN-15 **Time:** 13:20	**Date**: 08-JUL-15 **Time**: 9:25
Water Temperature	ºC	14.64	12.0
Conductivity	uS/cm	1123	1332
Dissolved Oxygen	mg/L	11.10	8.17
Dissolved Oxygen	%	109.6	75.7
pH		7.95	8.42
Turbidity	NTU	0.73	1.60
Air Temperature	ºC	25.0	18.0
Channel Width	m	1.10	1.10
Sample Depth	m	0.30	0.25
Velocity	m/s	0.71	0.13
Salinity		0.56	0.67
Oxygen Reduction Potential	ORP	114.5	107.1

Table 4.6-3: Laboratory Water Quality Results for Site 6				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 09-JUN-15 **Time:** 13:20	**Date:** 08-JUL-15 **Time:** 9:25
Bacteriological				
Escherichia Coli	MPN/100mL	100	3	76
Total Coliforms	MPN/100mL	1,000	**1,300**	**>2,420**
Physical				
Conductivity (EC)	uS/cm	N/A	1110	1250
pH		6.5-8.5	8.02	8.12
Total Dissolved Solids	mg/L	N/A	606	757
Turbidity	NTU	<10% of natural	1.17	1.51
Nutrients and Anions				
Ammonia-N, Total	mg/L	N/A	<0.020	0.170
Chloride (Cl)	mg/L	N/A	180.00	212.00
Nitrate-N (NO3-N)	mg/L	N/A	0.845	1.140
Nitrite-N (NO2-N)	mg/L	N/A	<0.010	<0.050
Phosphorus (P)-Total	mg/L	0.030	0.0071	0.0081
Sulfate (SO4)	mg/L	N/A	23.80	31.00
Metals				
Aluminum (Al)	mg/L	0.075	0.0396	0.0441
Cadmium (Cd)	mg/L	0.0002 (interim)	0.0000275	0.0000394
Cobalt (Co)	mg/L	0.0009	0.00033	0.00048
Copper (Cu)	mg/L	0.005 (interim)	0.00383	0.00330
Iron (Fe)	mg/L	0.300	0.161	0.250
Lead (Pb)	mg/L	0.001 (interim)	<0.000050	<0.000050
Sodium (Na)	mg/L	N/A	111.00	130.00

Bold indicates exceedance above PWQO guidelines

Table 4.6-4: Flora Observed at Site 6			
FEC V-Type: V15 White Spruce Mixedwood			
Forest Density /Stream Cover	65% stream cover		
Terrestrial Species			
Trees	**Shrubs**	**Herbs**	**Ferns / Horsetails / Mosses / Grasses**
Balsam Poplar Trembling Aspen White Spruce Tamarack	Pincherry Willow spp. Speckled Alder	Dandelion Rough-Stemmed-Goldenrod White Clover Common Cattail Ox-Eye Daisy Red Clover Swamp Thistle	Fringed Brome Grass Lady Fern
Aquatic Macrophytes and Algae			
Emergent	-	**Floating Algae**	-
Rooted Floating	-	**Filaments**	-
Submergent	-	**Attached Algae**	-
Free Floating	-	**Slimes or Crusts**	-

Table 4.6-5: Fauna Observed at Site 6	
Fauna Species	
Amphibians	-
Birds	-
Crustaceans	-
Fish	-
Insects	Black Flies Mosquitoes Water Striders Asian Ladybug Grasshoppers Butterflies Black Ants White Admiral
Mammals	-
Mollusca	-
Reptiles	-

Table 4.6-6: Physical Features Observed at Site 6							
FEC Soil Type: S10 – Moist / Fine Loamy - Clayey							
In-stream Substrate							
Bedrock	**Boulder**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Muck**	**Clay**
-	-	30%	-	35%	35%	-	-
Bank Stability/Erosion	Stable/ abundant vegetation						

4.7 Site 7

Site 7 was located on the east side Loch Lomond Road, 400 meters from Gregor Road. There was a beaver dam upstream which could be causing some water blockage. The substrate was composed of muck. The banks of the shoreline were stable with abundant vegetation in the riparian zone including black spruce, balsam poplar, tamarack, trembling aspen, willow, cow vetch, orange jewelweed and ox-eye daisies. Aquatic vegetation was not present during both site visits. The soil type present at this site was silty-loam in the "A" Horizon, silty-clay loam in the "B" Horizon and sandy-loam with gravel in the "C" Horizon.

The laboratory results from the July 7, 2015 sampling period determined that phosphorus exceeded the PWQO criterion of 0.030 mg/L with a value of 0.21 mg/L. Total coliforms exceeded the PWQO criterion of 1,000 MPN/100mL with a value of 1,730 MPN/100mL on June 9, 2015. Cobalt exceeded the PWQO criterion of 0.0009 mg/L with a value of 0.00159 mg/L on July 7, 2015. Iron was in exceedance of the PWQO criterion of 0.3 mg/L with values of 0.904 mg/L on June 9, 2015 and 3.770 mg/L on July 7, 2015.

Table 4.7-1: Location References for Site 7	
Location Description	East side of Loch Lomond Road, 400 meters from Gregor Road
UTM Coordinates	Northing 5353576 Easting 324939
Altitude/Elevation	222.60 metres above sea level

Table 4.7-2: Field Measurements for Site 7			
Parameter	**Unit**	**Date:** 09-JUN-15 **Time:** 10:40	**Date**: 07-JUL-15 **Time**: 14:30
Water Temperature	ºC	N/A	19.35
Conductivity	uS/cm	390	520
Dissolved Oxygen	mg/L	5.87	2.26
Dissolved Oxygen	%	61.9	23.1
pH		7.43	7.48
Turbidity	NTU	1.22	3.86
Air Temperature	ºC	20.0	25.0
Channel Width	m	2.10	0.90
Sample Depth	m	0.40	0.20
Velocity	m/s	0.26	0.08
Salinity		0.19	0.25
Oxygen Reduction Potential	ORP	58.7	N/A

Table 4.7-3: Laboratory Water Quality Results for Site 7				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 09-JUN-15 **Time:** 10:40	**Date:** 07-JUL-15 **Time:** 14:30
Bacteriological				
Escherichia Coli	MPN/100mL	100	6	9
Total Coliforms	MPN/100mL	1000 (prior to 1994)	**1,730**	435
Physical				
Conductivity (EC)	uS/cm	N/A	378	482
pH		6.5-8.5	7.41	7.33
Total Dissolved Solids	mg/L	N/A	252	295
Turbidity	NTU	<10% of natural	2.27	6.30
Nutrients and Anions				
Ammonia-N, Total	mg/L	N/A	<0.020	0.123
Chloride (Cl)	mg/L	N/A	37.80	46.20
Nitrate-N (NO3-N)	mg/L	N/A	0.020	<0.020
Nitrite-N (NO2-N)	mg/L	N/A	<0.010	<0.010
Phosphorus (P)-Total	mg/L	0.030	**0.0651**	**0.2100**
Sulfate (SO4)	mg/L	N/A	5.69	<0.30
Metals				
Aluminum (Al)	mg/L	0.075	0.0528	0.0313
Cadmium (Cd)	mg/L	0.0002 (interim)	0.0000157	0.0000087
Cobalt (Co)	mg/L	0.0009	0.00043	**0.00159**
Copper (Cu)	mg/L	0.005 (interim)	0.00145	0.00060
Iron (Fe)	mg/L	0.300	**0.904**	**3.770**
Lead (Pb)	mg/L	0.001 (interim)	<0.000050	0.000063
Sodium (Na)	mg/L	N/A	22.10	24.10

Bold indicates exceedance above PWQO guidelines

Table 4.7-4: Flora Observed at Site 7			
FEC V-Type: V14 Balsam Fir Mixedwood			
Forest Density / Stream Cover	80% stream cover		
Terrestrial Species			
Trees	**Shrubs**	**Herbs**	**Ferns / Horsetails / Mosses / Grasses**
Balsam Fir White Spruce Balsam Poplar Black Ash Black Spruce Tamarack Trembling Aspen	Willow Spp. Speckled Alder	Common Cattail Tall Buttercup Cow Vetch Ox-Eye Daisy Dandelion Orange Jewelweed	
Aquatic Macrophytes and Algae			
Emergent	-	**Floating Algae**	-
Rooted Floating	-	**Filaments**	-
Submergent	-	**Attached Algae**	-
Free Floating	-	**Slimes or Crusts**	-

Table 4.7-5: Fauna Observed at Site 7	
Fauna Species	
Amphibians	-
Birds	-
Crustaceans	-
Fish	-
Insects	Black Flies Bumblebees Eastern Tiger Swallowtail Mosquitoes Spring Azure White Admiral
Mammals	-
Mollusca	-
Reptiles	-

Table 4.7-6: Physical Features Observed at Site 7							
FEC Soil Type: S10 – Moist / Fine Loamy - Clayey							
In-stream Substrate							
Bedrock	**Boulder**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Muck**	**Clay**
-	-	-	-	-	-	100%	-
Bank Stability/ Erosion	Stable/ abundant vegetation						

4.8 Site 8

Site 8 was located on the privately owned property of 2176 Trendiak Road, 150 metres west from Loch Lomond Road. The substrate was composed of muck. The banks of the

shoreline were stable with abundant vegetation in the riparian zone including jack pine, white birch, black spruce, tall yellow aster, water parsnip, cow vetch and swamp thistle. Aquatic vegetation was visible during both visits including broad-leaved arrowhead and common cattail. The soil type present at this site was silty-loam in both the "A" and "B" Horizons.

The laboratory results from the June 9, 2015 and July 7, 2015 sampling periods showed that total coliforms, aluminum and iron all exceeded the PWQO guidelines. Total coliforms were above the pre-1994 PWQO criterion of 1,000 MPN/100mL with a value of 2,420 MPN/100mL on June 9, 2015 and 1,990 MPN/100mL on July 7, 2015. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.3370 mg/L on June 9, 2015 and 0.1480 mg/L on July 7, 2015. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 0.643 mg/L on June 9, 2015 and 0.805 mg/L on July 7, 2015.

Table 4.8-1: Location References for Site 8	
Location Description	2176 Trendiak Road, about 150 meters west from Loch Lomond Road
UTM Coordinates	Northing 5352181 Easting 324761
Altitude/Elevation	235.89 metres above sea level

Table 4.8-2: Field Measurements for Site 8			
Parameter	**Unit**	**Date:** 09-JUN-15	**Date**: 07-JUL-15
		Time: 9:45	**Time**: 13:35
Water Temperature	°C	16.09	21.17
Conductivity	uS/cm	114	166
Dissolved Oxygen	mg/L	9.01	7.14
Dissolved Oxygen	%	92.2	38.0
pH		7.54	7.88
Turbidity	NTU	3.45	2.83
Air Temperature	°C	19.0	23.0
Channel Width	m	2.70	2.70
Sample Depth	m	0.29	0.30
Velocity	m/s	0.12	N/A
Salinity		0.05	0.08
Oxygen Reduction Potential	ORP	106.9	17.8

Table 4.8-3: Laboratory Water Quality Results for Site 8				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 09-JUN-15	**Date:** 07-JUL-15
			Time: 9:45	**Time:** 13:35
Bacteriological				
Escherichia Coli	MPN/100mL	100	30	20
Total Coliforms	MPN/100mL	1,000 (prior to 1994)	**2,420**	**1,990**
Physical				
Conductivity (EC)	uS/cm	N/A	108	162
pH		6.5-8.5	7.39	7.65
Total Dissolved Solids	mg/L	N/A	97	133
Turbidity	NTU	<10% of natural	5.99	3.74
Nutrients and Anions				

Ammonia-N, Total	mg/L	N/A	<0.020	0.031
Chloride (Cl)	mg/L	N/A	0.32	0.41
Nitrate-N (NO3-N)	mg/L	N/A	0.021	<0.020
Nitrite-N (NO2-N)	mg/L	N/A	<0.010	<03010
Phosphorus (P)-Total	mg/L	0.030	0.0177	0.0217
Sulfate (SO4)	mg/L	N/A	1.39	0.75
Metals				
Aluminum (Al)	mg/L	0.075	**0.3370**	**0.1480**
Cadmium (Cd)	mg/L	0.0002 (interim)	0.0000225	0.0000204
Cobalt (Co)	mg/L	0.0009	0.00027	0.000301
Copper (Cu)	mg/L	0.005 (interim)	0.00349	0.00204
Iron (Fe)	mg/L	0.300	**0.643**	**0.805**
Lead (Pb)	mg/L	0.001 (interim)	0.000108	0.000089
Sodium (Na)	mg/L	N/A	1.99	2.20

Bold indicates exceedance above PWQO guidelines

Table 4.8-4: Flora Observed at Site 8

FEC V-Type: V17 Jack Pine Mixedwood/Shrub Rich			
Forest Density / Stream Cover	0% stream cover		
Terrestrial Species			
Trees	**Shrubs**	**Herbs**	**Ferns / Horsetails / Mosses / Grasses**
Black Spruce Green Ash Jack Pine White Birch White Spruce	Beaked Hazel Speckled Alder	Common Cattail Dandelion Swamp Thistle Cow Vetch Tall Yellow Aster Water Parsnip Square-Stemmed Monkey Flower	
Aquatic Macrophytes and Algae			
Emergent	Broad-Leaved Arrowhead	**Floating Algae**	-
Rooted Floating	-	**Filaments**	-
Submergent	-	**Attached Algae**	-
Free Floating	-	**Slimes or Crusts**	-

Table 4.8-5: Fauna Observed at Site 8

Fauna Species	
Amphibians	-
Birds	
Crustaceans	-
Fish	Minnows
Insects	Black Flies Mosquitoes Water Striders
Mammals	-
Mollusca	-
Reptiles	Garter Snake

Table 4.8-6: Physical Features Observed at Site 8							
FEC Soil Type: S9 – Moist / Silty - Silt Loamy							
In-stream Substrate							
Bedrock	**Boulder**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Muck**	**Clay**
-	-	-	-	-	-	100%	-
Bank Stability/ Erosion	Stable/ abundant vegetation						

4.9 Watershed Report Card Results

The overall surface water quality for the Mosquito Creek Watershed maintained a total averaged point score that is greater than 3.5. With minimal exceedances for phosphorus and for *E.coli*, the rating of the surface water quality for the Mosquito Creek watershed was determined to have a grade of B.

The forest coverage for the Mosquito Creek watershed was 19.5 square kilometres (61.4 percent), interior forest coverage was 11.8 square kilometres (37.2 percent) and the riparian forest cover was 1.1 square kilometres (3.5 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 4.9-1: Mosquito Creek Watershed Surface Water Indicators and Overall Grade Calculation							
Site Number	**Average Total Phosphorus (mg/L)**	**Average E. coli (MPN/ 100mL)**	**Average of Benthic Invertebrates**	**Total Point Score**	**Grade**	**Overall Surface Water Quality Grade**	
						Final Points	**Grade**
1	0.0275	33	N/A	8	B	4	B
2	0.0175	17	N/A	10	A	5	A
3	0.0269	76	N/A	8	B	4	B
4	0.0320	64	N/A	7	B	3.5	B
5	0.0383	10.5	N/A	8	B	4	B
6	0.0076	39.5	N/A	9	A	4.5	A
7	0.1376	7.5	N/A	7	B	3.5	B
8	0.0197	25	N/A	10	A	5	A

Table 4.9-2: Mosquito Creek Watershed Forest Conditions and Overall Grade Calculation						
					Overall Forest Conditions	
% Forest Cover	**% Forest Interior**	**% Riparian Zone Forested**	**Total Point Score**	**Grade**	**Final Points**	**Final Grade**
61.4	37.2	3.5	11	B	3.7	B

5 Discussion

The Mosquito 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. Two visits were completed for each site. The first sampling period ran June 9th and 10th and the second sampling period on July 7th and 8th.

The average air temperature for the June 2015 sampling period was 20.8 degrees Celsius which exceeded the monthly average temperature of 14 degrees Celsius for June 2015 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 23.6 degrees Celsius which exceeded the monthly average temperature of 18.2 degrees Celsius for July 2015 as well as the historical average of 17.6 degrees Celsius for July 1971-2000. Precipitation for the month of June totaled 83.5 millimetres which was below the historical monthly average of 85.7 millimetres for Thunder Bay from June 1971-2000. In July, precipitation totaled 39.8 millimetres which was also below the historical monthly average of 89 millimetres for July 1971-2000. During the June sampling period, the sky was mostly clear with few clouds. During the July sampling period, it was sunny and partly cloudy.

Water temperature ranged from 13.95 degrees Celsius to 19.02 degrees Celsius in June and 12.0 degrees Celsius to 21.18 degrees Celsius in July which can be seen on Figure 12: Mosquito Creek Watershed Water Temperature. A comparable trend can be seen during both sample periods. The stream depths observed ranged from 0.20 metres to 0.70 metres for both June and July. Water levels increased at Sites 1, 5, and 8 and decreased at Sites 3, 6, and 7 between June and July.

From the eight sample locations, all of them were water crossings which required a bridge or culvert to support the road. There was one bridge in total, at Site 1. The bridge was made out of reinforced concrete and steel beams and did not appear to alter flow in a significant way, or change the natural stream course. The fill used for the footing on either bank, consisted of boulders, cobble and gravel. The fill used was similar to the natural stream bank substrate and aided in bridge support as well as erosion and sedimentation control from road run-off. Culverts were present at Sites 2, 3, 4, 5, 6, 7 and 8. The culverts at these sites were in good condition, except for Site 8, and were large enough to withstand increased velocity and water levels from heavy rainfall. The culverts at Site 8 were completely rusted over, collapsing on themselves and covered in vegetation causing blockage. The road on the downstream side was starting to collapse also.

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-14 White Spruce Mixedwood, was

the most common and occurred at Sites 1, 4, 5 and 7. The remaining sites still had a similar mixedwood forest type, sometimes favouring coniferous species as opposed to hardwood. The dominant tree species within the Mosquito 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, pincherry, beaked hazel, serviceberry, 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, buttercup, common bulrush, cow vetch, red and white clover. No invasive plant species or species at risk were seen at the sample sites within the Mosquito Creek watershed. Some of the aquatic vegetation identified was broad-leaved arrowhead, small yellow water crowfoot, and waterlily.

Overall, the stream banks documented within the Mosquito Creek watershed were stable. The main soil type was silty-loam with some clay content, which tends to be a compacting type soil and aids in river stability. Some of the sites were mainly muck 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 Mosquito Creek watershed was 7.33 to 8.33 as illustrated on Figure 11: pH Level at Mosquito Creek Sample Sites. The average pH lies within a good water quality range, being slightly more basic in some areas of the watershed.

There is currently no PWQO for conductivity. The highest recorded level was 1,250 microSiemens per centimetre (uS/cm) at Site 6 on July 8, 2015. The lowest recorded level was 108 uS/cm on June 9, 2015 at Site 8. The conductivity levels are illustrated on Figure 14: Conductivity at Mosquito Creek Sample Sites.

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 14: Conductivity at Mosquito Creek Sample Sites and Figure 13: Total Dissolved Solids (TDS) at Mosquito Creek Sample Sites, the highest reading for TDS and conductivity were at Site 6, and the lowest readings for both parameters were at Site 8. The highest TDS reading was 757 mg/L at Site 6 on July 8, 2015. The lowest TDS reading found was 97 mg/L at Site 8 on June 9, 2015.

Turbidity in the Mosquito Creek watershed ranged from 0.96 NTU to 24.6 NTU, as seen in Figure 15: Turbidity at Mosquito Creek Sample Sites. All sites were below the

Canadian Recreational Water Quality drinking guidelines of 50 NTU (Health Canada, 1992). The lowest recorded turbidity value was 0.96 NTU at Site 5 on June 9, 2015. The highest recorded turbidity value was 24.6 NTU at Site 1 on June 10, 2015.

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 7 with a value of 0.0651 mg/L. During the July sampling period Sites 3, 4, 5 and 7 were all in exceedance with a range of 0.0330 mg/L to 0.2100 mg/L. The average concentration of phosphorus was 0.0248 mg/L for all sites during the June sampling month and 0.0519 mg/L during the July sampling month.

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* level at Site 3 was in exceedance of the PWQO of 100 MPN/100mL on June 10, 2015 with a value of 102 MPN/100mL. The rest of the sampling sites did not show any exceedances. The presence of *E. coli* in the watershed ranged from 3 to 102 MPN/100mL which is considered to be low. 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. 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 7 during the July sampling period. The highest level of total coliform present was >2,420 MPN/100mL at Sites 2 and 6 on July 8, 2015. Total coliforms ranged from 435 to >2,420 MPN/100mL.

Nitrogen was analyzed in three biologically-usable forms: nitrate (NO_3), nitrate (NO_2) and ammonia (NH_3). All three forms of nitrogen in the Mosquito Creek watershed were below the maximum concentrations published in the PWQO and CCREM guidelines. All nitrate concentrations at the sampling sites ranged from <0.020 to 1.14 mg/L (with a CCREM criterion of 2.900 mg/L). All nitrite concentrations at the sampled sites were < 0.010 mg/L (with a CCREM criterion of 0.060 mg/L). Total ammonia ranged from <0.020 mg/L to 0.170 mg/L. Total ammonia does not have a singular criterion because its speciation between un-ionized (NH_3) and (NH_4) forms are dependent on pH and temperature parameters. Total ammonia concentrations reported by the laboratory were converted into un-ionized (NH_3) ammonia concentrations using the conversion table provided in the PWQO guidelines. All un-ionized ammonia concentrations in the

Mosquito Creek watershed were <0.004 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, and 8, as well as Sites 1, 3, 4, and 8 during the July sampling period. Aluminum concentrations ranged from 0.0146 mg/L at Site 5 on July 8, 2015 to 0.7300 mg/L at Site 1 on June 10, 2015. The average concentration of aluminum was 0.2087 mg/L for all sites during the June sampling period and 0.1444 mg/L during the July sampling period.

All sites except for Site 6 were above the PWQO criterion of 0.3 mg/L for iron during both the sampling months of June and July, 2015. Iron concentrations ranged between 0.161 mg/L at Site 6 on June 9, 2015 and 1.380 mg/L at Site 4 on July 8, 2015. The average concentration of iron was 0.648 mg/L for the June sampling period and 1.212 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 PWQO criterion of 0.0009 mg/L for *c*obalt was exceeded on July 07, 2015 with a value of 0.00159 mg/L. Cobalt concentrations ranged from 0.00016 mg/L to 0.00159 mg/L. The average concentration of cobalt was 0.00031 mg/L for all sites during the June sampling period and 0.00057 mg/L during the July sampling period.

Copper was below the PWQO criterion of 0.005 mg/L at all sites except for Site 1 on June 10, 2015 with a value of 0.00507 mg/L. The copper concentrations ranged from 0.00075 mg/L to 0.00507 mg/L during sampling. The average concentration of copper was 0.00322 mg/L for all sites during the June sampling period and 0.00241 mg/L during the July sampling period.

The overall health of the Mosquito 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 Mosquito Creek watershed surface water quality has maintained a rating (B) for its Watershed Report Card rating. The Mosquito 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 Mosquito Creek watershed has been determined to have good overall health.

6 Conclusion

The Mosquito 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 seemed 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 2015 Mosquito Creek Watershed Assessment, the following recommendations have been made for considerations:

- Staff and funding permitting it is recommended that an update to the 2015 Mosquito 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
- If the Provincial Water Quality Monitoring Network program was ever expanded, a monitoring location within the Mosquito Creek watershed should be considered.
- A copy of this report should be provided to the City of Thunder Bay, 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

Canadian Council of Ministers of the Environment (CCME). "Canadian Environmental Quality Guidelines Summary Table – Protection of Aquatic Life". Online. Accessed: August 9, 2015. Available: <http://st-ts.ccme.ca/en/index.html>

City of Thunder Bay. Golf Courses/Facilities. Fort William Country Club. Online. Accessed: January 11, 2016. Available: <http://www.thunderbay.ca/Visiting/Sports_Central/Sports_Facilities/Golf_Courses_Facilities/Fort_William_Country_Club.htm>

City of Thunder Bay. Arenas. Thunder Bay Tournament Centre. Online. Accessed: January 11, 2016. Available: <http://www.thunderbay.ca/Visiting/Sports_Central/Sports_Facilities/Arenas/Thunder_Bay_Tournament_Centre.htm>

City of Thunder Bay. "City of Thunder Bay Zoning By-Law 100-2010". Online. Accessed: July 12, 2015. Available: <http://www.thunderbay.ca/City_Government/Departments/Development___Emergency_Services/Planning_Division/Zoning_By-law_100-2010.htm>

Conservation Ontario. "2011 Guide to Developing Conservation Authority Watershed Report Cards". 2011. Print.

Cudmore, Becky and Nicholas E. Mandrak. "The Baitfish Primer". Fisheries and Oceans Canada. Winnipeg, Manitoba. 2011. Print.

Dickinson, T., Metsger, D., Bull, J., & R. Dickinson. "The ROM Field Guide to Wildflowers of Ontario". Royal Ontario Museum and McClelland and Stewart Ltd., Toronto, Ontario. 2004. Print.

EDDMapS Ontario. 2015. Early Detection & Distribution Mapping System for Ontario. Online. Accessed June 16, 2015. Available: <http://www.eddmaps.org/ontario/distribution/results.cfm?id=7&name=Thunder%20Bay >

Environment Canada. Canadian Climate Normals 1971-2000 Station Data. Online. Accessed: August 4, 2015. Available: <http://climate.weather.gc.ca/climate_normals/results_e.html?stnID=4055&lang=e&StationName=thu&SearchType=BeginsWith&stnNameSubmit=go&dCode=>

Environment Canada. "Daily Data Report - Thunder Bay". Online. Accessed: August 4, 2015. Available: <http://climate.weather.gc.ca/climateData/dailydata_e.html?StationID=30682&timeframe=2&cmdB1=Go&cmdB2=Go&Year=2015&Month=7&cmdB2=Go#>

Fenco MacLaren Inc. "Mosquito Creek Post Development Study". Report to Lakehead Region Conservation Authority. March 1996. Print.

Fort William Country Club Limited. "Home". Online. Accessed: January 11, 2016. Available: <http://www.fwcc.ca/article/welcome-1.asp>

Harris, Allan G., S.C. McMurray, P.W.C. Uhlig, J.K. Jeglum, R.F. Foster and G.D. Racey. "Field Guide to Wetland Ecosystem Classification for Northwestern Ontario". Queen's Printer for Ontario, Ontario, Canada. 1996. Print.

Health Canada. "Guidelines for Canadian Recreational Water Quality". Ministry of National Health and Family Welfare. 1992. Ottawa: Supply and Services Canada. Online. Accessed: June 17, 2015. Available: <http://www.hc-sc.gc.ca>

Lakehead Region Conservation Authority. "Thunder Bay Aquifer Characterization, Groundwater Management and Protection Study". July 2005. Print.

Lakehead Region Conservation Authority. "Lakehead Source Protection Area Watershed Characterization Report". March 2008. Print.

Legasy, Karen, Shayna LaBelle-Beadman, and Brenda Chambers. "Forest Plants of Northeastern Ontario". Canada. Lone Pine Publishing & Queen's Printer for Ontario. 1995. Print.

Lenntech B.V. "Aluminum and water: reaction mechanisms, environmental impact and health effects". Online. Accessed: August 9, 2015. Available: <http://www.lenntech.com/periodic/water/aluminium/aluminum-and-water.htm#ixzz2bJ86RbwN>

Ministry of the Environment and Climate Change(MOECC). "Policies, Guidelines, Provincial Water Quality Objectives". Toronto, Ontario. Queen's Printer. July 1994. Online. Accessed: August 4, 2015. Available: <https://www.ontario.ca/document/water-management-policies-guidelines-provincial-water-quality-objectives >

Municipality of Neebing. "Municipality of Neebing Zoning By-Law No. 806-2010". Online. Accessed: July 12, 2015. Available: <http://www.neebing.org/by-laws-and-policies.html>

Municipality of Oliver Paipoonge. "Municipality of Oliver Paipoonge By-Law 185-01". Online. Accessed: July 12, 2015. Available: <http://www.oliverpaipoonge.ca/by-laws-policies >

Natural Resources Canada. Forest Classification. Online. Accessed: June 25, 2015. Available: <http://www.nrcan.gc.ca/forests/measuring reporting/classification/13179>

Newmaster, Steven G., Allen G. Harris, and Linda J. Kershaw. "Wetland Plants of Ontario". Toronto, Ontario. Queen's Printer. 1997. Print.

Nor'wester View Public School . "Home". Online. Accessed: January 11, 2016. Available: <http://norwesterview.lakeheadschools.ca/>

Ontario Nature. 2015. Ontario Reptile and Amphibian Atlas. Online. Accessed: July 21, 2015. Available: <http://www.ontarioinsects.org/herpatlas/herp_online.html>

Ontario Geological Survey. "Map 2545 Bedrock geology of Ontario, explanatory notes and legend". Ontario. Queen's Printer. 1991. Print.

Ontario Ministry of Natural Resources and Forestry. "How Government Combats Invasive Species." Queen's Printer for Ontario. Online. Accessed: June 25, 2015. Available: <https://www.ontario.ca/environment-and-energy/species-risk-region?name=Thunder%20Bay >

Ontario Ministry of Natural Resources and Forestry. "Species at Risk in Thunder Bay Region." Queen's Printer for Ontario. Online. Accessed: June 25, 2015. Available: <https://www.ontario.ca/environment-and-energy/species-risk-region?name=Thunder%20Bay >

R. J. Burnside and Associates Limited, AMEC Earth and Environmental, and Lakehead Region Conservation Authority. "The Lakehead Region Conservation Authority Thunder Bay Area Aquifer Characterization Groundwater Management and Protection Study Final Report". July 2005. Print.

Sims, Richard A., William D. Towill, Kenneth A. Baldwin, and Gregory M. Wickware. "Field Guide to Forest Ecosystem Classification for Northwestern Ontario". Twin Offset Ltd., Ontario, Canada. 1997. Print.

The Lathem Group Inc. Consulting Engineers. "Mosquito Creek Hydrology Study". November 23, 1983. Print.

Toronto Entomologists' Association. Ontario Butterfly Atlas Online. Online. Accessed: July 21, 2015. Available: <http://www.ontarioinsects.org/atlas_online.htm>

United States Geographical Survey (USGS). Hem, John D. "Study and interpretation of the chemical characteristics of natural water". 3rd ed. U.S. Geological Survey Water-supply Paper 2254. Department of the Interior. United States Government Printing Office. 1985. Print.

211 Ontario North. "South Neebing Community Centre". Online. Accessed: February 2, 2016. Available: <http://search.211north.ca/record/TBY1425>

MAPS

LAKEHEAD REGION
CONSERVATION AUTHORITY

Mosquito Creek Watershed

M-1: Key Plan

N

Legend

- Mosquito Creek Watershed
- Municipal Boundary
- First Nations Land
- LRCA Jurisdiction Boundary
- Water Body

0 10 20 km

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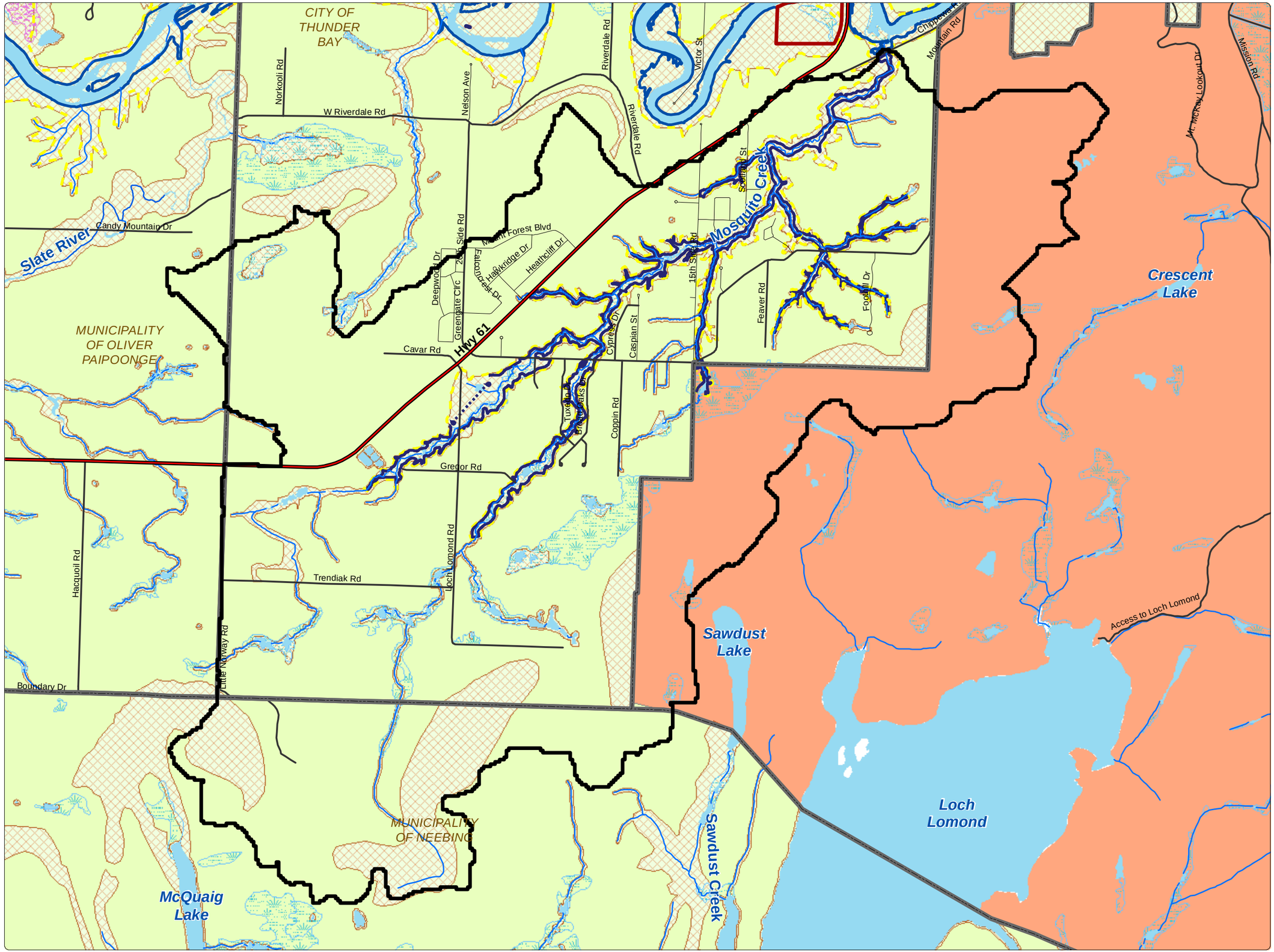

LAKEHEAD REGION CONSERVATION AUTHORITY

Mosquito Creek Watershed

M-2: Regulated Area

Legend

- Mosquito Creek Watershed
- Approximate Regulated Area
- LRCA Owned Lands
- Municipal Boundary
- First Nations Land
- LRCA Jurisdiction Boundary

Drainage

- Water Body
- Provincially Significant Wetland
- Wetland
- Stream
- River
- Ditch
- Regional Floodline
- 100 Year Floodline
- Identified Spillway
- Fill Line
- Interpolated Floodline
- End of Study Area

Roads

- Highway
- Road
- Street

0 500 1,000 1,500 m

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LAKEHEAD REGION CONSERVATION AUTHORITY

Mosquito Creek Watershed

M-3: Topography

N

Legend

- Mosquito Creek Watershed
- Highest Point in Watershed
- Municipal Boundary

Drainage

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

Contour Lines

- 10m Contour Intervals
- 50m Contour Intervals

Roads

- Highway
- Road
- Street

0 500 1,000 1,500 m

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LAKEHEAD REGION CONSERVATION AUTHORITY

Mosquito Creek Watershed

M-4: Bedrock Geology

N

Legend

- Mosquito Creek Watershed
- Municipal Boundary

Bedrock Formation

MESOPROTEROZOIC

- 31a, Mafic and related intrusive rocks

PALEOPROTEROZOIC

- 22a, Sedimentary rocks

Drainage

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

Roads

- Highway
- Road
- Street

0 500 1,000 1,500 m

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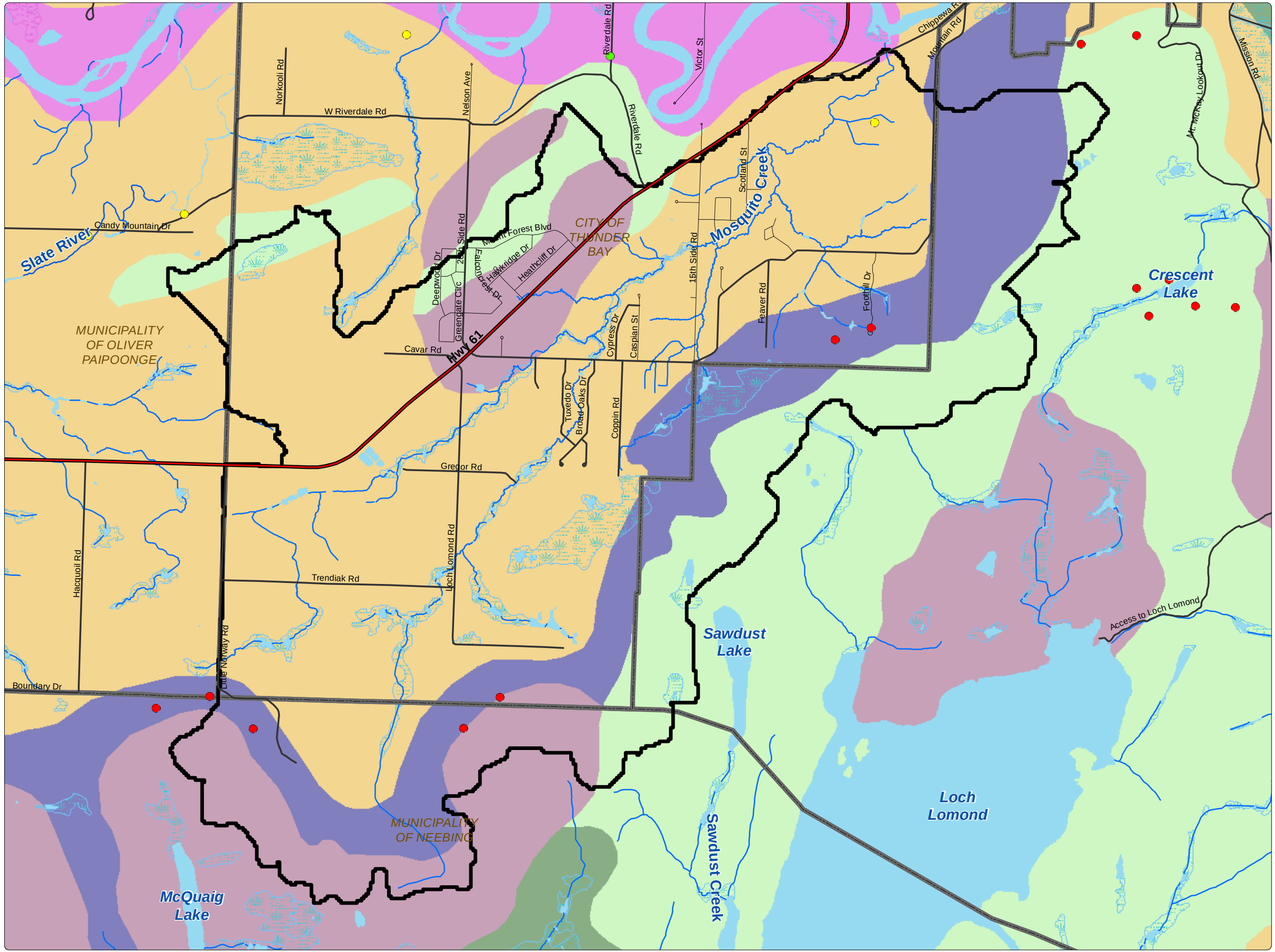
LAKEHEAD REGION CONSERVATION AUTHORITY

Mosquito Creek Watershed

M-5: Surficial Geology

N



Legend

- Mosquito Creek Watershed
- Municipal Boundary

Surficial Geology

- Alluvial
- Bedrock
- Esker/Kame/Outwash plain
- Glaciolacustrine plain
- Moraine
- Organics
- Slope/Talus pile

Surficial Points Features

- QUARRY/MINE WORKINGS
- SAND/GRAVEL PIT
- TALUS

Drainage

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

Roads

- Highway
- Road
- Street

0 500 1,000 1,500 m

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LAKEHEAD REGION CONSERVATION AUTHORITY

Mosquito Creek Watershed

M-6: Soils

N

Legend

- Mosquito Creek Watershed
- Municipal Boundary
- Soil Sampling Sites
- Soil/Water Sampling Sites
- NOEGTS Boreholes

Drainage

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

OMAFRA Soils

- Organic (O)
- Clay (c)
- Clay Loam (cl)
- Fine Sandy Loam (fsl)
- Gravel (g)
- Gravelly Sand (gs)
- Gravelly Sand Loam (gsl)
- Medium to Moderately Fine Loam (l)
- 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)

Roads

- Highway
- Road
- Street

0 500 1,000 1,500 m

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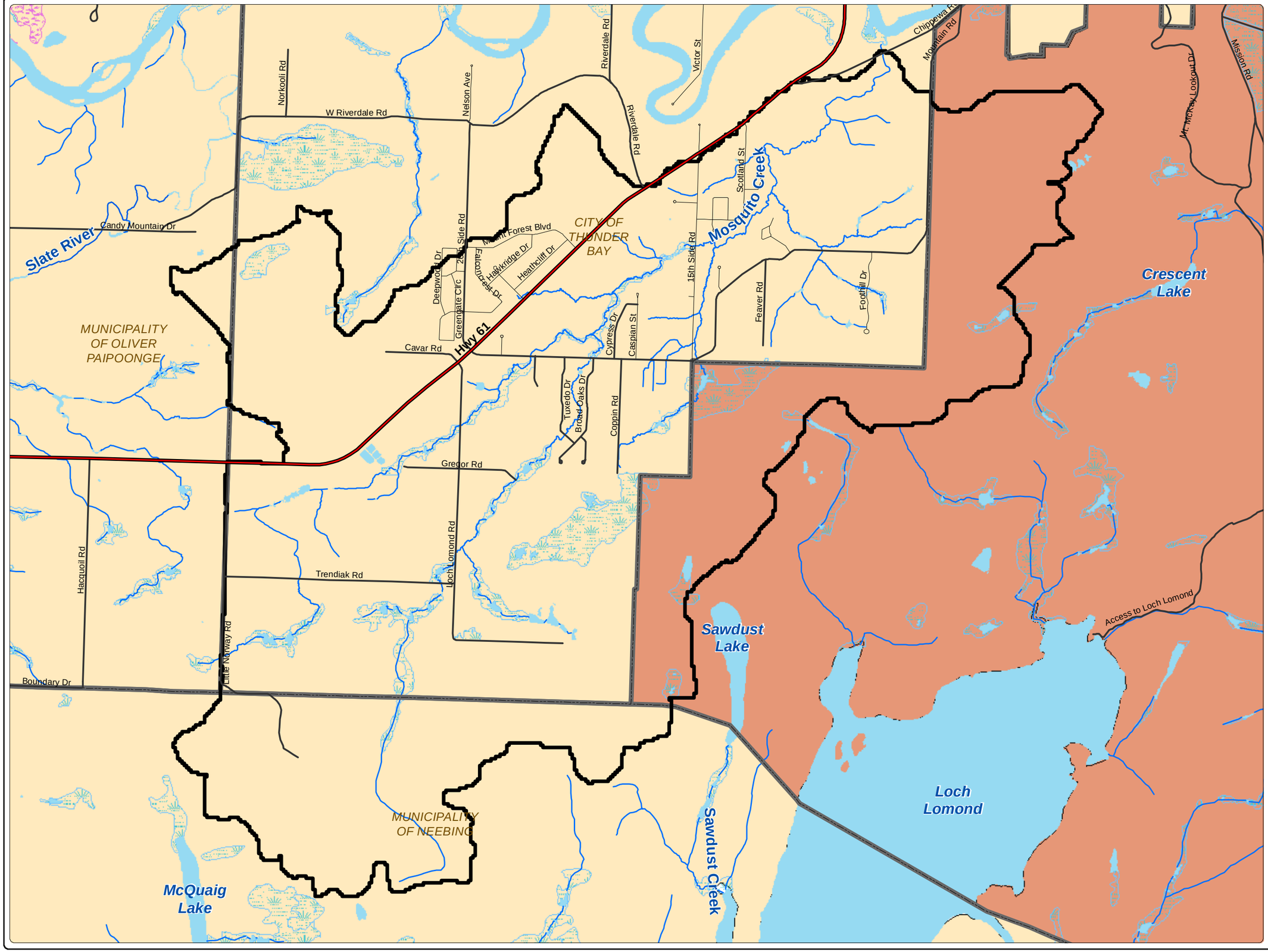
LAKEHEAD REGION CONSERVATION AUTHORITY

Mosquito Creek Watershed

M-7: Land Ownership

N



Legend

- Mosquito Creek Watershed
- Municipal Boundary

Land Ownership

- Federal Land Indian Reserve
- Private Land

Roads

- Highway
- Road
- Street

Drainage

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

0 500 1,000 1,500 m

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LAKEHEAD REGION CONSERVATION AUTHORITY

Mosquito Creek Watershed

M-8: Site Plan

N

Legend

- Mosquito Creek Watershed
- Township Boundary
- Sampling Sites
- First Nations Land

Drainage

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

Roads

- Highway
- Road
- Street

0 500 1,000 1,500 m

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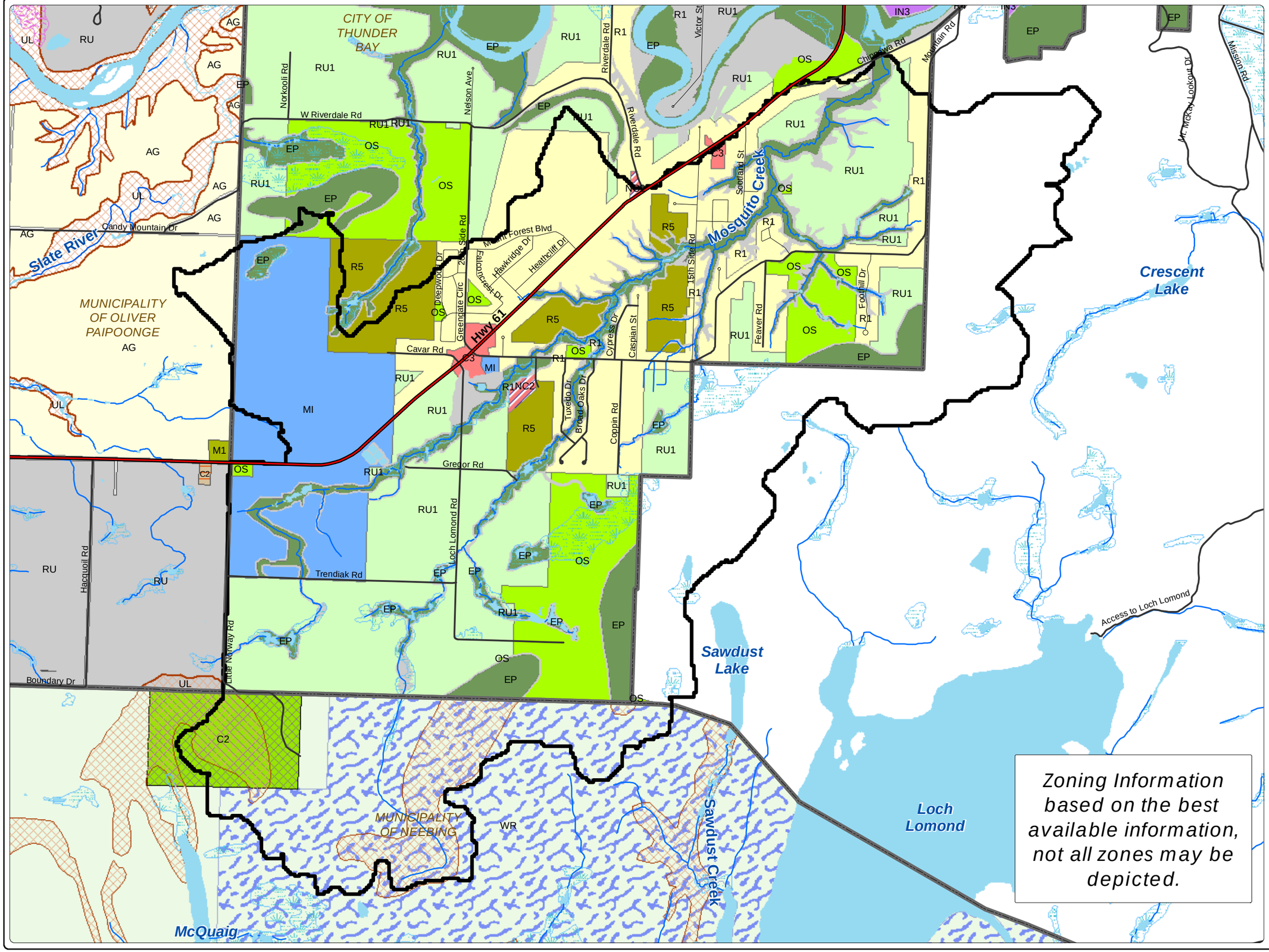

LAKEHEAD REGION CONSERVATION AUTHORITY

Mosquito Creek Watershed

M-9: Zoning

N

Legend

- Mosquito Creek Watershed
- Municipal Boundary

City of Thunder Bay Zoning

- C3 - Highway Commercial Zone
- EP - Environmental Protection Zone
- IN3 - Heavy Industrial Zone
- MI - Major Institutional Zone
- NC2 - Neighbourhood Centre Two Zone
- OS - Open Space Zone
- R1 - Residential Zone 1
- R5 - Residential Future Zone
- RU1 - Rural Area Zone

Municipality of Neebing Zoning

- C2 - Recreation Commercial Zone
- WR - Watershed Reserve Zone
- UL - Use Limitation Zone
- Rural Zone

Municipality of Oliver-Paipoonge Zoning

- AG - General Agriculture
- C2 - General Commercial
- M1 - Light Industrial
- RU - Rural
- UL - Use Limitation

Drainage

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

Roads

- Highway
- Road
- Street

0 500 1,000 1,500 m

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LAKEHEAD REGION CONSERVATION AUTHORITY

Mosquito Creek Watershed

M-10: Bridge & Culvert Sites

N

Legend

- Mosquito Creek Watershed
- Municipal Boundary
- Confluence
- Bridge
- Culvert

Drainage

- Water Body
- Wetland
- Stream
- River
- Ditch

Roads

- Highway
- Road
- Street

0 500 1,000 1,500 m

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Figures

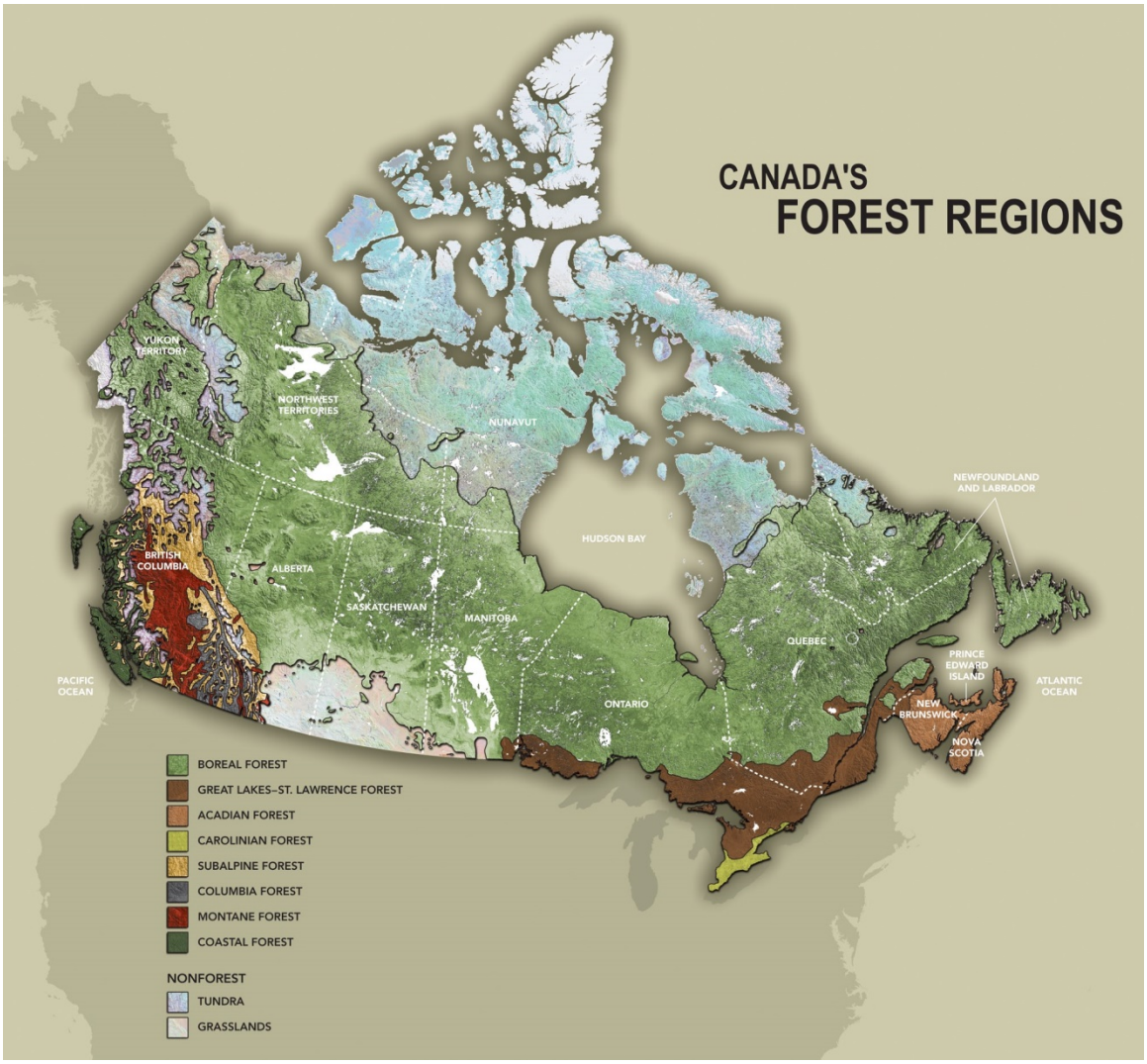


Figure 1: Canada's Forest Regions (Canadian Forest Service, 2013)

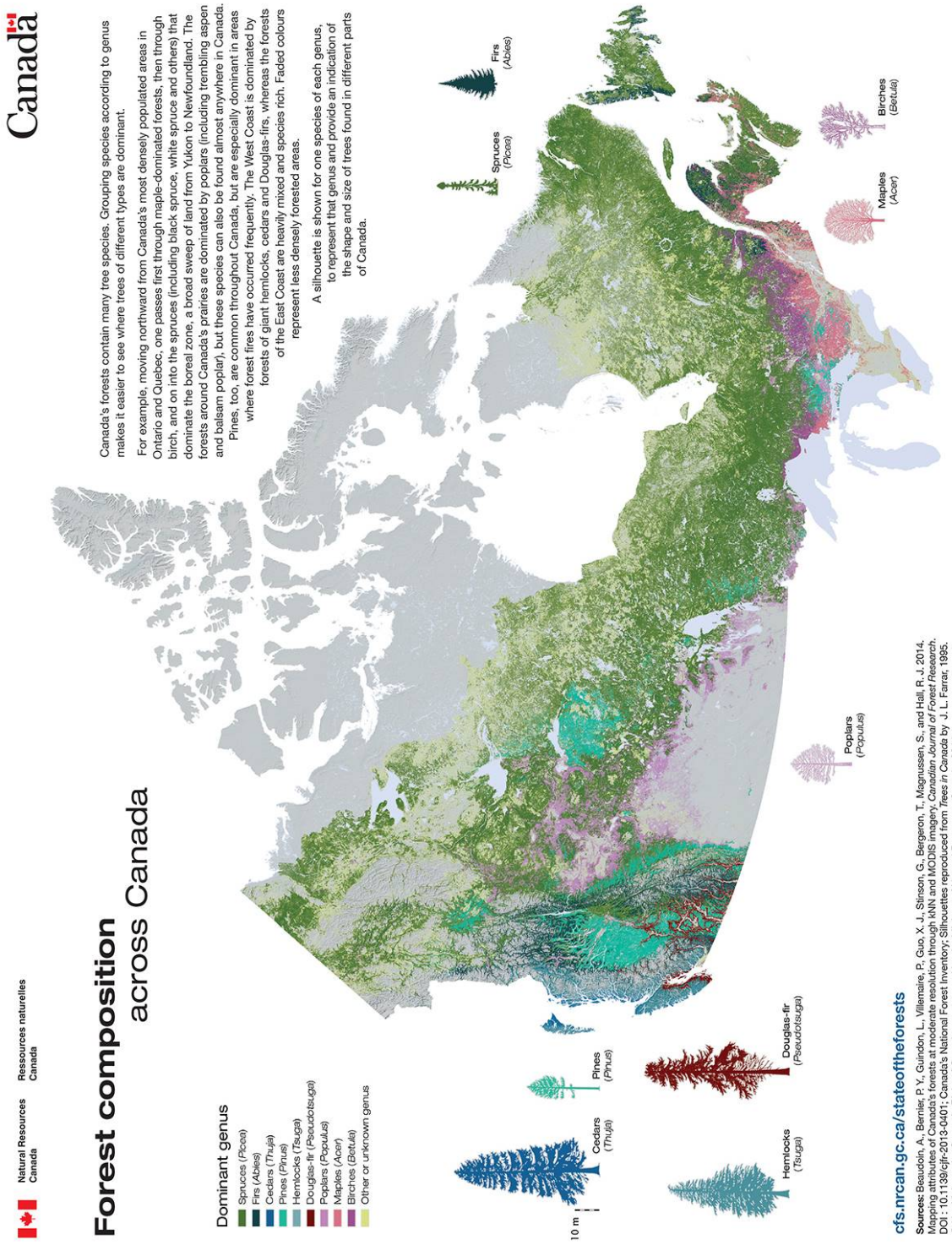
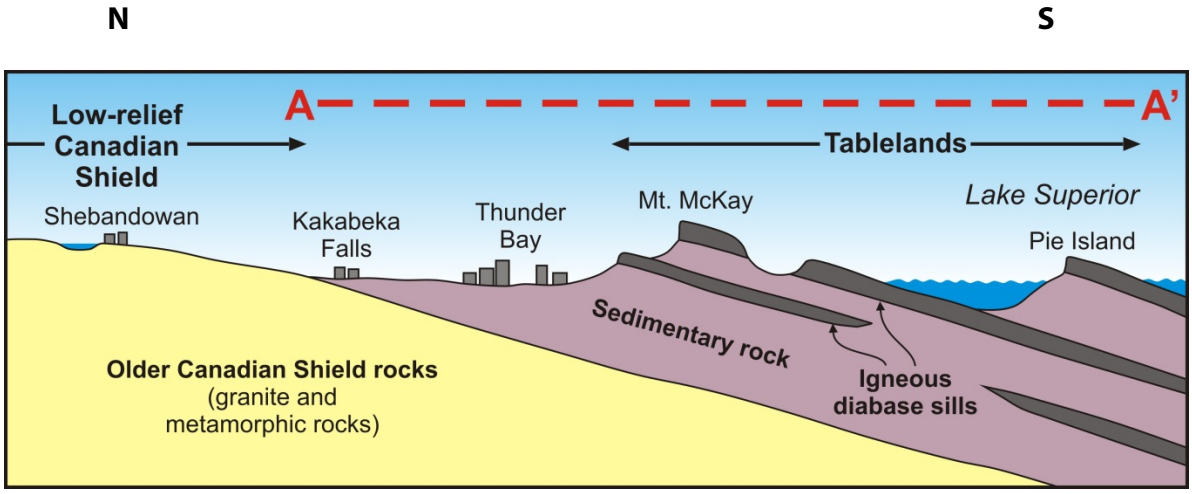


Figure 2: Forest Composition across Canada (Natural Resources Canada, 2014)



The Mosquito 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 3: Rock Formations South of Thunder Bay

Figure 4: Fort William Country Club

Figure 5: Nor'Wester View Public School

Figure 6: South Neebing Community Centre

Figure 7: Thunder Bay Tournament Centre

Figure 8: Loch Lomond Ski Area

Figure 9: Thunder Bay Correctional Centre

Figure 10: Thunder Bay Correctional Centre Lagoons

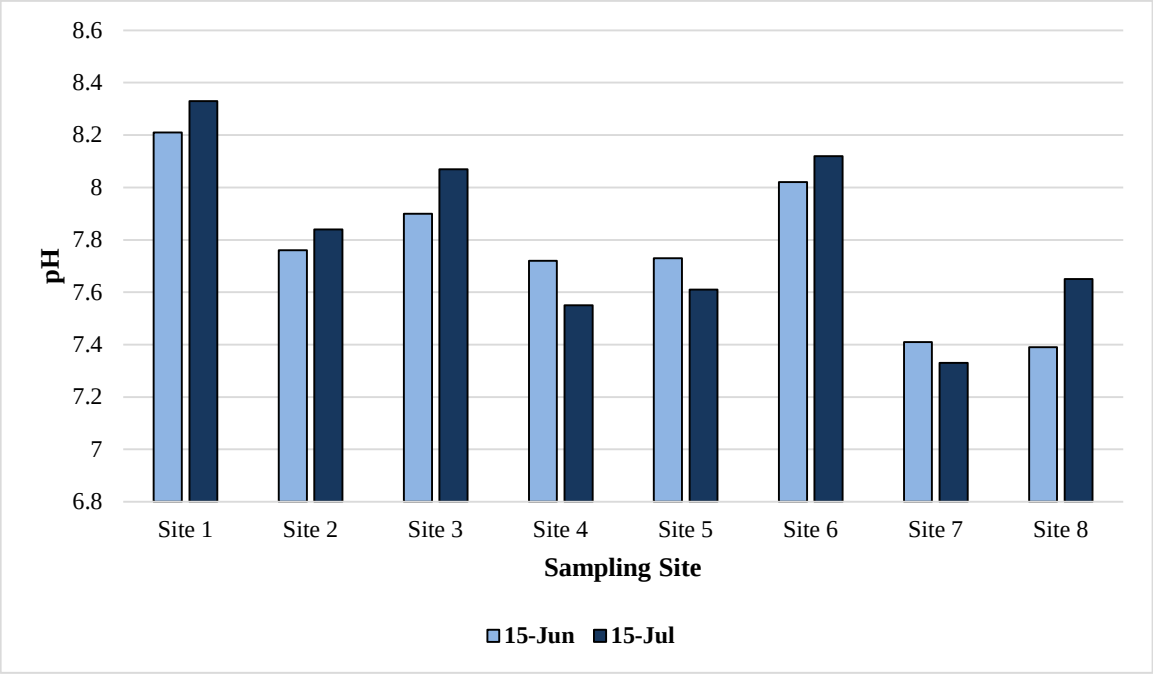


Figure 11: pH Level at Mosquito Creek Sample Sites

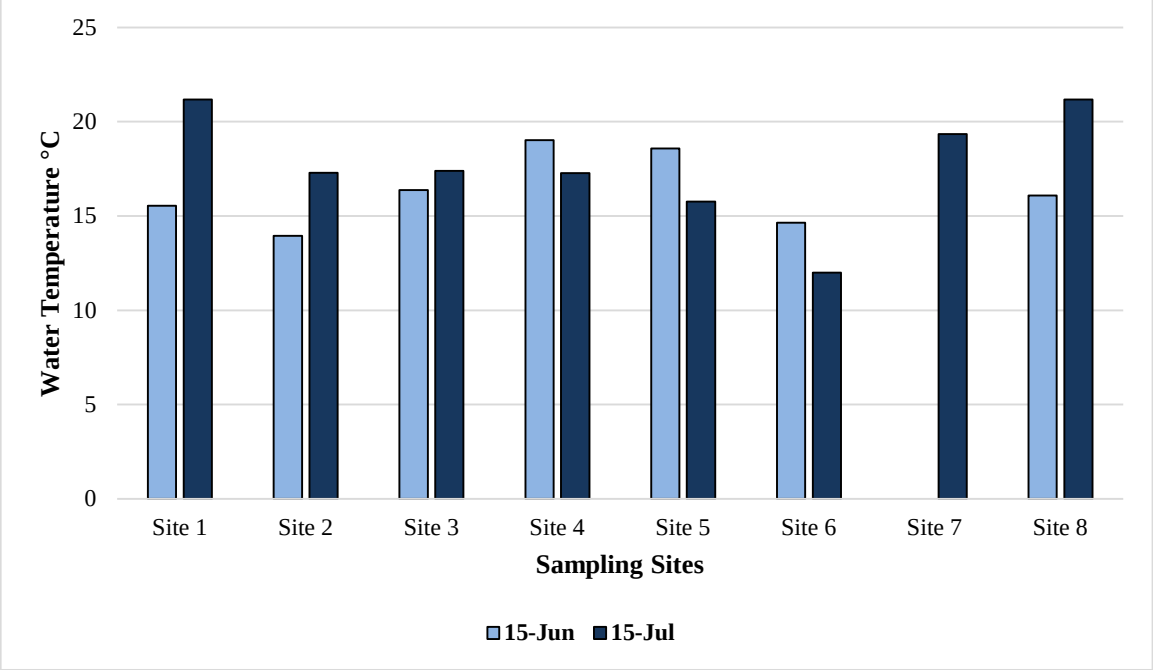


Figure 12: Water Temperature at Mosquito Creek Sample Sites

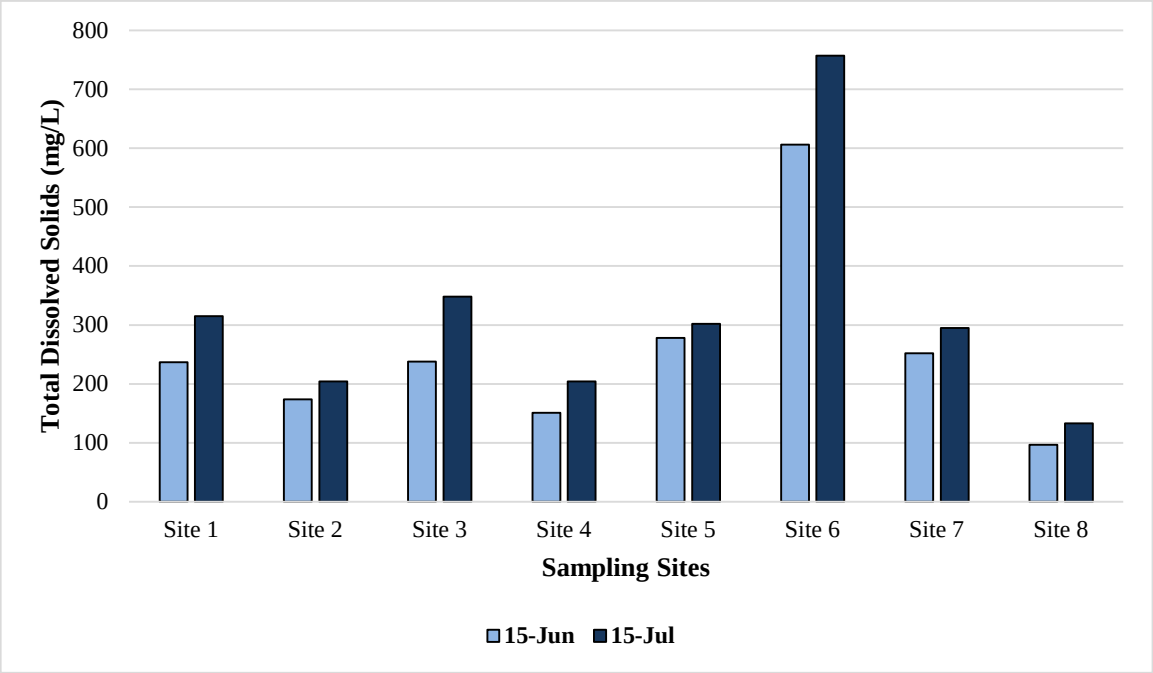


Figure 13: Total Dissolved Solids at Mosquito Creek Sample Sites

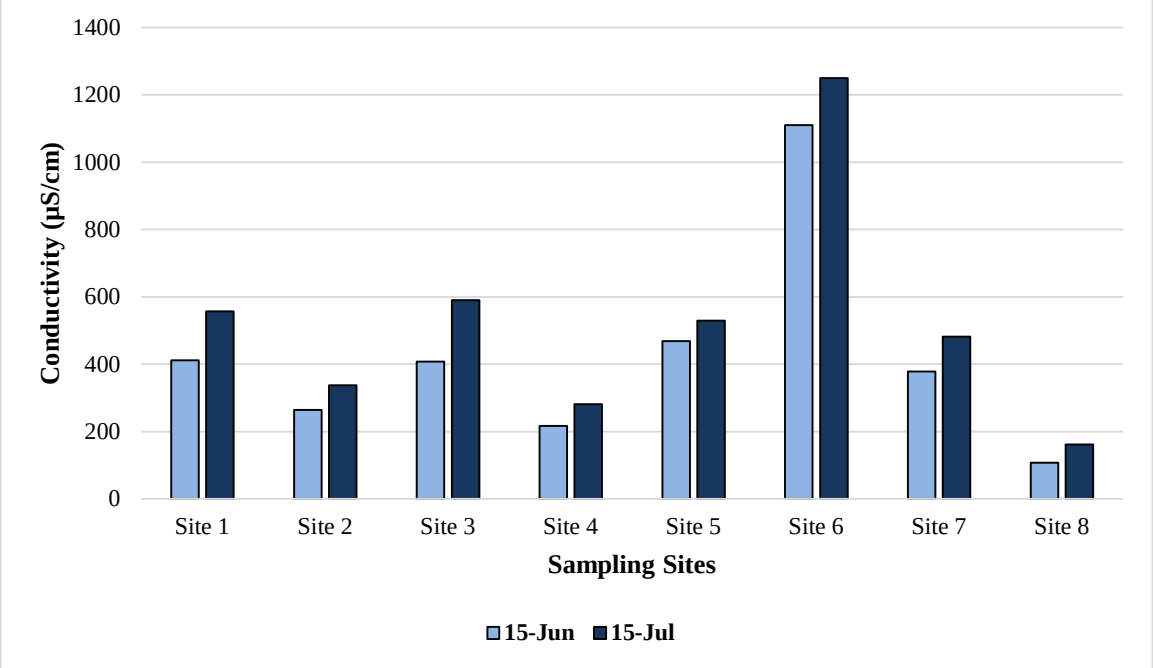


Figure 14: Conductivity at Mosquito Creek Sample Sites

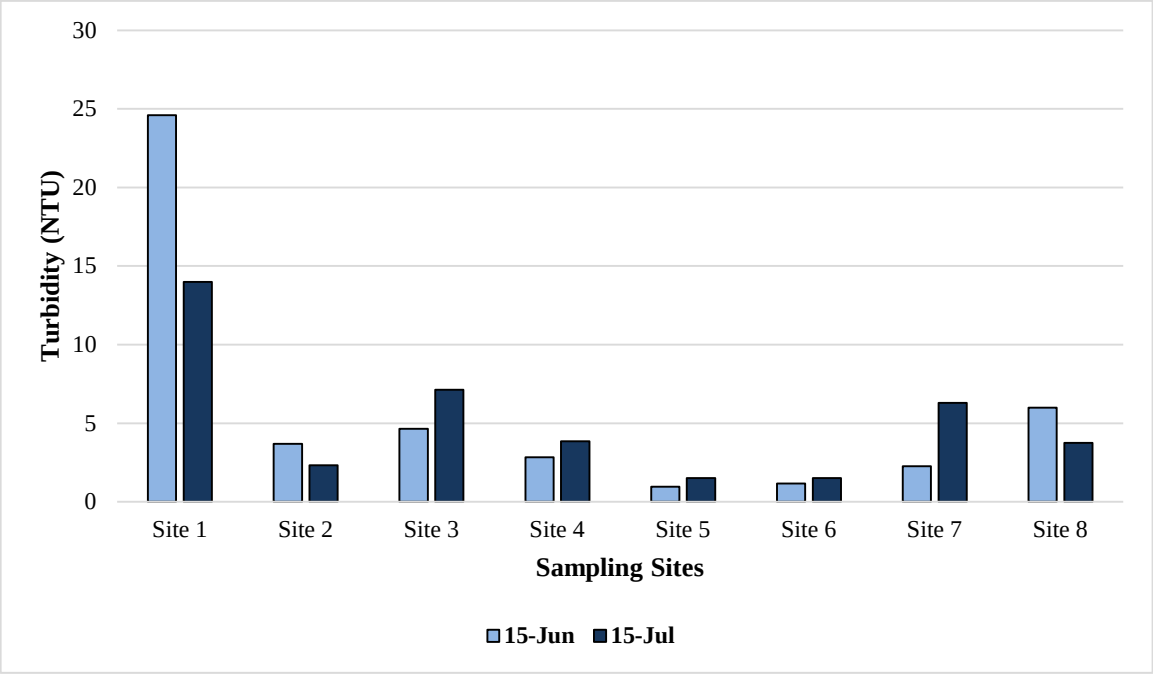


Figure 15: Turbidity at Mosquito Creek Sample Sites

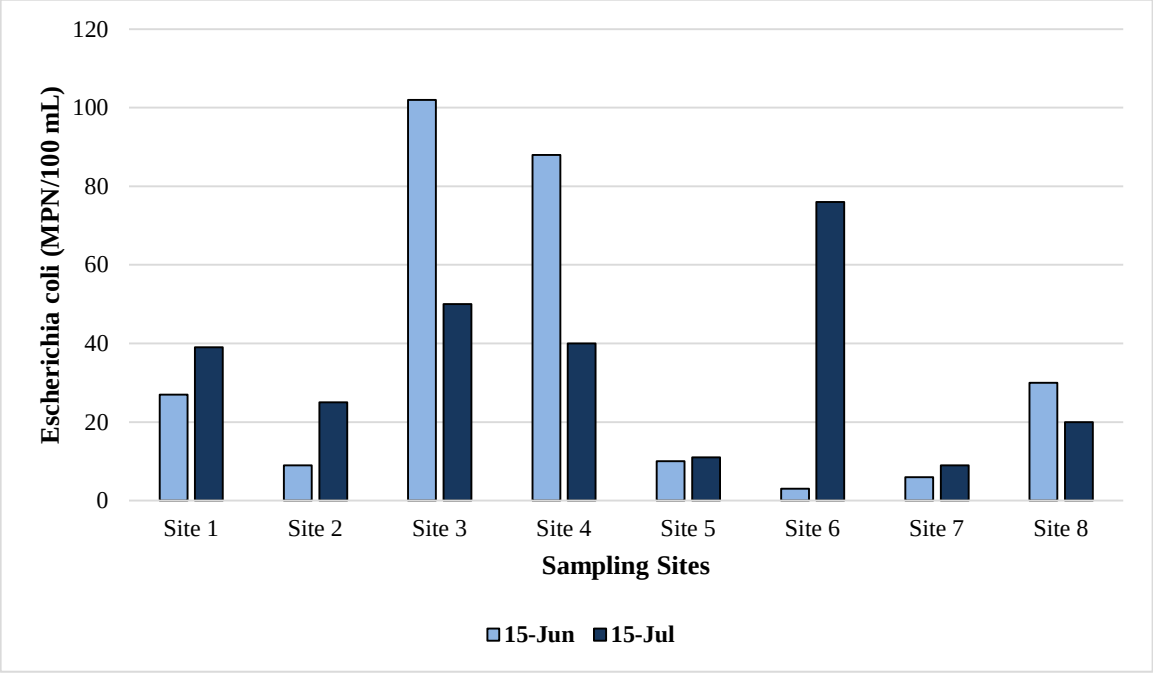


Figure 16: *Escherichia Coli* Bacteria Counts at Mosquito Creek Sample Sites

Figure 17: Animal Tracks

Appendix A:

Summary of Water Quality Parameters

Appendix A: 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 micro seimens 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 (NO_3) and nitrite (NO_2). 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 (NO_3-N mg/L), and Nitrite-nitrogen (NO_2-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 (PO_4) or orthophosphate ion (PO_4^{-3}) 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 mg/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 mg/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 mg/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 mg/L and if the $CaCO_3$ is <75 mg/L the maximum concentration of Beryllium is 11 mg/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 mg/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 mg/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 mg/L for Chromium (VI) and 8.9 mg/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 mg/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 mg/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 mg/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 $CaCO_3$ (mg/L). The maximum lead concentration is 25 mg/L.

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 mg/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 mg/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 mg/L.

Silicon
Silicon is the most abundant element on earth after oxygen. In drinking water only silicic acid is present, which is relatively safe. However, there are a number of silicon compounds that are carcinogenic. There are currently no PWQO guidelines for silicon.

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 mg/L.

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.

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 mg/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 mg/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 mg/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 mg/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 mg/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 mg/L.

Appendix B:
Water Quality Guidelines

Appendix B: 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):

Dissolved Oxygen Concentration				
Temperature	Cold Water Biota		Warm Water Biota	
°C	% Saturation	mg/L	% Saturation	mg/L
0	54	8	47	7
5	54	7	47	6
10	54	6	47	5
15	54	6	47	5
20	57	5	47	4
25	63	5	48	4

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).*

Turbidity:
Suspended matter should not be added to surface water in concentrations that will change the natural Secchi disc reading by more than **10 percent**.

Nutrients

Ammonia (un-ionized):
The amount of un-ionized ammonia should not exceed 20 µg/L.

The percentages of un-ionized ammonia (NH3) in aqueous ammonia solution for different temperature and pH conditions are listed in the table below. For example, at 20ºC and pH of 8.0, a total ammonia concentration of 500 µg/L would give an un-ionized ammonia concentration of 500 x 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:

$f = 1/(10^{pKa-pH} + 1)$, where ***f*** **is the fraction of NH3**

pKa = 0.09018 + 2729.92/T, where T = 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 NH3 in aqueous ammonia solutions for 0-30 °C and pH 6-10

Temp.	**pH**								
°C	**6.0**	**6.5**	**7.0**	**7.5**	**8.0**	**8.5**	**9.0**	**9.5**	**10.0**
0	.0083	.026	.083	.26	.82	2.6	7.6	21.	45.
1	.0090	.028	.090	.28	.89	2.8	8.3	22.	47.
2	.0098	.031	.098	.31	.97	3.0	8.9	24.	49.
3	.011	.034	.11	.34	1.1	3.3	9.6	25.	52.
4	.012	.036	.12	.36	1.1	3.5	10.	27.	54.
5	.013	.040	.13	.39	1.2	3.8	11.	28.	56.
6	.014	.043	.14	.43	1.3	4.1	12.	30.	58.
7	.015	.046	.15	.46	1.5	4.4	13.	32.	60.
8	.016	.050	.16	.50	1.6	4.8	14.	34.	61.
9	.017	.054	.17	.54	1.7	5.2	15.	35.	63.
10	.019	.059	.19	.59	1.8	5.6	16.	37.	65.

Temp.	pH								
°C	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
11	.020	.064	.20	.63	2.0	6.0	17.	39.	67.
12	.022	.069	.22	.68	2.1	6.4	18.	41.	69.
13	.024	.074	.24	.74	2.3	6.9	19.	43.	70.
14	.025	.080	.25	.80	2.5	7.4	20.	45.	72.
15	.027	.087	.27	.86	2.7	8.0	22.	46.	73.
16	.030	.093	.29	.93	2.9	8.5	23.	48.	75.
17	.032	.10	.32	1.0	3.1	9.1	24.	50.	76.
18	.034	.11	.34	1.1	3.3	9.8	26.	52.	77.
19	.037	.11	.37	1.2	3.6	11.	27.	54.	79.
20	.040	.13	.40	1.2	3.8	11.	28.	56.	80.
21	.043	.14	.43	1.3	4.1	12.	30.	58.	81.
22	.046	.15	.46	1.4	4.4	13.	32.	59.	82.
23	.049	.16	.49	1.5	4.7	14.	33.	61.	83.
24	.053	.17	.53	1.7	5.0	14.	35.	63.	84.
25	.057	.18	.57	1.8	5.4	15.	36.	64.	85.
26	.061	.19	.61	1.9	5.8	16.	38.	66.	86.
27	.065	.21	.65	2.0	6.2	17.	40.	67.	87.
28	.070	.22	.70	2.2	6.6	18.	41.	69.	88.
29	.075	.24	.75	2.3	7.0	19.	43.	70.	88.
30	.081	.25	.80	2.5	7.5	20.	45.	72.	89.

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.

Nitrate:
The amount of nitrate in freshwater should not exceed 13,000 µg NO_3/L to avoid long term effects and should not exceed 550,000 µg NO_3/L to avoid short term effects. These guidelines are only for protection from direct toxic effects, the guidelines do not consider indirect effects due to eutrophication.

Nitrite:
The amount of nitrite in freshwater should not exceed 60µg NO_2-N/L (197 NO_2/L). These guidelines are for protection from direct toxic effects, the guidelines do not consider indirect effects due to eutrophication.

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:

PH values	Interim PWQO (µg/L)
4.5 to 5.5	15
>5.5 to 6.5	No more than 10 % of natural background
> 6.5 to 9.0	75

Antimony:
The amount of Antimony should not exceed 20 mg/L.

Arsenic:
The amount of Arsenic should not exceed 5 mg/L.

Barium:
There are currently no PWQO guidelines for Barium.

Beryllium:
Beryllium amounts should not exceed the following:

Hardness as CaCO3 (mg/L)	Interim PWQO (µg/L)
< 75	11
>75	1100

Bismuth:
There are currently no PWQO guidelines for Bismuth.

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

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

Hardness as CaCO3 (mg/L)	Interim PWQO (µg/L)
0 – 100	0.1
>100	0.5

Calcium:
There are currently no PWQO guidelines for Calcium.

Chromium:
Chromium amounts should not exceed the following:

	Interim PWQO (µg/L)
Hexavalent Chromium (Cr VI)	1
Trivalent Chromium (Cr III)	8.9

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

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

Hardness as CaCO3 (mg/L)	**Interim PWQO (µg/L)**
0-20	1
>20	5

Iron:
The amount of Iron should not exceed 300µg/L.

Lead:
Lead amounts should not exceed the following:

Hardness as CaCO3 (mg/L)	**Interim PWQO (µg/L)**
< 30	1
30 to 80	3
> 80	5

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 mg/L.

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

Potassium:
There are currently no PWQO guidelines for Potassium.

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

Silicon:
There are currently no PWQO guidelines for Silicon.

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

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

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

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

Zirconium:
The amount of Zirconium should not exceed 4 mg/L.

The following are taken from the Canadian Council of Resource and Environment Ministers (CCREM) Canadian water quality guidelines for the protection of aquatic life: Summary table, September 2007.

The information in these guidelines and supporting text is used to complement the Provincial Water Quality Objectives and Interim Objectives:

Nitrate:
The amount of nitrate in freshwater should not exceed 2900 µg NO_3-N/ L.
For protection from direct toxic effects: the guidelines do not consider indirect effects due to eutrophication.

Nitrite:
The amount of nitrite in freshwater should not exceed 60 µg NO_2-N/L.
For protection from direct toxic effects: the guidelines do not consider indirect effects due to eutrophication.

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 600 QS. 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 600 QS 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*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 2005 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 600 QS 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 in the laboratory as well as in the field. A LaMotte 2020we Turbidity meter was used for field measurements. The sample collection bottle was filled at each site. The vial provided in the kit was used for a “no-blank” turbidity scan.

Water Temperature
Water temperature was measured with the YSI 600 QS. 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	Description
Boulder	> 25.6 cm in diameter
Cobbles	6.4 - 25.6 cm in diameter
Gravel	0.2 – 6.4 cm in diameter
Sand	< 0.2 cm in diameter
Silt	Finer inorganic material than sand
Muck	Mainly organic combination of silt and clay
Clay	Inorganic origin with no apparent structure

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:

Description	% Cover
Dense	75-100% shaded by canopy
Partly Open	25-75% shaded by canopy
Open	0-25% shaded by canopy

Appendix D:

Common and Scientific Names of Identified Flora and Fauna

Appendix D: Common and Scientific Names of Identified Flora and Fauna

Flora	
Common Name	**Scientific (Latin) Name**
Trees	
Balsam Fir	*Abies balsamea*
Balsam Poplar	*Populus balsamifera*
Black Ash	*Fraxinus nigra*
Black Spruce	*Picea mariana*
Green Ash	*Fraxinus pennsylvanica*
Jack Pine	*Pinus banksiana*
Red Pine	*Pinus resinosa*
Tamarack	*Larix laricina*
Trembling Aspen	*Populus tremuloides*
White Birch	*Betula papyrifera*
White Pine	*Pinus strobus*
White Spruce	*Picea glauca*
Shrubs	
Alder	*Alnus spp.*
Beaked Hazel	*Corylus cornuta*
Chokecherry	*Prunus virginiana*
Green Alder	*Alnus viridis*
Pincherry	*Prunus pensylvanica*
Saskatoon (serviceberry)	*Amelanchier alnifolia*
Showy Mountain-Ash	*Sorbus americana*
Slender Willow	*Salix petiolaris*
Willow	*Salix spp.*
Herbs	
Canada Goldenrod	*Solidago canadensis*
Coltsfoot	*Tussilago farfara*
Swamp Thistle	*Cirsium sp.*
Corn Sow-Thistle	*Sonchus arvensis*
Cow Vetch	*Vivia cracca*
Dandelion	*Taraxacum officinale*
Lupines	*Lupinus albus*
Orange Jewelweed	*Impatiens capensis*
Ox-Eye Daisy	*Leucanthemum vulgare*
Red Clover	*Trifolium pratense*
Rhubarb	*Rheum rhabarbarum*
Rough-Stemmed Goldenrod	*Solidago rugosa*
Square-Stemmed Monkeyflower	*Mimulus ringens*

Tall Buttercup	*Ranunculus acris*
Wood Lily	*Lilium sp.*
Water Parsnip	*Sium suave*
White Clover	*Trifolium repens*
Yarrow	*Achillea millefolium*
Yellow Hawkweed	*Hieracium pratense*
Ferns/Mosses/Graminoids/Lichens	
Canada Blue Joint	*Calamagrostis canadensis*
Common Reed	*Phragmites australis*
Dark-Green Bulrush	*Scirpus atrovirens*
Fringed Brome Grass	*Bromus ciliatus*
Horsetail - Field	*Equisetum arvense*
Horsetail - Meadow	*Equisetum pratense*
Horsetail - Swamp	*Equisetum fluviatile*
Lady Fern	*Athyrium filix-femina*
Sedge	*Carex spp.*
Sphagnum Moss	*Sphagnum spp.*
Aquatic Plants	
Broad-Leaved Arrowhead	*Sagittaria latifolia*
Common Cattail	*Typha latifolia*
Small Yellow Water Crowfoot	*Ranunculus gmelinii*
Waterlily	*Nymphaeaceae* spp.

Fauna	
Common Name	**Scientific (Latin) Name**
Reptiles and Amphibians	
Common Garter Snake	*Thamnophis sirtalis*
Common Frog	*Rana temporaria*
Fish	
Minnow	*Cyprinidae* spp.
Invertebrates	
Common Black Ant	*Lasius niger*
Black Fly	*Simuliidae spp.*
Bumblebee	*Bombus spp.*
Butterfly	*Rhopalocera* spp.
Cricket	*Gryllidae* spp.
Dragonfly	*Anisoptera* spp.
Eastern Tiger Swallowtail	*Papilio glaucus*
Grasshopper	*Caelifera* spp.
Ladybug	*Coccinellidae* sp.
Midge	*Pseudochironomus spp.*

Mosquito	*Culicidae spp.*
Red Ant	*Solenopsis spp.*
Spring Azure	*Celastrina ladon*
Water Spider	*Papilio glaucus*
Water Strider	*Gerridae spp.*
White Admiral	*Limenitis camilla*
Aves	
Belted Kingfisher	*Megaceryle alcyon*
Canada Goose	*Branta canadensis*
Peregrine Falcon	*Falco peregrinus*
Mammals	
Bear	*Ursidae spp.*
Eastern Gray Squirrel	*Sciurus carolinensis*
Grey Wolf	*Canis lupus*
North-American Beaver	*Castor canadensis*
Raccoon	*Procyon lotor*
White-Tailed Deer	*Odocoileus virginianus*

Appendix E: Common and Scientific Names of Mosquito Creek Post Development Study Identified Flora and Fauna

Appendix E: Common and Scientific Names of Mosquito Creek Post Development Study Identified Flora and Fauna

Source: Fenco MacLaren Inc., 1996

Flora	
Common Name	**Scientific (Latin) Name**
Trees	
Aspen	*Populus* sp.
Balsam Fir	*Abies balsamea*
Black Ash	*Fraxinus nigra*
Black Spruce	*Picea mariana*
Cedar	*Thuja* sp.
Elm	*Ulmus* sp.
Jack Pine	*Pinus banksiana*
Larch	*Larix laricina*
Manitoba Maple	*Acer negundo*
Poplar	*Populus* sp.
Red Maple	*Acer rubrum*
Silver Maple	*Acer saccharinum*
White Birch	*Betula papyrifera*
White Spruce	*Picea glauca*
Shrubs	
Beaked Hazel	*Corylus cornuta*
Bulrush	*Scirpus* spp.
Choke Cherry	*Prunus virginiana*
Red-Osier Dogwood	*Cornus stolonifera*
Willow	*Salix* spp.
Herbs	
Canada Blue Joint	*Calamagrostis canadensis*
Eastern Skunk Cabbage	*Symplocarpus foetidus*
Fireweed	*Epilobium angustifolium*
Scouring Rush	*Equisetum hyemale*
Water Parsnip	*Sium suave*
White Sweet Clover	*Melilotus alba*
Ferns/Mosses/Graminoids/Lichens	
Sedges	*Cyperaceae* spp.
Aquatic Plants	
Common Cattail	*Typha latifolia*
Duckweed	*Lemna* sp.
Pondweed	*Potamogeton* sp.
Reed Canary Grass	*Phalaris arundinacea*

Fauna	
Common Name	**Scientific (Latin) Name**
Reptiles and Amphibians	
Leopard Frog	*Rana* sp.
Fish	
Brook Stickleback	*Culaea Inconstans*
Common Shiner	*Notropis cornutus*
Creek Chub	*Semotilus atromaculatus*
Cyprinid	*Cyprinidae* sp.
Darter	*Percidae* sp.
Fathead Minnow	*Pimephales promelas*
Finescale Dace	*Phoxinus neogaeus*
Freshwater Smelt	*Osmeridae* sp.
Johnny Darter	*Etheostoma nigrum*
Lake Chub	*Couesius plumbeus*
Longnose Dace	*Rhinichthys cataractae*
Minnow	*Cyprinidae* sp.
Mottled Sculpin	*Cottus bairdi*
Mudpuppy	*Necturus* sp.
Northern Redbelly Dace	*Phoxinus eos*
Pearl Dace	*Semotilus margarita*
Rock Bass	*Ambloplites rupestris*
Sculpin	*Cottoidea* sp.
Shorthead Redhorse	*Moxostoma macrolepidotum*
Smallmouth Bass	*Micropterus dolomieu*
Sturgeon	*Acipenseridae* sp.
Trout-Perch	*Percopsis omiscomaycus*
Walleye	*Sander vitreus*
White Sucker	*Catostomus commersonii*
Invertebrates	
Caddisfly	*Trichoptera* sp.
Crayfish	*Decapoda* sp.
Freshwater Leech	*Macrobdella decora*
Freshwater Shrimp	*Amphipoda* sp.
Freshwater Worm	*Oligochaeta* sp.
Giant Crane Fly	*Tipula* sp.
Midge/Chironomid	*Chironomidae* sp.
Mollusks	*Mollusca* sp.
Net-Spinning Caddisfly	*Hydropsyche* sp.
Stonefly	*Plecoptera* sp.
Water Strider	*Gerridae* sp.

Aves	
Canada Goose	*Branta canadensis*
Duck	*Anatidae* sp.
Great Blue Heron	*Ardea herodias*
Mammals	
American Mink	*Neovison vison*
Bear	*Ursus* sp.
Cougar	*Puma concolor*
Moose	*Alces alces*
North American Beaver	*Castor canadensis*
Red Fox	*Vulpes vulpes*
Striped Skunk	*Mephitis mephitis*
White Tailed Deer	*Odocoileus virginianus*

Appendix F:

Forest Ecosystem Classification

Appendix F: Forest Ecosystem Classification

Site 2: V24 White Spruce – Balsam Fir / Shrub Rich

Description: A conifer type with white spruce and/or balsam fir as the main canopy species. The understory tends to be shrub rich with balsam fir, *Acer spicatum*, *Corylus cornuta* and, on the wetter sites, *Alnus rugosa* potentially abundant. The herb layer varies from rich to poor. Occurring on deep, fresh to moist, mineral soils across a range of texture classes.

Common Overstory Species (in descending order):
Picea glauca, Abies balsamea, Picea mariana, Pinus banksiana, Betula papyrifera

Common Understory Species:

Shrubs:	*Abies balsamea, Rubus pubescens, Amelanchier spp., Sorbus decora, Acer spicatum, Corylus cornuta, Diervilla lonicera, Linnaea borealis, Rosa acicularis*
Herbs:	*Clintonia borealis, Aralia nudicaulis, Cornus canadensis, Galium triflorum, Maianthemum canadense, Streptopus roseus, Aster macrophyllus, Trientalis borealis, Mitella nuda, Anemone quinquefolia, Viola renifolia, Petasites palmatus, Fragaria virginiana*
Mosses:	*Pleurozium schreberi, Ptilium crista-castrensis, Rhytidiadelphus triquetrus, Dicranum polysetum*

Forest Floor Cover:

Cover Type	Broadleaf Litter	Moss	Conifer Litter	Wood
Forest Floor Cover (%)	23	32	34	7

Site 3 and Site 6: 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 3

Site 6

Common Overstory Species (in descending order):
Picea glauca, Abies balsamea, Populus tremuloides, Betula papyrifera, Picea mariana, Populus balsamifera, Acer rubrum, Pinus banksiana

Common Understory Species:

Shrubs:	*Abies balsamea, Acer spicatum, Rubus pubescens, Corylus cornuta, Sorbus decora, Linnaea borealis, Diervilla lonicera, Rosa acicularis, Amelanchier* spp., *Populus tremuloides*
Herbs:	*Aralia nudicaulis, Cornus canadensis, Clintonia borealis, Maianthemum canadense, Streptopus roseus, Trientalis borealis, Galium triflorum, Aster macrophyllus, Mitella nuda, Viola renifolia, Anemone quinquefolia, Petasites palmatus*
Mosses:	*Pleurozium schreberi, Ptilium crista-castrensis, Rhytidiadelphus triquetrus, Plagiomnium, cuspidatum*

Forest Floor Cover:

Cover Type	Broadleaf Litter	Moss	Conifer Litter	Wood
Forest Floor Cover (%)	61	16	13	5

Site 1, Site 4, Site 5 and Site 7: 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.

Site 1

Site 4

Site 5

Site 7

Common Overstory Species (in descending order):
Abies balsamea, Populus tremuloides, Betula papyrifera, Picea glauca, Picea mariana, Pinus banksiana, Populus balsamifera, Thuja occidentalis

Common Understory Species:

Shrubs:	*Abies balsamea, Acer spicatum, Rubus pubescens, Linnaea borealis, Diervilla lonicera, Sorbus decora, Populus tremuloides, Corylus cornuta, Amelanchier* spp., *Rosa acicularis*
Herbs:	*Maianthemum canadense, Aralia nudicaulis, Clintonia borealis, Streptopus roseus, Cornus canadensis, Trientalis borealis, Viola renifolia, Mitella nuda, Aster macrophyllus, Galium triflorum, Coptis trifolia, Petasites palmatus*
Mosses:	*Pleurozium schreberi, Ptilium crista-castrensis, Hylocomium splendens, Plagiomnium cuspidatum*

Forest Floor Cover:

Species	Broadleaf Litter	Moss	Conifer Litter	Wood
Forest Floor Cover (%)	66	12	14	6

Site 8: V17 Jack Pine Mixedwood/Shrub Rich

Description: Jack Pine mixedwoods with spruce and fir occasional in the canopy. The understory is typically rich in herb and low shrub species, often with abundances of *Diervilla lonicera, Aralia nudicaulis, Aster macrophyllus* and *Cornus canadensis*. Occuring on upland, fresh to dry, coarse-textured mineral soils.

Common Overstory Species (in descending order):
Pinus banksiana, Populus tremuloides, Betula papyrifera, Picea mariana, Abies balsamea, Picea glauca

Common Understory Species:

Shrubs:	*Diervilla lonicera, Linnaea borealis, Abies balsamea, Vaccinium angustifolium, Corylus cornuta, Vaccinium myrtilloides, Populus tremuloides, Rubus pubescens, Amelanchier* spp., *Alnus crispa, Picea mariana, Rosa acicularis*
Herbs:	*Aralia nudicaulis, Maianthemum canadense, Clintonia borealis, Cornus canadensis, Aster macrophyllus, Trientalis borealis, Streptopus roseus, Viola* spp.
Mosses:	*Pleurozium schreberi, Dicranum polysetum, Ptilium crista-castrensis*

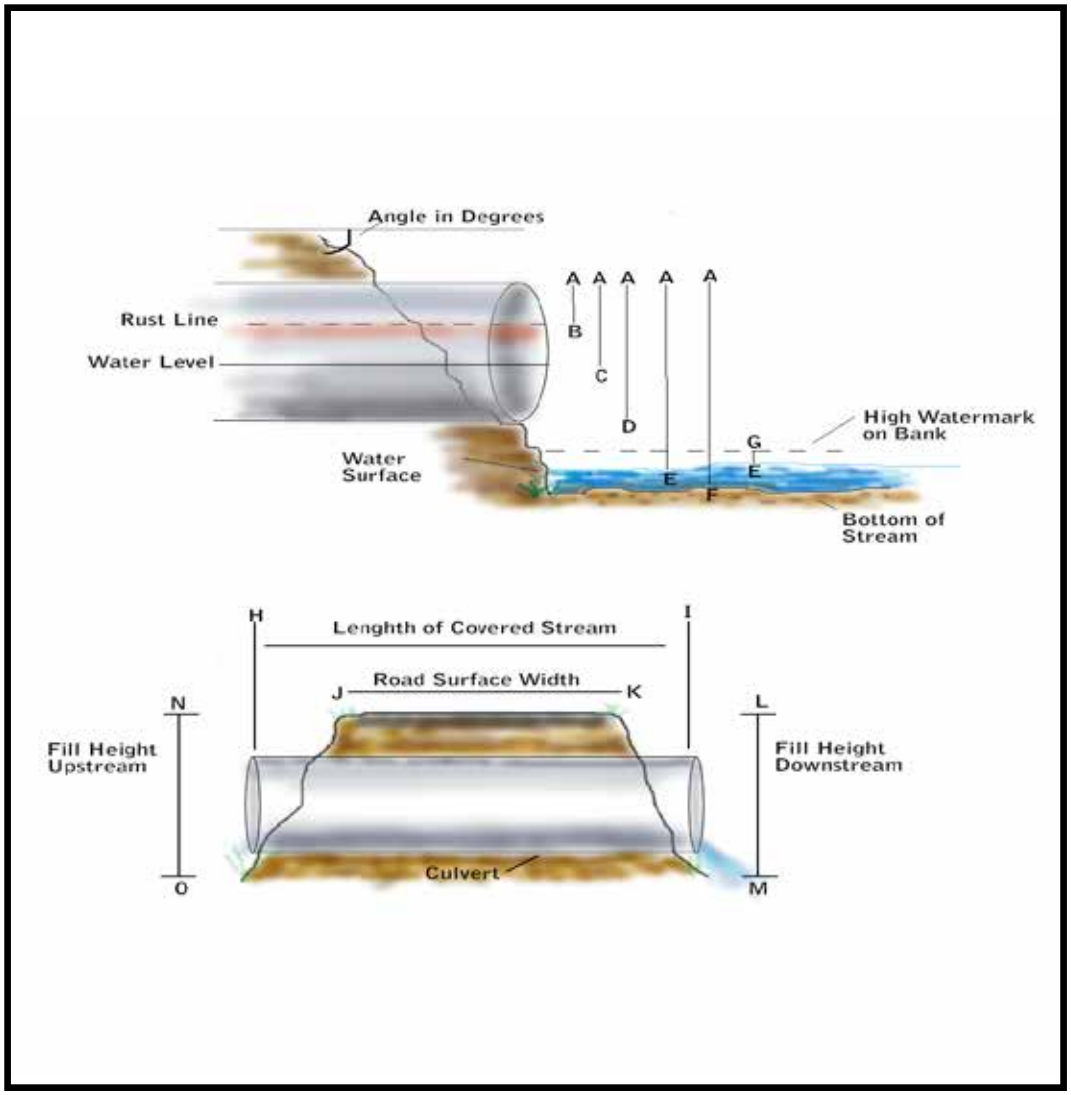
Forest Floor Cover:

Species	Broadleaf Litter	Moss	Conifer Litter	Wood
Forest Floor Cover (%)	36	27	32	0

Appendix G:

Culvert Assessments

Appendix G: Culvert Assessments



Mosquito Creek 2015 Culvert Assessments

Culvert Number/ Site Number	**J-K** Road Surface Width (m)	**H-I** Length of Covered Stream (m)	**N-O** Fill Height Upstream (m)	**L-M** Fill Height Downstream (m)		**A-D** Width of Opening (m)	**A-B** Inside Top to Rust Line (m)	**A-C** Inside Top to Water Surface (m)	**A-E** Height Above Outlet Pool (m)	**E-G** Water Surface to High Water Mark (m)	**A-F** Inside Top to Bottom of Stream (m)
C1/Site 2											
Culvert A (East)	8.60	41.50	4.60	4.60	Upstream	1.20	0.40	0.85	0.85	0.40	1.10
					Downstream	1.20	0.45	1.0	1.40	0.60	1.73
Culvert B (West)	8.60	41.50	4.60	4.60	Upstream	1.20	N/A	0.90	0.90	0.50	1.0
					Downstream	1.20	0.60	N/A	1.35	0.50	1.32
C2/Site 3											
Culvert A	9.60	23.0	6.20	5.90	Upstream	3.60	2.40	3.50	3.50	0.20	3.80
					Downstream	3.55	2.60	3.55	4.30	0.15	4.60
C3/Site 4											
Culvert A (North)	8.40	18.50	1.90	2.50	Upstream	1.60	0.60	1.25	1.25	0.15	1.74
					Downstream	1.50	0.60	1.10	1.10	0.50	1.75
Culvert B (South)	8.40	18.50	1.90	2.50	Upstream	1.60	0.50	1.35	1.35	0.15	1.90
					Downstream	1.50	0.40	1.0	1.0	0.25	1.75
C4/Site 5											
Culvert A (East)	8.35	18.4	2.10	1.80	Upstream	1.50	0.60	1.0	1.0	0.25	1.85
					Downstream	1.50	0.90	1.10	1.10	0.15	1.60
Culvert B (West)	8.35	18.4	2.10	1.80	Upstream	1.50	0.70	1.10	1.10	0.25	1.85
					Downstream	1.50	0.80	1.17	1.17	0.35	1.65

Culvert Number/ Site Number	**J-K** Road Surface Width (m)	**H-I** Length of Covered Stream (m)	**N-O** Fill Height Upstream (m)	**L-M** Fill Height Downstream (m)		**A-D** Width of Opening (m)	**A-B** Inside Top to Rust Line (m)	**A-C** Inside Top to Water Surface (m)	**A-E** Height Above Outlet Pool (m)	**E-G** Water Surface to High Water Mark (m)	**A-F** Inside Top to Bottom of Stream (m)
C5/Site 6											
Culvert A	16.34	31.64	2.95	3.20	Upstream	2.20	1.60	1.93	1.93	0.30	2.18
					Downstream	2.20	1.25	1.65	1.65	0.25	1.67
C6/Site 7											
Culvert A	7.40	16.30	1.80	1.80	Upstream	1.20	0.75	1.0	1.0	0.25	1.0
					Downstream	1.20	0.45	0.80	0.80	0.25	1.0
Culvert B	7.40	16.30	1.80	1.80	Upstream	1.20	0.75	1.0	1.0	0.25	1.20
					Downstream	1.20	N/A	N/A	N/A	0.25	1.0
Culvert C	7.40	16.30	1.80	1.80	Upstream	1.20	0.65	1.0	1.0	0.25	1.18
					Downstream	1.20	N/A	0.60	0.60	0.25	0.70
Culvert D	7.40	16.30	1.80	1.80	Upstream	1.20	0.50	0.85	0.85	0.25	0.90
					Downstream	1.20	0.55	0.75	0.75	0.25	0.80
C7/Site 8											
Culvert A	6.40	9.40	1.60	1.20	Upstream	0.90	N/A	0.35	N/A	0.20	0.60
					Downstream	0.80	0.30	N/A	N/A	0.30	N/A
Culvert B	6.40	9.40	1.60	1.20	Upstream	N/A	N/A	0.40	N/A	0.20	0.60
					Downstream	0.80	N/A	0.50	0.60	0.30	0.80

Culvert 1 / Site 2

Location: Mountain Road, near the White Fox Inn and across from the Fort William Country Club.

GPS Coordinates: Northing 5355158 Easting 328149

Description: This site had two concrete culverts. The culverts were perched on the downstream side and had abundant vegetation and boulders surrounding them. Both culverts seemed to be in good condition except one of the downstream side culverts did not have water flowing, which could indicate a blockage.

Upstream

Downstream

Culvert 2 / Site 3

Location: 15th Side Road, halfway between Highway 61 and Mountain Road.

GPS Coordinates: Northing 5355172 Easting 327045

Description: The corrugated steel culvert is very large and seems to be able to handle a high amount of water. The water level was relatively low compared to the size of the culvert opening. The downstream side is perched and the bottom is starting to deteriorate. The bank on the right side of the culvert downstream appears to be eroding.

Upstream

Downstream

Culvert 3 / Site 4

Location: Mountain Road adjacent to South Neebing Community Center.

GPS Coordinates: Northing 5354184 Easting 326100

Description: The two corrugated steel double culverts are in good condition with abundant vegetation surrounding the culverts on both sides. There is a beaver dam located downstream.

Upstream

Downstream

Culvert 4 / Site 5

Location: Mountain Road, between 1947 and 1953 Mountain Road, across from Nor'Wester View Public School.

GPS Coordinates: Northing 5354200 Easting 325568

Description: The two corrugated steel culverts appear to be in excellent condition, except for one end of the culverts on the downstream side is bent inwards on the top. There is abundant vegetation surrounding the culverts and the banks appear to be stable.

Upstream

Downstream

Culvert 5 / Site 6

Location: Highway 61, adjacent to 1956 Highway 61, approximately 700 metres from Mountain Road.

GPS Coordinates: Northing 5354742 Easting 325576

Description: The corrugated steel culvert is in excellent condition. 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.

Upstream

Downstream

Culvert 6 / Site 7

Location: Loch Lomond Road, 400 meters from Gregor Road.

GPS Coordinates: Northing 5353577 Easting 324937

Description: The four corrugated steel culverts are in excellent condition. Rip rap was used to prevent erosion around the culverts. There is abundant vegetation surrounding the culverts and the banks appear to be stable. There is a beaver dam upstream that is causing the water to back up.

Upstream

Downstream

Culvert 7 / Site 8

Location: Trendiak Road, 150 metres west from Loch Lomond Road.

GPS Coordinates: Northing 5352207 Easting 324748

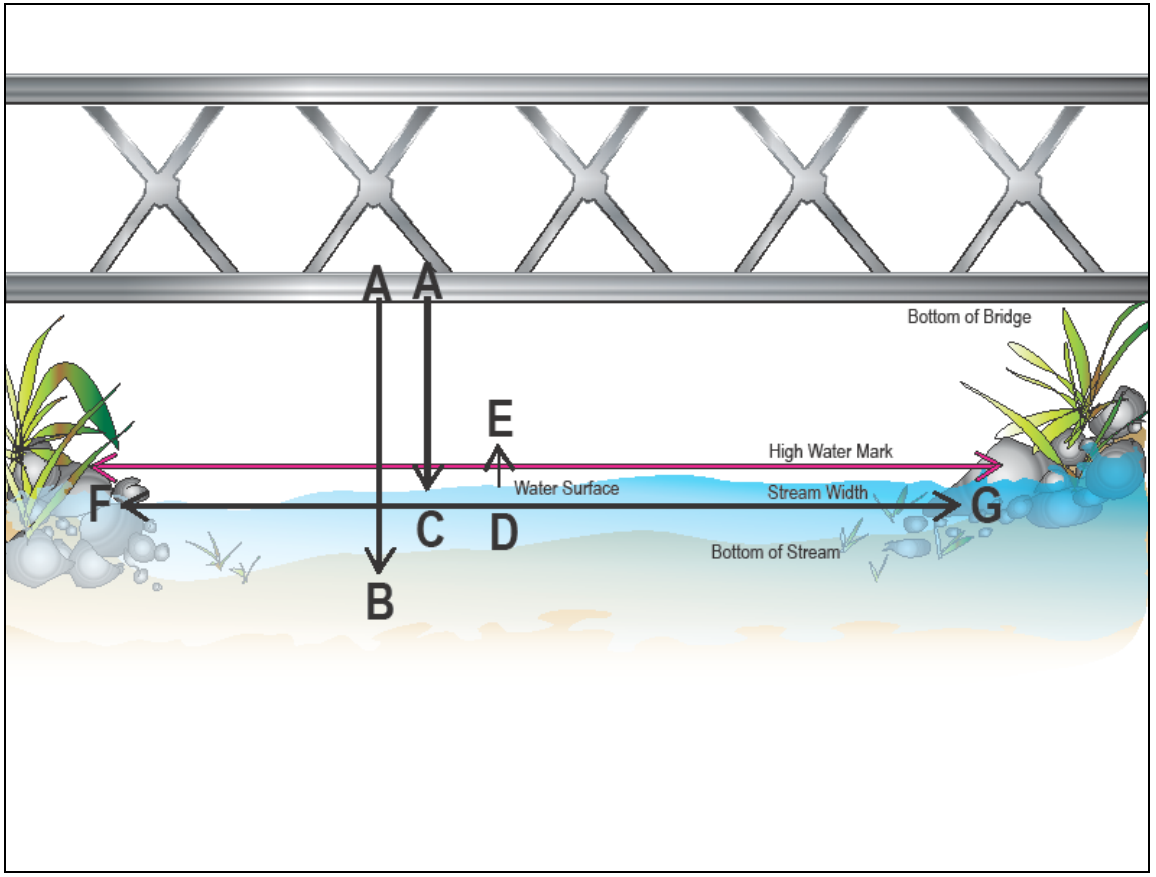
Description: The two corrugated steel culverts are in bad condition. The culverts are deteriorating and starting to collapse. The road on that side is also starting to cave in. Vegetation completely covers one of the culverts on the downstream side.

Upstream

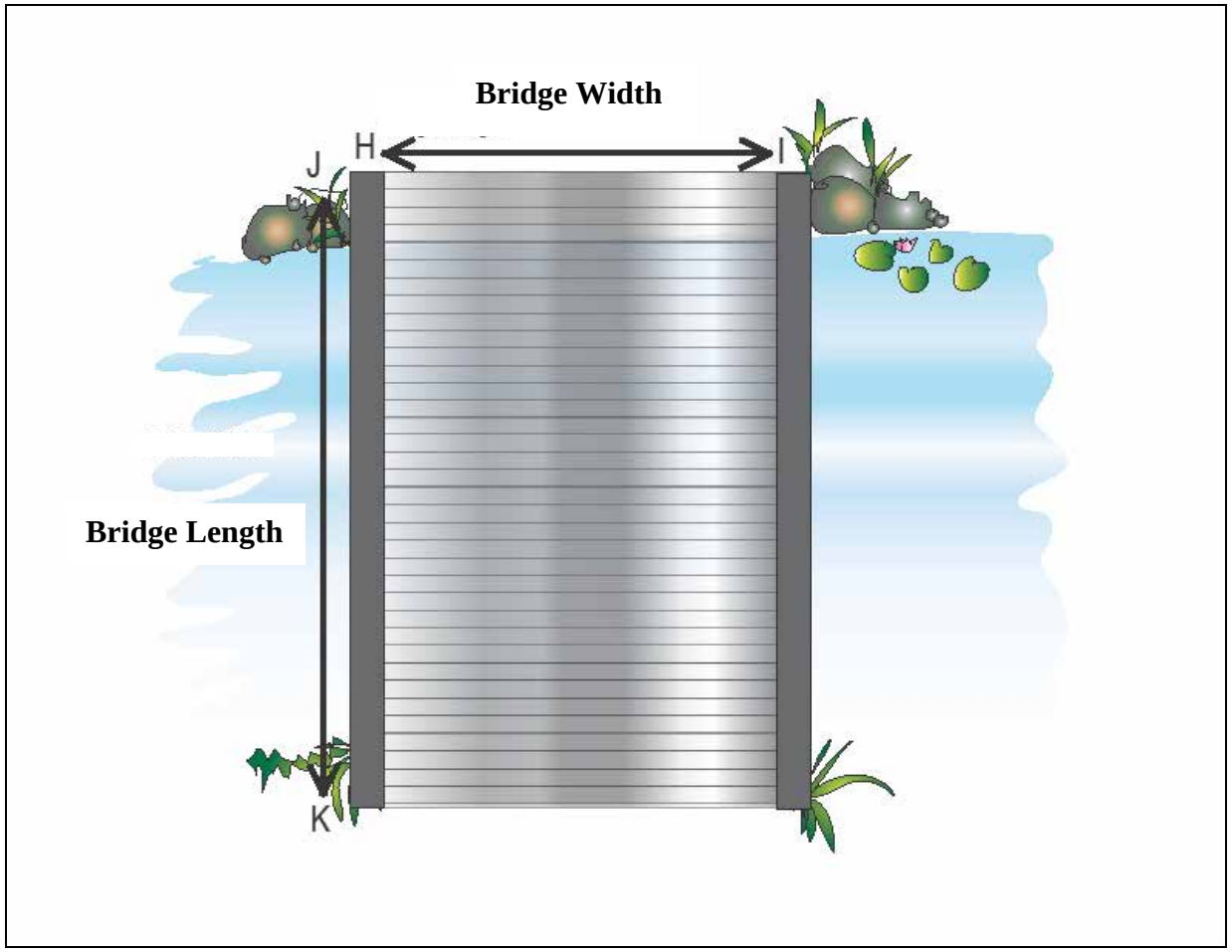
Downstream

Appendix H:
Bridge Assessments

Appendix H: Bridge Assessments



Bridge Measurement Parameters


Bridge Width
H
I
J
K
Bridge Length

Mosquito Creek 2015 Bridge Measurements

Site Number	Bridge Number	**A-C** Bottom of Bridge to Water Surface (m)	**A-B** Bottom of Bridge to Bottom of Stream (m)	**D-E** Outlet Pool Water Surface to Outlet Pool High Water Mark (m)	**F-G** Width of Stream (m)	**H-I** Length of Bridge (m)	**J-K** Width of Bridge (m)
1	1	5.7	6.1	0.30	6.4	26	11.6

Bridge 1

Location: Chippewa Road

GPS Coordinates: Northing 5356865 Easting 328683

Description: This bridge is a single-span structure made out of steel beams and reinforced concrete including a metal rail on each side of the bridge. It was completed in 1970. Rip rap was placed for erosion control on the banks. The height and width did not appear to alter the natural channel characteristics. The banks surrounding the bridge were fairly steep, but appeared to be stable due to the density of vegetation. The bridge was in very good condition, but regular maintenance should be conducted as it is a high traffic area.

Upstream

Downstream

Appendix I:
Site Photography

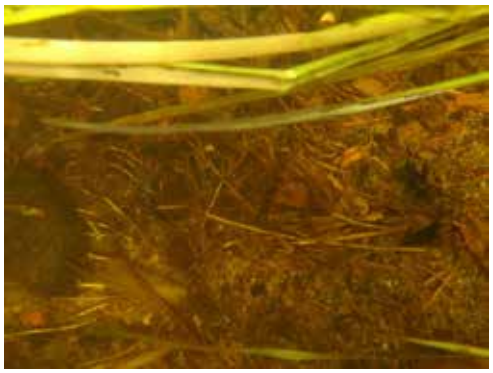
Appendix I: Site Photography

Site 1 – Chippewa Road, Mosquito Creek confluence at Kaministiquia River	
A: Upstream	**B: Downstream**
	
C: Vegetation	**D: Substrate**
	

Site 2 – North side of Mountain Road - Near White Fox Inn, across from the Fort William Country Club	
A: Upstream	**B: Downstream**
	
C: Vegetation	**D: Substrate**
	

Site 3 – East side of 15th Side Road, between Highway 61 and Mountain Road	
A: Upstream	**B: Downstream**
	
C: Vegetation	**D: Substrate**
	

Site 4 - North side of Mountain Road beside the South Neebing Community Centre	
A: Upstream	**B: Downstream**
	
C: Vegetation	**D: Substrate**
	

Site 5 - North side of Mountain Road, between 1947 and 1953 Mountain Road, across from Nor'Wester View Public School	
A: Upstream	**B: Downstream**
	
C: Vegetation	**D: Substrate**
	

Site 6 - South side of Highway 61, adjacent to 1956 Highway 61, approximately 700 metres from Mountain Road	
A: Upstream	**B: Downstream**
	
C: Vegetation	**D: Substrate**
	

Site 7 – East side of Loch Lomond Road, 400 meters from Gregor Road	
A: Upstream	**B: Downstream**
	
C: Vegetation	**D: Substrate**
	

Site 8 - 2176 Trendiak Road, about 150 meters west from Loch Lomond Road	
A: Upstream	**B: Downstream**
	
C: Vegetation	**D: Substrate**
	

Appendix J:

Soils Summary, Borehole Logs and Soil Photos

Appendix J: Soils Summary, Borehole Logs and Soil Photos

Soil Logging Summary

SITE ID	Organic Layer "O"	"A" Horizon	"B" Horizon	"C" Horizon
MC1	0-6cm , brown	6-50cm sandy loam		50cm – cobbles / rock no sample
MC2	0-16cm grey	16-50cm sand	50-90cm sandy clay- loam	90-120cm silty-clay
MC3	0-5cm brown-grey peaty	5-30cm loamy sand	30-78cm silty clay loam	78cm cobbles / rock no sample
MC4	0-15cm dark brown, peaty	15-38cm sand and minor organics	38-65cm sand	65-100cm + silty clay turning into clay at 1m
MC5	0-20cm brown peaty	20-100cm silty clay		100cm_> cobbles / rock no sample
MC6	0-18cm folic organics	18-36cm sandy clay loam		36cm-120cm loamy sand
MC7	0-10cm	10-21cm silty loam	21-65cm silty clay loam	65-120cm sandy loam with gravel
MC8	0-12cm	12-18cm silty loam minor organic	18—120cm silty loam	
MC9		0-40cm loamy sand		40-100cm sandy silt , gravel boulder/till at construction site
MC10	0-10cm folic , woody	10-30cm loamy sand		30-100cm sandy silt loam , rocky till
MC11	0-10cm			10-120cm silty clay
MC12	0-5cm	5-58cm silty loam		100cm -> loam, gravel bits
MC13	0-5cm	5-25cm loamy sand		25-120 cm sand
MC14	none	0-38cm sand		38cm-gravel, shale

Borehole Logs

Boreholes **618962** & **618963** are located close to the intersection of the 20th Side Road and Highway 61.

Borehole ID 618962

Completion Year : *1970*
Elevation (DEM) : *227.6 m*
Total Depth : *8.1 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 0.2 m soil, sand, brown, loose, amorphous
0.2 ~ 3.4 m silt, clay, brown, stiff, amorphous
3.4 ~ 5.8 m silt, clay, gravel, firm, amorphous
5.8 ~ 8.1 m silt, sand, clay, gravel, hard, amorphous

Borehole ID 618963

Completion Year : *1970*
Elevation (DEM) : *227.6 m*
Total Depth : *9.1 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 0.3 m soil, sand, brown, loose, amorphous
0.3 ~ 4.9 m silt, clay, brown, soft, amorphous
4.9 ~ 9.1 m silt, clay, gravel, grey, soft, amorphous

Boreholes **618973** & **618974** are located close to the mouth of Mosquito Creek along Chippewa Road

Borehole ID 618973

Completion Year : *1967*
Elevation (DEM) : *185.5 m*
Total Depth : *10.1 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 1.4 m fill, sand, silt
1.4 ~ 2 m sand, silt, brown, compact, medium grained

2 ~ 3.2 m silt, clay, grey, hard, amorphous
3.2 ~ 7 m sand, silt, grey, dense, medium grained
7 ~ 10.1 m bedrock, shale, grey

Borehole ID 618974

Completion Year : *1967*
Elevation (DEM) : *190.1 m*
Total Depth : *9.7 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 0.1 m soil
0.1 ~ 1.2 m fill, sand, silt, brown, compact, amorphous
1.2 ~ 3 m sand, silt, brown, loose, amorphous
3 ~ 5 m sand, silt, grey, dense, medium grained
5 ~ 6.6 m sand, silt, gravel, grey, compact, amorphous
6.6 ~ 9.7 m bedrock, shale, grey

Soil Sampling with Auger at Main Sites

(Note: Photos not taken at Sites 4 and 7)

Site 1

Site 2

Site 3

Site 5

Site 6

Site 8

Soil Sampling with Auger at Extra Sites

Site 9

Site 10

Site 11

Site 12

Site 13

Site 14

Appendix K:

Laboratory Water Quality Results Summary Tables

Mosquito Creek Watershed Assessment 2015
Laboratory Water Quality Results Summary Tables

Laboratory Water Quality Results for July 7-8, 2015

Parameter	Units	PWQO Criterion	MC1 Mosquito Creek - SITE#1 08-Jul-15	MC2 Mosquito Creek - SITE#2 08-Jul-15	MC3 Mosquito Creek - SITE#3 08-Jul-15	MC4 Mosquito Creek - SITE#4 08-Jul-15	MC5 Mosquito Creek - SITE#5 08-Jul-15	MC6 Mosquito Creek - SITE#6 08-Jul-15	MC7 Mosquito Creek - SITE#7 07-Jul-15	MC8 Mosquito Creek - SITE#8 07-Jul-15	Average July
Physical Tests											
Conductivity (EC)	(uS/cm)	N/A	557	337	590	281	529	1250	482	162	524
pH		6.5-8.5	8.33	7.84	8.07	7.55	7.61	8.12	7.33	7.65	7.81
Total Dissolved Solids	(mg/L)	N/A	315	204	348	204	302	757	295	133	320
Turbidity	(NTU)	<10% of natural	14.00	2.33	7.13	3.85	1.52	1.51	6.30	3.74	5.05
Anions and Nutrients											
Alkalinity, Total (as CaCO3)	(mg/L)	25% of natural	172.0	130.0	188.0	121.0	196.0	357.0	187.0	95.4	180.8
Ammonia-N, Total	(mg/L)	N/A	0.056	0.074	0.050	0.068	0.031	0.170	0.123	0.031	0.075
Chloride (Cl)	(mg/L)	N/A	76.30	33.80	83.90	23.10	59.60	212.00	46.20	0.41	66.91
Nitrate-N (NO3-N)	(mg/L)	N/A	0.072	0.044	0.043	<0.020	<0.020	1.140	<0.020	<0.020	0.172
Nitrite-N (NO2-N)	(mg/L)	N/A	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.010	<0.010	0.015
Total Kjeldahl Nitrogen	(mg/L)	N/A	0.70	0.52	0.94	0.98	0.86	0.56	1.36	0.93	0.86
Phosphorus (P)-Total	(mg/L)	0.03	0.0266	0.0205	**0.0330**	**0.0449**	**0.0504**	0.0081	**0.2100**	0.0217	0.0519
Sulphate (SO4)	(mg/L)	N/A	9.57	6.83	6.30	0.77	0.96	31.00	<0.30	0.75	7.06
Bacteriological Tests											
Escherichia Coli	(MPN/100mL)	100	39	25	50	40	11	76	09	20	34
Total Coliforms	(MPN/100mL)	1000 (prior to 1994)	**>2420**	**1990**	**1990**	**1990**	**2420**	**>2420**	0435	**1990**	**1803**
Total Metals											
Aluminum (Al)-Total	(mg/L)	0.075	**0.4350**	0.0605	**0.2850**	**0.1370**	0.0146	0.0441	0.0313	**0.1480**	**0.1444**
Antimony (Sb)-Total	(mg/L)	0.02	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Arsenic (As)-Total	(mg/L)	0.005 (interim)	0.00135	0.00097	0.00125	0.00125	0.00148	0.00054	0.00258	0.00103	0.00131
Barium (Ba)-Total	(mg/L)	N/A	0.0795	0.0184	0.1090	0.0173	0.0388	0.0619	0.0292	0.0108	0.0456
Beryllium (Be)-Total	(mg/L)	0.011	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth (Bi)-Total	(mg/L)	N/A	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000075	<0.000050	0.000053
Boron (B)-Total	(mg/L)	0.2	0.022	0.018	0.022	0.013	0.015	0.045	0.014	0.011	0.020
Cadmium (Cd)-Total	(mg/L)	0.0001	0.0000425	0.0000139	0.0000241	0.0000115	0.0000103	0.0000394	0.0000087	0.0000204	0.0000214
Calcium (Ca)-Total	(mg/L)	N/A	47.1	33.2	48.1	29.0	45.5	92.4	43.8	19.2	44.8
Chromium (Cr)-Total	(mg/L)	N/A	0.00115	0.00052	0.00082	0.00097	0.00044	0.00040	0.00049	0.00071	0.00069
Cobalt (Co)-Total	(mg/L)	0.0009	0.00051	0.00023	0.00045	0.00038	0.00059	0.00048	**0.00159**	0.00031	0.00057
Copper (Cu)-Total	(mg/L)	0.001 (<20 mg/L $CaCO_3$) 0.005 (>20 mg/L CaCO3)	0.00490	0.00285	0.00300	0.00183	0.00075	0.00330	0.00060	0.00204	0.00241
Iron (Fe)-Total	(mg/L)	0.3	**0.959**	**0.657**	**0.912**	**1.380**	**0.961**	0.250	**3.770**	**0.805**	**1.212**
Lead (Pb)-Total	(mg/L)	0.001	0.000241	0.000051	0.000158	0.000146	<0.000050	<0.000050	0.000063	0.000089	0.000106
Lithium (Li)-Total	(mg/L)	N/A	0.0044	0.0023	0.0045	0.0014	0.0021	0.0085	0.0019	0.0010	0.0033
Magnesium (Mg)-Total	(mg/L)	N/A	17.90	12.00	18.80	11.50	20.4	34.20	19.30	8.61	17.84

Bold indicates exceedance of PWQO criteria

Mosquito Creek Watershed Assessment 2015
Laboratory Water Quality Results Summary Tables

Laboratory Water Quality Results for July 7-8, 2015

Parameter	Units	PWQO Criterion	MC1 Mosquito Creek - SITE#1 08-Jul-15	MC2 Mosquito Creek - SITE#2 08-Jul-15	MC3 Mosquito Creek - SITE#3 08-Jul-15	MC4 Mosquito Creek - SITE#4 08-Jul-15	MC5 Mosquito Creek - SITE#5 08-Jul-15	MC6 Mosquito Creek - SITE#6 08-Jul-15	MC7 Mosquito Creek - SITE#7 07-Jul-15	MC8 Mosquito Creek - SITE#8 07-Jul-15	Average July
Total Metals Continued											
Manganese (Mn)-Total	(mg/L)	N/A	0.0566	0.1400	0.1080	0.2100	0.8910	0.1110	1.4900	0.0627	0.3837
Molybdenum (Mo)-Total	(mg/L)	0.004	0.001050	0.000589	0.000985	0.000804	0.000770	0.001020	0.000381	0.000390	0.000749
Nickel (Ni)-Total	(mg/L)	0.025	0.00299	0.00186	0.00267	0.00195	0.00200	0.00408	0.00149	0.00176	0.00235
Potassium (K)-Total	(mg/L)	N/A	1.970	1.190	2.000	1.570	1.740	2.760	1.850	0.933	1.752
Selenium (Se)-Total	(mg/L)	0.1	0.000159	0.000129	0.000133	0.000193	0.000162	0.000106	0.000220	0.000172	0.000159
Silver (Ag)-Total	(mg/L)	0.0001	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.00010
Sodium (Na)-Total	(mg/L)	N/A	42.60	21.40	48.90	15.30	32.50	130.00	24.10	2.20	39.63
Strontium (Sr)-Total	(mg/L)	N/A	0.1240	0.0628	0.1520	0.0574	0.0948	0.2040	0.0796	0.0378	0.1016
Tellurium (Te)-Total	(mg/L)	N/A	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Thallium (Tl)-Total	(mg/L)	0.0003	0.000015	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000011
Tin (Sn)-Total	(mg/L)	N/A	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	(mg/L)	N/A	0.01500	0.00253	0.01000	0.00456	0.00082	0.00165	0.00178	0.00491	0.00516
Tungsten (W)-Total	(mg/L)	0.03	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Uranium (U)-Total	(mg/L)	0.005	0.000691	0.000314	0.000717	0.000241	0.000586	0.001270	0.000235	0.000117	0.000521
Vanadium (V)-Total	(mg/L)	N/A	0.00369	0.00106	0.00266	0.00173	0.00113	0.00085	0.00220	0.00160	0.00187
Zinc (Zn)-Total	(mg/L)	0.02 (interim)	0.0048	<0.0030	0.0039	<0.0030	0.0031	0.0048	<0.0030	0.0034	0.0036
Zirconium (Zr)-Total	(mg/L)	0.004	0.00047	<0.00030	0.00036	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	0.00033

Bold indicates exceedance of PWQO criteria

Mosquito Creek Watershed Assessment 2015
Laboratory Water Quality Results Summary Tables

Laboratory Water Quality Results for June 9-10, 2015

Parameter	Units	PWQO Criterion	MC1 Mosquito Creek - SITE#1 10-Jun-15	MC2 Mosquito Creek - SITE#2 10-Jun-15	MC3 Mosquito Creek - SITE#3 10-Jun-15	MC4 Mosquito Creek - SITE#4 09-Jun-15	MC5 Mosquito Creek - SITE#5 09-Jun-15	MC6 Mosquito Creek - SITE#6 09-Jun-15	MC7 Mosquito Creek - SITE#7 09-Jun-15	MC8 Mosquito Creek - SITE#8 09-Jun-15	Average June
Physical Tests											
Conductivity (EC)	(uS/cm)	N/A	412	264	408	217	469	1110	378	108	421
pH		6.5-8.5	8.21	7.76	7.90	7.72	7.73	8.02	7.41	7.39	7.77
Total Dissolved Solids	(mg/L)	N/A	237	174	238	151	278	606	252	97	254
Turbidity	(NTU)	<10% of natural	24.60	3.69	4.65	2.83	0.96	1.17	2.27	5.99	5.77
Anions and Nutrients											
Alkalinity, Total (as CaCO3)	(mg/L)	25% of natural	129.0	94.2	128.0	83.3	151.0	273.0	136.0	58.8	131.7
Ammonia-N, Total	(mg/L)	N/A	<0.020	<0.020	<0.020	<0.020	0.032	<0.020	<0.020	<0.020	0.022
Chloride (Cl)	(mg/L)	N/A	51.70	20.70	46.20	17.90	53.80	180.00	37.80	0.32	51.05
Nitrate-N (NO3-N)	(mg/L)	N/A	0.070	0.024	0.051	0.032	<0.020	0.845	0.020	0.021	0.135
Nitrite-N (NO2-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	0.45	0.39	0.43	0.38	0.63	0.41	0.54	0.48	0.46
Phosphorus (P)-Total	(mg/L)	0.03	0.0283	0.0145	0.0208	0.0190	0.0261	0.0071	**0.0651**	0.0177	0.0248
Sulphate (SO4)	(mg/L)	N/A	9.41	9.22	6.15	2.60	8.62	23.80	5.69	1.39	8.36
Bacteriological Tests											
Escherichia Coli	(MPN/100mL)	100	27	9	**102**	88	10	03	06	30	34
Total Coliforms	(MPN/100mL)	1000 (prior to 1994)	**1300**	**2420**	**1990**	**1300**	**1050**	**1300**	**1730**	**2420**	**1689**
Total Metals											
Aluminum (Al)-Total	(mg/L)	0.075	**0.7300**	**0.1420**	**0.2070**	**0.1410**	0.0204	0.0396	0.0528	**0.3370**	**0.2087**
Antimony (Sb)-Total	(mg/L)	0.02	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.0001	<0.00010	<0.00010	0.00010
Arsenic (As)-Total	(mg/L)	0.005 (interim)	0.00095	0.00070	0.00085	0.00073	0.00072	0.00048	0.00085	0.00056	0.00073
Barium (Ba)-Total	(mg/L)	N/A	0.0516	0.0155	0.0479	0.0138	0.0286	0.0529	0.0206	0.0114	0.0303
Beryllium (Be)-Total	(mg/L)	0.011	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth (Bi)-Total	(mg/L)	N/A	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	(mg/L)	0.2	0.017	0.017	0.017	0.012	0.015	0.035	0.014	0.011	0.017
Cadmium (Cd)-Total	(mg/L)	0.0001	0.0000329	0.0000177	0.0000182	0.0000167	0.0000087	0.0000275	0.0000157	0.0000225	0.0000200
Calcium (Ca)-Total	(mg/L)	N/A	35.9	25.1	35.7	21.2	39.6	77.7	34.4	14.0	35.5
Chromium (Cr)-Total	(mg/L)	N/A	0.00146	0.00070	0.00068	0.00094	0.00033	0.00036	0.00045	0.00098	0.00074
Cobalt (Co)-Total	(mg/L)	0.0009	0.00057	0.00023	0.00029	0.00023	0.00016	0.00033	0.00043	0.00027	0.00031
Copper (Cu)-Total	(mg/L)	0.001 (<20 mg/L $CaCO_3$) 0.005 (>20 mg/L CaCO3)	**0.00507**	0.00371	0.00327	0.00314	0.00177	0.00383	0.00145	0.00349	0.00322
Iron (Fe)-Total	(mg/L)	0.3	**1.210**	**0.539**	**0.689**	**0.663**	**0.377**	0.161	**0.904**	**0.643**	**0.648**
Lead (Pb)-Total	(mg/L)	0.001	0.000311	0.000072	0.000090	0.000088	0.000088	<0.000050	<0.000050	0.000108	0.000107
Lithium (Li)-Total	(mg/L)	N/A	0.0026	0.0011	0.0018	<0.0010	0.0016	0.0063	0.0013	<0.0010	0.0021
Magnesium (Mg)-Total	(mg/L)	N/A	14.80	10.10	14.70	9.03	18.00	28.50	16.10	6.11	14.67

Bold indicates exceedance of PWQO criteria

Mosquito Creek Watershed Assessment 2015
Laboratory Water Quality Results Summary Tables

Laboratory Water Quality Results for June 9-10, 2015

Parameter	Units	PWQO Criterion	MC1 Mosquito Creek - SITE#1 10-Jun-15	MC2 Mosquito Creek - SITE#2 10-Jun-15	MC3 Mosquito Creek - SITE#3 10-Jun-15	MC4 Mosquito Creek - SITE#4 09-Jun-15	MC5 Mosquito Creek - SITE#5 09-Jun-15	MC6 Mosquito Creek - SITE#6 09-Jun-15	MC7 Mosquito Creek - SITE#7 09-Jun-15	MC8 Mosquito Creek - SITE#8 09-Jun-15	Average June
Total Metals Continued											
Manganese (Mn)-Total	(mg/L)	N/A	0.0495	0.0852	0.0756	0.0590	0.0417	0.0438	0.212	0.0264	0.0742
Molybdenum (Mo)-Total	(mg/L)	0.004	0.000720	0.000483	0.000768	0.000629	0.000721	0.000947	0.000662	0.000406	0.000667
Nickel (Ni)-Total	(mg/L)	0.025	0.00273	0.00166	0.00193	0.00174	0.00161	0.00330	0.00165	0.00164	0.00203
Potassium (K)-Total	(mg/L)	N/A	1.690	1.110	1.730	1.420	1.640	2.580	1.440	1.020	1.5788
Selenium (Se)-Total	(mg/L)	0.1	0.000174	0.000160	0.000157	0.000152	0.000130	0.000123	0.000188	0.000153	0.000155
Silver (Ag)-Total	(mg/L)	0.0001	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000013	0.000010
Sodium (Na)-Total	(mg/L)	N/A	28.70	14.80	30.20	11.60	30.80	111.00	22.10	1.99	31.40
Strontium (Sr)-Total	(mg/L)	N/A	0.0858	0.0511	0.0906	0.0454	0.0834	0.1730	0.0671	0.0284	0.0781
Tellurium (Te)-Total	(mg/L)	N/A	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Thallium (Tl)-Total	(mg/L)	0.0003	0.000013	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000010
Tin (Sn)-Total	(mg/L)	N/A	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	(mg/L)	N/A	0.02390	0.00459	0.00642	0.00391	0.00083	0.00133	0.00196	0.008460	0.00643
Tungsten (W)-Total	(mg/L)	0.03	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Uranium (U)-Total	(mg/L)	0.005	0.000561	0.000269	0.000475	0.000185	0.000736	0.001190	0.000487	0.000095	0.000500
Vanadium (V)-Total	(mg/L)	N/A	0.00331	0.00119	0.00182	0.00153	0.00087	0.00072	0.00135	0.00163	0.00155
Zinc (Zn)-Total	(mg/L)	0.02 (interim)	0.0036	0.0031	<0.0030	<0.0030	<0.0030	0.0038	<0.0030	<0.0030	0.0032
Zirconium (Zr)-Total	(mg/L)	0.004	0.00053	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	0.00033

Bold indicates exceedance of PWQO criteria

Appendix L:

Laboratory Certificates of Analysis and Test Results

LAKEHEAD REGION CONSERVATION AUTHORITY
ATTN: Tammy Cook / Scott Drebit
130 CONSERVATION ROAD
P.O. BOX 10427
THUNDER BAY ON P7B 6T8

Date Received: 08-JUL-15
Report Date: 21-JUL-15 14:48 (MT)
Version: FINAL

Client Phone: 807-344-5857

Certificate of Analysis

Lab Work Order #: L1639120

Project P.O. #: NOT SUBMITTED
Job Reference: MOSQUITO CREEK
C of C Numbers:
Legal Site Desc:

Laura Dowswell
Project Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1639120-1	L1639120-2	L1639120-3	L1639120-4	L1639120-5
	Description	GRAB	GRAB	GRAB	GRAB	GRAB
	Sampled Date	07-JUL-15	07-JUL-15	08-JUL-15	08-JUL-15	08-JUL-15
	Sampled Time	13:40	14:35	09:30	10:15	10:45
	Client ID	MC8 - MOSQUITO CREEK - SITE #8	MC7 - MOSQUITO CREEK - SITE #7	MC6 - MOSQUITO CREEK - SITE #6	MC5 - MOSQUITO CREEK - SITE #5	MC4 - MOSQUITO CREEK - SITE #4
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (EC) (uS/cm)	162	482	1250	529	281
	Hardness (as CaCO3) (mg/L)	83.4	189	371	198	120
	pH (pH)	7.65	7.33	8.12	7.61	7.55
	Total Dissolved Solids (mg/L)	133	295	757	302	204
	Turbidity (NTU)	3.74	6.30	1.51	1.52	3.85
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	95.4	187	357	196	121
	Ammonia, Total (as N) (mg/L)	0.031	0.123	0.170	0.031	0.068
	Chloride (Cl) (mg/L)	0.41	46.2	212	59.6	23.1
	Nitrate (as N) (mg/L)	<0.020	<0.020	1.14	<0.020	<0.020
	Nitrite (as N) (mg/L)	<0.010	<0.010	<0.050 DLA	<0.010	<0.010
	Total Kjeldahl Nitrogen (mg/L)	0.93	1.36	0.56	0.86	0.98
	Phosphorus (P)-Total (mg/L)	0.0217	0.210	0.0081	0.0504	0.0449
	Sulfate (SO4) (mg/L)	0.75	<0.30	31.0	0.96	0.77
Bacteriological Tests	Escherichia Coli (MPN/100mL)	20	9	76	11	40
	Total Coliforms (MPN/100mL)	1990	435	>2420	2420	1990
Total Metals	Aluminum (Al)-Total (mg/L)	0.148	0.0313	0.0441	0.0146	0.137
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Total (mg/L)	0.00103	0.00258	0.00054	0.00148	0.00125
	Barium (Ba)-Total (mg/L)	0.0108	0.0292	0.0619	0.0388	0.0173
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	0.000075	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	0.011	0.014	0.045	0.015	0.013
	Cadmium (Cd)-Total (mg/L)	0.0000204	0.0000087	0.0000394	0.0000103	0.0000115
	Calcium (Ca)-Total (mg/L)	19.2	43.8	92.4	45.5	29.0
	Cesium (Cs)-Total (mg/L)	0.000011	<0.000010	0.000011	<0.000010	0.000010
	Chromium (Cr)-Total (mg/L)	0.00071	0.00049	0.00040	0.00044	0.00097
	Cobalt (Co)-Total (mg/L)	0.00031	0.00159	0.00048	0.00059	0.00038
	Copper (Cu)-Total (mg/L)	0.00204	0.00060	0.00330	0.00075	0.00183
	Iron (Fe)-Total (mg/L)	0.805	3.77	0.250	0.961	1.38
	Lead (Pb)-Total (mg/L)	0.000089	0.000063	<0.000050	<0.000050	0.000146
	Lithium (Li)-Total (mg/L)	0.0010	0.0019	0.0085	0.0021	0.0014
	Magnesium (Mg)-Total (mg/L)	8.61	19.3	34.2	20.4	11.5
	Manganese (Mn)-Total (mg/L)	0.0627	1.49	0.111	0.891	0.210
	Molybdenum (Mo)-Total (mg/L)	0.000390	0.000381	0.00102	0.000770	0.000804
	Nickel (Ni)-Total (mg/L)	0.00176	0.00149	0.00408	0.00200	0.00195
	Phosphorus (P)-Total (mg/L)	<0.050	0.215	<0.050	0.072	0.050

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1639120-6	L1639120-7	L1639120-8		
	Description	GRAB	GRAB	GRAB		
	Sampled Date	08-JUL-15	08-JUL-15	08-JUL-15		
	Sampled Time	11:30	12:45	13:20		
	Client ID	MC3 - MOSQUITO CREEK - SITE #3	MC2 - MOSQUITO CREEK - SITE #2	MC1 - MOSQUITO CREEK - SITE #1		
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (EC) (uS/cm)	590	337	557		
	Hardness (as CaCO3) (mg/L)	198	132	191		
	pH (pH)	8.07	7.84	8.33		
	Total Dissolved Solids (mg/L)	348	204	315		
	Turbidity (NTU)	7.13	2.33	14.0		
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	188	130	172		
	Ammonia, Total (as N) (mg/L)	0.050	0.074	0.056		
	Chloride (Cl) (mg/L)	83.9	33.8	76.3		
	Nitrate (as N) (mg/L)	0.043	0.044	0.072		
	Nitrite (as N) (mg/L)	<0.010	<0.010	<0.010		
	Total Kjeldahl Nitrogen (mg/L)	0.94	0.52	0.70		
	Phosphorus (P)-Total (mg/L)	0.0330	0.0205	0.0266		
	Sulfate (SO4) (mg/L)	6.30	6.83	9.57		
Bacteriological Tests	Escherichia Coli (MPN/100mL)	50	25	39		
	Total Coliforms (MPN/100mL)	1990	1990	>2420		
Total Metals	Aluminum (Al)-Total (mg/L)	0.285	0.0605	0.435		
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Arsenic (As)-Total (mg/L)	0.00125	0.00097	0.00135		
	Barium (Ba)-Total (mg/L)	0.109	0.0184	0.0795		
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050		
	Boron (B)-Total (mg/L)	0.022	0.018	0.022		
	Cadmium (Cd)-Total (mg/L)	0.0000241	0.0000139	0.0000425		
	Calcium (Ca)-Total (mg/L)	48.1	33.2	47.1		
	Cesium (Cs)-Total (mg/L)	0.000024	<0.000010	0.000044		
	Chromium (Cr)-Total (mg/L)	0.00082	0.00052	0.00115		
	Cobalt (Co)-Total (mg/L)	0.00045	0.00023	0.00051		
	Copper (Cu)-Total (mg/L)	0.00300	0.00285	0.00490		
	Iron (Fe)-Total (mg/L)	0.912	0.657	0.959		
	Lead (Pb)-Total (mg/L)	0.000158	0.000051	0.000241		
	Lithium (Li)-Total (mg/L)	0.0045	0.0023	0.0044		
	Magnesium (Mg)-Total (mg/L)	18.8	12.0	17.9		
	Manganese (Mn)-Total (mg/L)	0.108	0.140	0.0566		
	Molybdenum (Mo)-Total (mg/L)	0.000985	0.000589	0.00105		
	Nickel (Ni)-Total (mg/L)	0.00267	0.00186	0.00299		
	Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050		

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1639120-1	L1639120-2	L1639120-3	L1639120-4	L1639120-5
	Description	GRAB	GRAB	GRAB	GRAB	GRAB
	Sampled Date	07-JUL-15	07-JUL-15	08-JUL-15	08-JUL-15	08-JUL-15
	Sampled Time	13:40	14:35	09:30	10:15	10:45
	Client ID	MC8 - MOSQUITO CREEK - SITE #8	MC7 - MOSQUITO CREEK - SITE #7	MC6 - MOSQUITO CREEK - SITE #6	MC5 - MOSQUITO CREEK - SITE #5	MC4 - MOSQUITO CREEK - SITE #4
Grouping	**Analyte**					
WATER						
Total Metals	Potassium (K)-Total (mg/L)	0.933	1.85	2.76	1.74	1.57
	Rubidium (Rb)-Total (mg/L)	0.00077	0.00101	0.00167	0.00079	0.00090
	Selenium (Se)-Total (mg/L)	0.000172	0.000220	0.000106	0.000162	0.000193
	Silicon (Si)-Total (mg/L)	3.34	6.16	10.1	5.21	3.39
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	2.20	24.1	130	32.5	15.3
	Strontium (Sr)-Total (mg/L)	0.0378	0.0796	0.204	0.0948	0.0574
	Sulfur (S)-Total (mg/L)	<0.50	0.55	12.2	0.90	0.62
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Total (mg/L)	0.00491	0.00178	0.00165	0.00082	0.00456
	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Uranium (U)-Total (mg/L)	0.000117	0.000235	0.00127	0.000586	0.000241
	Vanadium (V)-Total (mg/L)	0.00160	0.00220	0.00085	0.00113	0.00173
	Zinc (Zn)-Total (mg/L)	0.0034	<0.0030	0.0048	0.0031	<0.0030
	Zirconium (Zr)-Total (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1639120-6	L1639120-7	L1639120-8		
	Description	GRAB	GRAB	GRAB		
	Sampled Date	08-JUL-15	08-JUL-15	08-JUL-15		
	Sampled Time	11:30	12:45	13:20		
	Client ID	MC3 - MOSQUITO CREEK - SITE #3	MC2 - MOSQUITO CREEK - SITE #2	MC1 - MOSQUITO CREEK - SITE #1		
Grouping	**Analyte**					
WATER						
Total Metals	Potassium (K)-Total (mg/L)	2.00	1.19	1.97		
	Rubidium (Rb)-Total (mg/L)	0.00139	0.00088	0.00163		
	Selenium (Se)-Total (mg/L)	0.000133	0.000129	0.000159		
	Silicon (Si)-Total (mg/L)	4.31	6.03	4.98		
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010		
	Sodium (Na)-Total (mg/L)	48.9	21.4	42.6		
	Strontium (Sr)-Total (mg/L)	0.152	0.0628	0.124		
	Sulfur (S)-Total (mg/L)	2.72	2.83	3.88		
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020		
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	0.000015		
	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Titanium (Ti)-Total (mg/L)	0.0100	0.00253	0.0150		
	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Uranium (U)-Total (mg/L)	0.000717	0.000314	0.000691		
	Vanadium (V)-Total (mg/L)	0.00266	0.00106	0.00369		
	Zinc (Zn)-Total (mg/L)	0.0039	<0.0030	0.0048		
	Zirconium (Zr)-Total (mg/L)	0.00036	<0.00030	0.00047		

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

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Total Kjeldahl Nitrogen	MS-B	L1639120-1, -2
Matrix Spike	Ammonia, Total (as N)	MS-B	L1639120-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Ammonia, Total (as N)	MS-B	L1639120-1, -2, -3, -4, -5, -6, -7, -8

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit adjusted for required dilution
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-TB	Water	Alkalinity	APHA 2320

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.

CL-L-IC-N-TB	Water	Chloride in Water by IC (Low Level)	EPA 300.1 (mod)

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

EC-TITR-TB	Water	Conductivity	APHA 2510 B

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

ETL-HARDNESS-TOT-ED	Water	Hardness (from Total Ca and Mg)	APHA 2340 B-Calculation
MET-T-CCMS-ED	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

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.

NH3-COL-TB	Water	Ammonia by Discrete Analyzer	APHA 4500-NH3 G. (modified)

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

NO2-IC-TB	Water	Nitrite in Water by IC	EPA 300.1 (mod)

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

NO3-IC-TB	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Anions in aqueous matrices are analyzed using ion chromatography with conductivity and/or UV absorbance detectors.

P-T-COL-TB	Water	Total Phosphorus by Discrete Analyzer	APHA 4500-P B, F, G (modified)

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

PH-TITR-TB	Water	pH	APHA 4500-H

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

SO4-IC-N-TB	Water	Sulfate in Water by IC	EPA 300.1 (mod)

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

TC,EC-QT97-TB	Water	Total Coliform and E.coli	APHA 9223 B

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.

TDS-TB	Water	Total Dissolved Solids	APHA 2540 C (modified)

Aqueous matrices are analyzed using gravimetry and evaporation

TKN-COL-TB	Water	Total Kjeldahl Nitrogen	APHA 4500-Norg (modified)

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

TURBIDITY-TB	Water	Turbidity	APHA 2130 B-Nephelometer

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

Reference Information

** 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:

Laboratory Definition Code	Laboratory Location
ED	ALS ENVIRONMENTAL - EDMONTON, ALBERTA, CANADA
TB	ALS ENVIRONMENTAL - THUNDER BAY, ONTARIO, CANADA

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 based on dry weight of sample.
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) / Analyt Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L1639120-COFC

ere L1639120

COC Number: 14 -

Page 1 of 1

Report To		Report Format / Distribution		Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Lakehead Region Conservation Authority	Select Report Format:	☒ PDF ☐ EXCEL ☐ EDD (DIGITAL)	R ☑ Regular (Standard TAT if received by 3 pm - business days)
Contact:	Tammy Cook	Quality Control (QC) Report with Report	☐ Yes ☒ No	P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	130 Conservation Road PO Box 10427	☐ Criteria on Report - provide details below if box checked		E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
Phone:	807-344-5857 ext 224	Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX	E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
		Email 1 or Fax	tammy@lakeheadca.com	Specify Date Required for E2,E or P:
		Email 2	Scott@lakeheadca.com	

Invoice To	Same as Report To ☑ Yes ☐ No	Invoice Distribution	
	Copy of Invoice with Report ☑ Yes ☐ No	Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Company:		Email 1 or Fax	
Contact:		Email 2	

Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:	Q51234	Approver ID:	Cost Center:
Job #:	Mosquito Creek	GL Account:	Routing Code:
PO / AFE:		Activity Code:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		ALS Contact:	Sampler: SD JH

Analysis Request

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

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Alkalinity, Conductivity, pH	Chloride, Nitrate, Nitrite, Sulphate	TDS, Turbidity	NH3, TKN, TP	Metals, Total & Hardness	TC/EC	Number of Containers
	MC8 - Mosquito Creek - Site #8	07-JUL-15	13:40	grab	X	X	X	X	X	X	5
	MC7 - Mosquito Creek - Site #7	07-JUL-15	14:35	grab	X	X	X	X	X	X	5
	MC6 - Mosquito Creek - Site #6	08-JUL-15	09:30	grab	X	X	X	X	X	X	5
	MC5 - Mosquito Creek - Site #5	08-JUL-15	10:15	grab	X	X	X	X	X	X	5
	MC4 - Mosquito Creek - Site #4	08-JUL-15	10:45	grab	X	X	X	X	X	X	5
	MC3 - Mosquito Creek - Site #3	08-JUL-15	11:30	grab	X	X	X	X	X	X	5
	MC2 - Mosquito Creek - Site #2	08-JUL-15	12:45	grab	X	X	X	X	X	X	5
	MC1 - Mosquito Creek - Site #1	08-JUL-15	13:20	grab	X	X	X	X	X	X	5

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report (client Use)
Are samples taken from a Regulated DW System? ☐ Yes ☒ No	
Are samples for human drinking water use? ☐ Yes ☒ No	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen	☐	SIF Observations	Yes ☐	No ☐	
Ice packs	Yes ☒	No ☐	Custody seal intact	Yes ☐	No ☐
Cooling Initiated	☐				

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
				12.1	

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date: Jul 8/15	Time:	Received By: MM	Date: 7/8/15	Time: 3:49	Received by: MT	Date: 8/7/15	Time: 17:00

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

NA FM-0328e v08 Front/04 January 2014

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

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

LAKEHEAD REGION CONSERVATION AUTHORITY
ATTN: Tammy Cook
130 CONSERVATION ROAD
P.O. BOX 10427
THUNDER BAY ON P7B 6T8

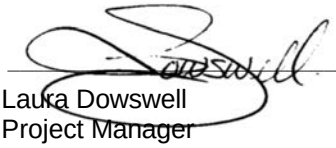
Date Received: 10-JUN-15
Report Date: 18-JUN-15 14:00 (MT)
Version: FINAL

Client Phone: 807-344-5857

Certificate of Analysis

Lab Work Order #: L1624721

Project P.O. #: NOT SUBMITTED
Job Reference: MOSQUITO CREEK
C of C Numbers:
Legal Site Desc:



Laura Dowswell
Project Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1624721-1	L1624721-2	L1624721-3	L1624721-4	L1624721-5
	Description	GRAB	GRAB	GRAB	GRAB	GRAB
	Sampled Date	09-JUN-15	09-JUN-15	09-JUN-15	09-JUN-15	09-JUN-15
	Sampled Time	09:50	10:45	13:30	14:20	15:00
	Client ID	MC8 - MOSQUITO CREEK - SITE #8	MC7 - MOSQUITO CREEK - SITE #7	MC6 - MOSQUITO CREEK - SITE #6	MC5 - MOSQUITO CREEK - SITE #5	MC4 - MOSQUITO CREEK - SITE #4
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (EC) (uS/cm)	108	378	1110	469	217
	Hardness (as CaCO3) (mg/L)	60.1	152	312	173	90.2
	pH (pH)	7.39	7.41	8.02	7.73	7.72
	Total Dissolved Solids (mg/L)	97	252	606	278	151
	Turbidity (NTU)	5.99	2.27	1.17	0.96	2.83
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	58.8	136	273	151	83.3
	Ammonia, Total (as N) (mg/L)	<0.020	<0.020	<0.020	0.032	<0.020
	Chloride (Cl) (mg/L)	0.32	37.8	180	53.8	17.9
	Nitrate (as N) (mg/L)	0.021	0.020	0.845	<0.020	0.032
	Nitrite (as N) (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Total Kjeldahl Nitrogen (mg/L)	0.48	0.54	0.41	0.63	0.38
	Phosphorus (P)-Total (mg/L)	0.0177	0.0651	0.0071	0.0261	0.0190
	Sulfate (SO4) (mg/L)	1.39	5.69	23.8	8.62	2.60
Bacteriological Tests	Escherichia Coli (MPN/100mL)	30	6	3	10	88
	Total Coliforms (MPN/100mL)	2420	1730	1300	1050	1300
Total Metals	Aluminum (Al)-Total (mg/L)	0.337	0.0528	0.0396	0.0204	0.141
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	0.00010	<0.00010	<0.00010
	Arsenic (As)-Total (mg/L)	0.00056	0.00085	0.00048	0.00072	0.00073
	Barium (Ba)-Total (mg/L)	0.0114	0.0206	0.0529	0.0286	0.0138
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	0.011	0.014	0.035	0.015	0.012
	Cadmium (Cd)-Total (mg/L)	0.0000225	0.0000157	0.0000275	0.0000087	0.0000167
	Calcium (Ca)-Total (mg/L)	14.0	34.4	77.7	39.6	21.2
	Cesium (Cs)-Total (mg/L)	0.000026	<0.000010	<0.000010	<0.000010	<0.000010
	Chromium (Cr)-Total (mg/L)	0.00098	0.00045	0.00036	0.00033	0.00094
	Cobalt (Co)-Total (mg/L)	0.00027	0.00043	0.00033	0.00016	0.00023
	Copper (Cu)-Total (mg/L)	0.00349	0.00145	0.00383	0.00177	0.00314
	Iron (Fe)-Total (mg/L)	0.643	0.904	0.161	0.377	0.663
	Lead (Pb)-Total (mg/L)	0.000108	<0.000050	<0.000050	0.000088	0.000088
	Lithium (Li)-Total (mg/L)	<0.0010	0.0013	0.0063	0.0016	<0.0010
	Magnesium (Mg)-Total (mg/L)	6.11	16.1	28.5	18.0	9.03
	Manganese (Mn)-Total (mg/L)	0.0264	0.212	0.0438	0.0417	0.0590
	Molybdenum (Mo)-Total (mg/L)	0.000406	0.000662	0.000947	0.000721	0.000629
	Nickel (Ni)-Total (mg/L)	0.00164	0.00165	0.00330	0.00161	0.00174
	Phosphorus (P)-Total (mg/L)	<0.050	0.069	<0.050	<0.050	<0.050

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1624721-6	L1624721-7	L1624721-8		
	Description	GRAB	GRAB	GRAB		
	Sampled Date	10-JUN-15	10-JUN-15	10-JUN-15		
	Sampled Time	09:35	10:25	11:00		
	Client ID	MC3 - MOSQUITO CREEK - SITE #3	MC2 - MOSQUITO CREEK - SITE #2	MC1 - MOSQUITO CREEK - SITE #1		
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (EC) (uS/cm)	408	264	412		
	Hardness (as CaCO3) (mg/L)	150	104	151		
	pH (pH)	7.90	7.76	8.21		
	Total Dissolved Solids (mg/L)	238	174	237		
	Turbidity (NTU)	4.65	3.69	24.6		
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	128	94.2	129		
	Ammonia, Total (as N) (mg/L)	<0.020	<0.020	<0.020		
	Chloride (Cl) (mg/L)	46.2	20.7	51.7		
	Nitrate (as N) (mg/L)	0.051	0.024	0.070		
	Nitrite (as N) (mg/L)	<0.010	<0.010	<0.010		
	Total Kjeldahl Nitrogen (mg/L)	0.43	0.39	0.45		
	Phosphorus (P)-Total (mg/L)	0.0208	0.0145	0.0283		
	Sulfate (SO4) (mg/L)	6.15	9.22	9.41		
Bacteriological Tests	Escherichia Coli (MPN/100mL)	102	9	27		
	Total Coliforms (MPN/100mL)	1990	2420	1300		
Total Metals	Aluminum (Al)-Total (mg/L)	0.207	0.142	0.730		
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Arsenic (As)-Total (mg/L)	0.00085	0.00070	0.00095		
	Barium (Ba)-Total (mg/L)	0.0479	0.0155	0.0516		
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050		
	Boron (B)-Total (mg/L)	0.017	0.017	0.017		
	Cadmium (Cd)-Total (mg/L)	0.0000182	0.0000177	0.0000329		
	Calcium (Ca)-Total (mg/L)	35.7	25.1	35.9		
	Cesium (Cs)-Total (mg/L)	0.000015	0.000013	0.000066		
	Chromium (Cr)-Total (mg/L)	0.00068	0.00070	0.00146		
	Cobalt (Co)-Total (mg/L)	0.00029	0.00023	0.00057		
	Copper (Cu)-Total (mg/L)	0.00327	0.00371	0.00507		
	Iron (Fe)-Total (mg/L)	0.689	0.539	1.21		
	Lead (Pb)-Total (mg/L)	0.000090	0.000072	0.000311		
	Lithium (Li)-Total (mg/L)	0.0018	0.0011	0.0026		
	Magnesium (Mg)-Total (mg/L)	14.7	10.1	14.8		
	Manganese (Mn)-Total (mg/L)	0.0756	0.0852	0.0495		
	Molybdenum (Mo)-Total (mg/L)	0.000768	0.000483	0.000720		
	Nickel (Ni)-Total (mg/L)	0.00193	0.00166	0.00273		
	Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050		

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1624721-1	L1624721-2	L1624721-3	L1624721-4	L1624721-5
	Description	GRAB	GRAB	GRAB	GRAB	GRAB
	Sampled Date	09-JUN-15	09-JUN-15	09-JUN-15	09-JUN-15	09-JUN-15
	Sampled Time	09:50	10:45	13:30	14:20	15:00
	Client ID	MC8 - MOSQUITO CREEK - SITE #8	MC7 - MOSQUITO CREEK - SITE #7	MC6 - MOSQUITO CREEK - SITE #6	MC5 - MOSQUITO CREEK - SITE #5	MC4 - MOSQUITO CREEK - SITE #4
Grouping	**Analyte**					
WATER						
Total Metals	Potassium (K)-Total (mg/L)	1.02	1.44	2.58	1.64	1.42
	Rubidium (Rb)-Total (mg/L)	0.00085	0.00077	0.00150	0.00072	0.00076
	Selenium (Se)-Total (mg/L)	0.000153	0.000188	0.000123	0.000130	0.000152
	Silicon (Si)-Total (mg/L)	4.04	2.03	6.76	1.67	3.25
	Silver (Ag)-Total (mg/L)	0.000013	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	1.99	22.1	111	30.8	11.6
	Strontium (Sr)-Total (mg/L)	0.0284	0.0671	0.173	0.0834	0.0454
	Sulfur (S)-Total (mg/L)	0.74	2.34	10.5	3.75	1.22
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Total (mg/L)	0.00846	0.00196	0.00133	0.00083	0.00391
	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Uranium (U)-Total (mg/L)	0.000095	0.000487	0.00119	0.000736	0.000185
	Vanadium (V)-Total (mg/L)	0.00163	0.00135	0.00072	0.00087	0.00153
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030	0.0038	<0.0030	<0.0030
	Zirconium (Zr)-Total (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1624721-6	L1624721-7	L1624721-8		
	Description	GRAB	GRAB	GRAB		
	Sampled Date	10-JUN-15	10-JUN-15	10-JUN-15		
	Sampled Time	09:35	10:25	11:00		
	Client ID	MC3 - MOSQUITO CREEK - SITE #3	MC2 - MOSQUITO CREEK - SITE #2	MC1 - MOSQUITO CREEK - SITE #1		
Grouping	**Analyte**					
WATER						
Total Metals	Potassium (K)-Total (mg/L)	1.73	1.11	1.69		
	Rubidium (Rb)-Total (mg/L)	0.00095	0.00074	0.00154		
	Selenium (Se)-Total (mg/L)	0.000157	0.000160	0.000174		
	Silicon (Si)-Total (mg/L)	3.05	5.80	4.83		
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010		
	Sodium (Na)-Total (mg/L)	30.2	14.8	28.7		
	Strontium (Sr)-Total (mg/L)	0.0906	0.0511	0.0858		
	Sulfur (S)-Total (mg/L)	2.92	3.87	3.64		
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020		
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	0.000013		
	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	0.00011		
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Titanium (Ti)-Total (mg/L)	0.00642	0.00459	0.0239		
	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Uranium (U)-Total (mg/L)	0.000475	0.000269	0.000561		
	Vanadium (V)-Total (mg/L)	0.00182	0.00119	0.00331		
	Zinc (Zn)-Total (mg/L)	<0.0030	0.0031	0.0036		
	Zirconium (Zr)-Total (mg/L)	<0.00030	<0.00030	0.00053		

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

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Calcium (Ca)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Strontium (Sr)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Aluminum (Al)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Cadmium (Cd)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Calcium (Ca)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Copper (Cu)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Manganese (Mn)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Sodium (Na)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Strontium (Sr)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Sulfur (S)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Zinc (Zn)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-TB	Water	Alkalinity	APHA 2320

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.

CL-L-IC-N-TB	Water	Chloride in Water by IC (Low Level)	EPA 300.1 (mod)

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

EC-TITR-TB	Water	Conductivity	APHA 2510 B

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

HARDNESS-CALC-TB	Water	Hardness (as CaCO3)	CALCULATION
MET-T-CCMS-TB	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

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.

NH3-COL-TB	Water	Ammonia by Discrete Analyzer	APHA 4500-NH3 G. (modified)

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

NO2-IC-TB	Water	Nitrite in Water by IC	EPA 300.1 (mod)

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

NO3-IC-TB	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Anions in aqueous matrices are analyzed using ion chromatography with conductivity and/or UV absorbance detectors.

P-T-COL-TB	Water	Total Phosphorus by Discrete Analyzer	APHA 4500-P B, F, G (modified)

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

PH-TITR-TB	Water	pH	APHA 4500-H

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

SO4-IC-N-TB	Water	Sulfate in Water by IC	EPA 300.1 (mod)

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

TC,EC-QT97-TB	Water	Total Coliform and E.coli	APHA 9223 B

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

Reference Information

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.

TDS-TB	Water	Total Dissolved Solids	APHA 2540 C (modified)

Aqueous matrices are analyzed using gravimetry and evaporation

TKN-COL-TB	Water	Total Kjeldahl Nitrogen	APHA 4500-Norg (modified)

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

TURBIDITY-TB	Water	Turbidity	APHA 2130 B-Nephelometer

Aqueous matrices are analyzed using nephelometry with the light scatter measured at a 90” 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:

Laboratory Definition Code	Laboratory Location
TB	ALS ENVIRONMENTAL - THUNDER BAY, ONTARIO, CANADA

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 based on dry weight of sample.
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.

ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1624721-COFC

COC Number: 14 -

L1624721

Page 1 of 1

Report To		Report Format / Distribution		Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Lakehead Region Conservation Authority	Select Report Format:	☒ PDF ☐ EXCEL ☐ EDD (DIGITAL)	R ☑ Regular (Standard TAT if received by 3 pm - business days)
Contact:	Tammy Cook	Quality Control (QC) Report with Report	☐ Yes ☒ No	P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	130 Conservation Road PO Box 10427	☐ Criteria on Report - provide details below if box checked		E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
		Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX	E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	807-344-5857 ext 224	Email 1 or Fax	tammy@lakeheadca.com	Specify Date Required for E2, E or P:
		Email 2	Scott@lakeheadca.com	

Invoice To		Invoice Distribution	
	Same as Report To ☑ Yes ☐ No	Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
	Copy of Invoice with Report ☑ Yes ☐ No		
Company:		Email 1 or Fax	
Contact:		Email 2	

Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:	Q51234	Approver ID:	Cost Center:
Job #:	Mosquito Creek	GL Account:	Routing Code:
PO / AFE:		Activity Code:	
LSD:		Location:	

ALS Lab Work Order # (lab use only):

ALS Contact:

Sampler: SD, JH

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

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Alkalinity, Conductivity, pH	Chloride, Nitrate, Nitrite, Sulphate	TDS, Turbidity	NH3, TKN, TP	Metals, Total & Hardness	TC/EC	Number of Containers
	MC8 - Mosquito Creek - Site #8	09-JUN-15	09:50	grab	X	X	X	X	X	X	5
	MC7 - Mosquito Creek - Site #7	09-JUN-15	10:45	grab	X	X	X	X	X	X	5
	MC6 - Mosquito Creek - Site #6	09-JUN-15	13:30	grab	X	X	X	X	X	X	5
	MC5 - Mosquito Creek - Site #5	09-JUN-15	14:20	grab	X	X	X	X	X	X	5
	MC4 - Mosquito Creek - Site #4	09-JUN-15	15:00	grab	X	X	X	X	X	X	5
	MC3 - Mosquito Creek - Site #3	10-JUN-15	09:35	grab	X	X	X	X	X	X	5
	MC2 - Mosquito Creek - Site #2	10-JUN-15	10:25	grab	X	X	X	X	X	X	5
	MC1 - Mosquito Creek - Site #1	10-JUN-15	11:00	grab	X	X	X	X	X	X	5

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

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

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

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

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice packs Yes ☑ No ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C		FINAL COOLER TEMPERATURES °C	
	10.5		

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date: June 10/15	Time: 13:45	Received By: RT	Date: 6/10/15	Time: 1:50	Received by: BS Jun 10 15	Date:	Time: 3:00

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

ALS-PM-0326e v08 Front/04 January 2014

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

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

LAKEHEAD REGION CONSERVATION AUTHORITY
ATTN: Tammy Cook
130 CONSERVATION ROAD
P.O. BOX 10427
THUNDER BAY ON P7B 6T8

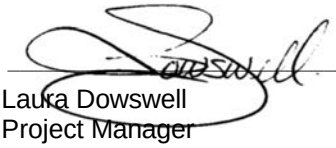
Date Received: 10-JUN-15
Report Date: 18-JUN-15 14:00 (MT)
Version: FINAL

Client Phone: 807-344-5857

Certificate of Analysis

Lab Work Order #: L1624721

Project P.O. #: NOT SUBMITTED
Job Reference: MOSQUITO CREEK
C of C Numbers:
Legal Site Desc:



Laura Dowswell
Project Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1624721-1	L1624721-2	L1624721-3	L1624721-4	L1624721-5
	Description	GRAB	GRAB	GRAB	GRAB	GRAB
	Sampled Date	09-JUN-15	09-JUN-15	09-JUN-15	09-JUN-15	09-JUN-15
	Sampled Time	09:50	10:45	13:30	14:20	15:00
	Client ID	MC8 - MOSQUITO CREEK - SITE #8	MC7 - MOSQUITO CREEK - SITE #7	MC6 - MOSQUITO CREEK - SITE #6	MC5 - MOSQUITO CREEK - SITE #5	MC4 - MOSQUITO CREEK - SITE #4
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (EC) (uS/cm)	108	378	1110	469	217
	Hardness (as CaCO3) (mg/L)	60.1	152	312	173	90.2
	pH (pH)	7.39	7.41	8.02	7.73	7.72
	Total Dissolved Solids (mg/L)	97	252	606	278	151
	Turbidity (NTU)	5.99	2.27	1.17	0.96	2.83
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	58.8	136	273	151	83.3
	Ammonia, Total (as N) (mg/L)	<0.020	<0.020	<0.020	0.032	<0.020
	Chloride (Cl) (mg/L)	0.32	37.8	180	53.8	17.9
	Nitrate (as N) (mg/L)	0.021	0.020	0.845	<0.020	0.032
	Nitrite (as N) (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Total Kjeldahl Nitrogen (mg/L)	0.48	0.54	0.41	0.63	0.38
	Phosphorus (P)-Total (mg/L)	0.0177	0.0651	0.0071	0.0261	0.0190
	Sulfate (SO4) (mg/L)	1.39	5.69	23.8	8.62	2.60
Bacteriological Tests	Escherichia Coli (MPN/100mL)	30	6	3	10	88
	Total Coliforms (MPN/100mL)	2420	1730	1300	1050	1300
Total Metals	Aluminum (Al)-Total (mg/L)	0.337	0.0528	0.0396	0.0204	0.141
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	0.00010	<0.00010	<0.00010
	Arsenic (As)-Total (mg/L)	0.00056	0.00085	0.00048	0.00072	0.00073
	Barium (Ba)-Total (mg/L)	0.0114	0.0206	0.0529	0.0286	0.0138
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	0.011	0.014	0.035	0.015	0.012
	Cadmium (Cd)-Total (mg/L)	0.0000225	0.0000157	0.0000275	0.0000087	0.0000167
	Calcium (Ca)-Total (mg/L)	14.0	34.4	77.7	39.6	21.2
	Cesium (Cs)-Total (mg/L)	0.000026	<0.000010	<0.000010	<0.000010	<0.000010
	Chromium (Cr)-Total (mg/L)	0.00098	0.00045	0.00036	0.00033	0.00094
	Cobalt (Co)-Total (mg/L)	0.00027	0.00043	0.00033	0.00016	0.00023
	Copper (Cu)-Total (mg/L)	0.00349	0.00145	0.00383	0.00177	0.00314
	Iron (Fe)-Total (mg/L)	0.643	0.904	0.161	0.377	0.663
	Lead (Pb)-Total (mg/L)	0.000108	<0.000050	<0.000050	0.000088	0.000088
	Lithium (Li)-Total (mg/L)	<0.0010	0.0013	0.0063	0.0016	<0.0010
	Magnesium (Mg)-Total (mg/L)	6.11	16.1	28.5	18.0	9.03
	Manganese (Mn)-Total (mg/L)	0.0264	0.212	0.0438	0.0417	0.0590
	Molybdenum (Mo)-Total (mg/L)	0.000406	0.000662	0.000947	0.000721	0.000629
	Nickel (Ni)-Total (mg/L)	0.00164	0.00165	0.00330	0.00161	0.00174
	Phosphorus (P)-Total (mg/L)	<0.050	0.069	<0.050	<0.050	<0.050

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1624721-6	L1624721-7	L1624721-8		
	Description	GRAB	GRAB	GRAB		
	Sampled Date	10-JUN-15	10-JUN-15	10-JUN-15		
	Sampled Time	09:35	10:25	11:00		
	Client ID	MC3 - MOSQUITO CREEK - SITE #3	MC2 - MOSQUITO CREEK - SITE #2	MC1 - MOSQUITO CREEK - SITE #1		
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (EC) (uS/cm)	408	264	412		
	Hardness (as CaCO3) (mg/L)	150	104	151		
	pH (pH)	7.90	7.76	8.21		
	Total Dissolved Solids (mg/L)	238	174	237		
	Turbidity (NTU)	4.65	3.69	24.6		
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	128	94.2	129		
	Ammonia, Total (as N) (mg/L)	<0.020	<0.020	<0.020		
	Chloride (Cl) (mg/L)	46.2	20.7	51.7		
	Nitrate (as N) (mg/L)	0.051	0.024	0.070		
	Nitrite (as N) (mg/L)	<0.010	<0.010	<0.010		
	Total Kjeldahl Nitrogen (mg/L)	0.43	0.39	0.45		
	Phosphorus (P)-Total (mg/L)	0.0208	0.0145	0.0283		
	Sulfate (SO4) (mg/L)	6.15	9.22	9.41		
Bacteriological Tests	Escherichia Coli (MPN/100mL)	102	9	27		
	Total Coliforms (MPN/100mL)	1990	2420	1300		
Total Metals	Aluminum (Al)-Total (mg/L)	0.207	0.142	0.730		
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Arsenic (As)-Total (mg/L)	0.00085	0.00070	0.00095		
	Barium (Ba)-Total (mg/L)	0.0479	0.0155	0.0516		
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050		
	Boron (B)-Total (mg/L)	0.017	0.017	0.017		
	Cadmium (Cd)-Total (mg/L)	0.0000182	0.0000177	0.0000329		
	Calcium (Ca)-Total (mg/L)	35.7	25.1	35.9		
	Cesium (Cs)-Total (mg/L)	0.000015	0.000013	0.000066		
	Chromium (Cr)-Total (mg/L)	0.00068	0.00070	0.00146		
	Cobalt (Co)-Total (mg/L)	0.00029	0.00023	0.00057		
	Copper (Cu)-Total (mg/L)	0.00327	0.00371	0.00507		
	Iron (Fe)-Total (mg/L)	0.689	0.539	1.21		
	Lead (Pb)-Total (mg/L)	0.000090	0.000072	0.000311		
	Lithium (Li)-Total (mg/L)	0.0018	0.0011	0.0026		
	Magnesium (Mg)-Total (mg/L)	14.7	10.1	14.8		
	Manganese (Mn)-Total (mg/L)	0.0756	0.0852	0.0495		
	Molybdenum (Mo)-Total (mg/L)	0.000768	0.000483	0.000720		
	Nickel (Ni)-Total (mg/L)	0.00193	0.00166	0.00273		
	Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050		

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1624721-1	L1624721-2	L1624721-3	L1624721-4	L1624721-5
	Description	GRAB	GRAB	GRAB	GRAB	GRAB
	Sampled Date	09-JUN-15	09-JUN-15	09-JUN-15	09-JUN-15	09-JUN-15
	Sampled Time	09:50	10:45	13:30	14:20	15:00
	Client ID	MC8 - MOSQUITO CREEK - SITE #8	MC7 - MOSQUITO CREEK - SITE #7	MC6 - MOSQUITO CREEK - SITE #6	MC5 - MOSQUITO CREEK - SITE #5	MC4 - MOSQUITO CREEK - SITE #4
Grouping	**Analyte**					
WATER						
Total Metals	Potassium (K)-Total (mg/L)	1.02	1.44	2.58	1.64	1.42
	Rubidium (Rb)-Total (mg/L)	0.00085	0.00077	0.00150	0.00072	0.00076
	Selenium (Se)-Total (mg/L)	0.000153	0.000188	0.000123	0.000130	0.000152
	Silicon (Si)-Total (mg/L)	4.04	2.03	6.76	1.67	3.25
	Silver (Ag)-Total (mg/L)	0.000013	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	1.99	22.1	111	30.8	11.6
	Strontium (Sr)-Total (mg/L)	0.0284	0.0671	0.173	0.0834	0.0454
	Sulfur (S)-Total (mg/L)	0.74	2.34	10.5	3.75	1.22
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Total (mg/L)	0.00846	0.00196	0.00133	0.00083	0.00391
	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Uranium (U)-Total (mg/L)	0.000095	0.000487	0.00119	0.000736	0.000185
	Vanadium (V)-Total (mg/L)	0.00163	0.00135	0.00072	0.00087	0.00153
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030	0.0038	<0.0030	<0.0030
	Zirconium (Zr)-Total (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1624721-6	L1624721-7	L1624721-8		
	Description	GRAB	GRAB	GRAB		
	Sampled Date	10-JUN-15	10-JUN-15	10-JUN-15		
	Sampled Time	09:35	10:25	11:00		
	Client ID	MC3 - MOSQUITO CREEK - SITE #3	MC2 - MOSQUITO CREEK - SITE #2	MC1 - MOSQUITO CREEK - SITE #1		
Grouping	**Analyte**					
WATER						
Total Metals	Potassium (K)-Total (mg/L)	1.73	1.11	1.69		
	Rubidium (Rb)-Total (mg/L)	0.00095	0.00074	0.00154		
	Selenium (Se)-Total (mg/L)	0.000157	0.000160	0.000174		
	Silicon (Si)-Total (mg/L)	3.05	5.80	4.83		
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010		
	Sodium (Na)-Total (mg/L)	30.2	14.8	28.7		
	Strontium (Sr)-Total (mg/L)	0.0906	0.0511	0.0858		
	Sulfur (S)-Total (mg/L)	2.92	3.87	3.64		
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020		
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	0.000013		
	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	0.00011		
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Titanium (Ti)-Total (mg/L)	0.00642	0.00459	0.0239		
	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Uranium (U)-Total (mg/L)	0.000475	0.000269	0.000561		
	Vanadium (V)-Total (mg/L)	0.00182	0.00119	0.00331		
	Zinc (Zn)-Total (mg/L)	<0.0030	0.0031	0.0036		
	Zirconium (Zr)-Total (mg/L)	<0.00030	<0.00030	0.00053		

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

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Calcium (Ca)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Strontium (Sr)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Aluminum (Al)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Cadmium (Cd)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Calcium (Ca)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Copper (Cu)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Manganese (Mn)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Sodium (Na)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Strontium (Sr)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Sulfur (S)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Zinc (Zn)-Total	MS-B	L1624721-1, -2, -3, -4, -5, -6, -7, -8

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-TB	Water	Alkalinity	APHA 2320

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.

CL-L-IC-N-TB	Water	Chloride in Water by IC (Low Level)	EPA 300.1 (mod)

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

EC-TITR-TB	Water	Conductivity	APHA 2510 B

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

HARDNESS-CALC-TB	Water	Hardness (as CaCO3)	CALCULATION
MET-T-CCMS-TB	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

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.

NH3-COL-TB	Water	Ammonia by Discrete Analyzer	APHA 4500-NH3 G. (modified)

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

NO2-IC-TB	Water	Nitrite in Water by IC	EPA 300.1 (mod)

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

NO3-IC-TB	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Anions in aqueous matrices are analyzed using ion chromatography with conductivity and/or UV absorbance detectors.

P-T-COL-TB	Water	Total Phosphorus by Discrete Analyzer	APHA 4500-P B, F, G (modified)

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

PH-TITR-TB	Water	pH	APHA 4500-H

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

SO4-IC-N-TB	Water	Sulfate in Water by IC	EPA 300.1 (mod)

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

TC,EC-QT97-TB	Water	Total Coliform and E.coli	APHA 9223 B

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

Reference Information

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.

TDS-TB	Water	Total Dissolved Solids	APHA 2540 C (modified)

Aqueous matrices are analyzed using gravimetry and evaporation

TKN-COL-TB	Water	Total Kjeldahl Nitrogen	APHA 4500-Norg (modified)

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

TURBIDITY-TB	Water	Turbidity	APHA 2130 B-Nephelometer

Aqueous matrices are analyzed using nephelometry with the light scatter measured at a 90” 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:

Laboratory Definition Code	Laboratory Location
TB	ALS ENVIRONMENTAL - THUNDER BAY, ONTARIO, CANADA

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 based on dry weight of sample.
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

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L1624721-COFC

COC Number: 14 - L1624721 (75)

Page 1 of 1

Report To		Report Format / Distribution	Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Lakehead Region Conservation Authority	Select Report Format: [X] PDF [ ] EXCEL [ ] EDD (DIGITAL)	R [✓] Regular (Standard TAT if received by 3 pm - business days)
Contact:	Tammy Cook	Quality Control (QC) Report with Report [ ] Yes [X] No	P [ ] Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	130 Conservation Road PO Box 10427	[ ] Criteria on Report - provide details below if box checked	E [ ] Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
		Select Distribution: [✓] EMAIL [ ] MAIL [ ] FAX	E2 [ ] Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	807-344-5857 ext 224	Email 1 or Fax tammy@lakeheadca.com	Specify Date Required for E2, E or P:
		Email 2 Scott@lakeheadca.com	

Invoice To		Invoice Distribution	Analysis Request
	Same as Report To [✓] Yes [ ] No	Select Invoice Distribution: [✓] EMAIL [ ] MAIL [ ] FAX	Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below
	Copy of Invoice with Report [✓] Yes [ ] No		
Company:		Email 1 or Fax	
Contact:		Email 2	

Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:	Q51234	Approver ID:	Cost Center:
Job #:	Mosquito Creek	GL Account:	Routing Code:
PO / AFE:		Activity Code:	
LSD:		Location:	

ALS Lab Work Order # (lab use only):

ALS Contact:

Sampler: SD, JH

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Alkalinity, Conductivity, pH	Chloride, Nitrate, Nitrite, Sulphate	TDS, Turbidity	NH3, TKN, TP	Metals, Total & Hardness	TC/EC	Number of Containers
	MC8 - Mosquito Creek - Site #8	09-JUN-15	09:50	grab	X	X	X	X	X	X	5
	MC7 - Mosquito Creek - Site #7	09-JUN-15	10:45	grab	X	X	X	X	X	X	5
	MC6 - Mosquito Creek - Site #6	09-JUN-15	13:30	grab	X	X	X	X	X	X	5
	MC5 - Mosquito Creek - Site #5	09-JUN-15	14:20	grab	X	X	X	X	X	X	5
	MC4 - Mosquito Creek - Site #4	09-JUN-15	15:00	grab	X	X	X	X	X	X	5
	MC3 - Mosquito Creek - Site #3	10-JUN-15	09:35	grab	X	X	X	X	X	X	5
	MC2 - Mosquito Creek - Site #2	10-JUN-15	10:25	grab	X	X	X	X	X	X	5
	MC1 - Mosquito Creek - Site #1	10-JUN-15	11:00	grab	X	X	X	X	X	X	5

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

Are samples taken from a Regulated DW System? [ ] Yes [X] No

Are samples for human drinking water use? [ ] Yes [X] No

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

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen [ ] SIF Observations Yes [ ] No [ ]

Ice packs Yes [✓] No [ ] Custody seal intact Yes [ ] No [ ]

Cooling Initiated [✓]

INITIAL COOLER TEMPERATURES °C		FINAL COOLER TEMPERATURES °C	
	10.5		

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date: June 10/15	Time: 13:45	Received By: RT	Date: 6/10/15	Time: 1:50	Received by: BS Jun 10 15	Date:	Time: 3:00

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

ALS-PM-0326e v08 Front/04 January 2014

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

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

LAKEHEAD REGION CONSERVATION AUTHORITY
ATTN: Tammy Cook / Scott Drebit
130 CONSERVATION ROAD
P.O. BOX 10427
THUNDER BAY ON P7B 6T8

Date Received: 08-JUL-15
Report Date: 21-JUL-15 14:48 (MT)
Version: FINAL

Client Phone: 807-344-5857

Certificate of Analysis

Lab Work Order #: L1639120

Project P.O. #: NOT SUBMITTED
Job Reference: MOSQUITO CREEK
C of C Numbers:
Legal Site Desc:

Laura Dowswell
Project Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1639120-1	L1639120-2	L1639120-3	L1639120-4	L1639120-5
	Description	GRAB	GRAB	GRAB	GRAB	GRAB
	Sampled Date	07-JUL-15	07-JUL-15	08-JUL-15	08-JUL-15	08-JUL-15
	Sampled Time	13:40	14:35	09:30	10:15	10:45
	Client ID	MC8 - MOSQUITO CREEK - SITE #8	MC7 - MOSQUITO CREEK - SITE #7	MC6 - MOSQUITO CREEK - SITE #6	MC5 - MOSQUITO CREEK - SITE #5	MC4 - MOSQUITO CREEK - SITE #4
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (EC) (uS/cm)	162	482	1250	529	281
	Hardness (as CaCO3) (mg/L)	83.4	189	371	198	120
	pH (pH)	7.65	7.33	8.12	7.61	7.55
	Total Dissolved Solids (mg/L)	133	295	757	302	204
	Turbidity (NTU)	3.74	6.30	1.51	1.52	3.85
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	95.4	187	357	196	121
	Ammonia, Total (as N) (mg/L)	0.031	0.123	0.170	0.031	0.068
	Chloride (Cl) (mg/L)	0.41	46.2	212	59.6	23.1
	Nitrate (as N) (mg/L)	<0.020	<0.020	1.14	<0.020	<0.020
	Nitrite (as N) (mg/L)	<0.010	<0.010	<0.050 DLA	<0.010	<0.010
	Total Kjeldahl Nitrogen (mg/L)	0.93	1.36	0.56	0.86	0.98
	Phosphorus (P)-Total (mg/L)	0.0217	0.210	0.0081	0.0504	0.0449
	Sulfate (SO4) (mg/L)	0.75	<0.30	31.0	0.96	0.77
Bacteriological Tests	Escherichia Coli (MPN/100mL)	20	9	76	11	40
	Total Coliforms (MPN/100mL)	1990	435	>2420	2420	1990
Total Metals	Aluminum (Al)-Total (mg/L)	0.148	0.0313	0.0441	0.0146	0.137
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Total (mg/L)	0.00103	0.00258	0.00054	0.00148	0.00125
	Barium (Ba)-Total (mg/L)	0.0108	0.0292	0.0619	0.0388	0.0173
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	0.000075	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	0.011	0.014	0.045	0.015	0.013
	Cadmium (Cd)-Total (mg/L)	0.0000204	0.0000087	0.0000394	0.0000103	0.0000115
	Calcium (Ca)-Total (mg/L)	19.2	43.8	92.4	45.5	29.0
	Cesium (Cs)-Total (mg/L)	0.000011	<0.000010	0.000011	<0.000010	0.000010
	Chromium (Cr)-Total (mg/L)	0.00071	0.00049	0.00040	0.00044	0.00097
	Cobalt (Co)-Total (mg/L)	0.00031	0.00159	0.00048	0.00059	0.00038
	Copper (Cu)-Total (mg/L)	0.00204	0.00060	0.00330	0.00075	0.00183
	Iron (Fe)-Total (mg/L)	0.805	3.77	0.250	0.961	1.38
	Lead (Pb)-Total (mg/L)	0.000089	0.000063	<0.000050	<0.000050	0.000146
	Lithium (Li)-Total (mg/L)	0.0010	0.0019	0.0085	0.0021	0.0014
	Magnesium (Mg)-Total (mg/L)	8.61	19.3	34.2	20.4	11.5
	Manganese (Mn)-Total (mg/L)	0.0627	1.49	0.111	0.891	0.210
	Molybdenum (Mo)-Total (mg/L)	0.000390	0.000381	0.00102	0.000770	0.000804
	Nickel (Ni)-Total (mg/L)	0.00176	0.00149	0.00408	0.00200	0.00195
	Phosphorus (P)-Total (mg/L)	<0.050	0.215	<0.050	0.072	0.050

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1639120-6	L1639120-7	L1639120-8		
	Description	GRAB	GRAB	GRAB		
	Sampled Date	08-JUL-15	08-JUL-15	08-JUL-15		
	Sampled Time	11:30	12:45	13:20		
	Client ID	MC3 - MOSQUITO CREEK - SITE #3	MC2 - MOSQUITO CREEK - SITE #2	MC1 - MOSQUITO CREEK - SITE #1		
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (EC) (uS/cm)	590	337	557		
	Hardness (as CaCO3) (mg/L)	198	132	191		
	pH (pH)	8.07	7.84	8.33		
	Total Dissolved Solids (mg/L)	348	204	315		
	Turbidity (NTU)	7.13	2.33	14.0		
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	188	130	172		
	Ammonia, Total (as N) (mg/L)	0.050	0.074	0.056		
	Chloride (Cl) (mg/L)	83.9	33.8	76.3		
	Nitrate (as N) (mg/L)	0.043	0.044	0.072		
	Nitrite (as N) (mg/L)	<0.010	<0.010	<0.010		
	Total Kjeldahl Nitrogen (mg/L)	0.94	0.52	0.70		
	Phosphorus (P)-Total (mg/L)	0.0330	0.0205	0.0266		
	Sulfate (SO4) (mg/L)	6.30	6.83	9.57		
Bacteriological Tests	Escherichia Coli (MPN/100mL)	50	25	39		
	Total Coliforms (MPN/100mL)	1990	1990	>2420		
Total Metals	Aluminum (Al)-Total (mg/L)	0.285	0.0605	0.435		
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Arsenic (As)-Total (mg/L)	0.00125	0.00097	0.00135		
	Barium (Ba)-Total (mg/L)	0.109	0.0184	0.0795		
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050		
	Boron (B)-Total (mg/L)	0.022	0.018	0.022		
	Cadmium (Cd)-Total (mg/L)	0.0000241	0.0000139	0.0000425		
	Calcium (Ca)-Total (mg/L)	48.1	33.2	47.1		
	Cesium (Cs)-Total (mg/L)	0.000024	<0.000010	0.000044		
	Chromium (Cr)-Total (mg/L)	0.00082	0.00052	0.00115		
	Cobalt (Co)-Total (mg/L)	0.00045	0.00023	0.00051		
	Copper (Cu)-Total (mg/L)	0.00300	0.00285	0.00490		
	Iron (Fe)-Total (mg/L)	0.912	0.657	0.959		
	Lead (Pb)-Total (mg/L)	0.000158	0.000051	0.000241		
	Lithium (Li)-Total (mg/L)	0.0045	0.0023	0.0044		
	Magnesium (Mg)-Total (mg/L)	18.8	12.0	17.9		
	Manganese (Mn)-Total (mg/L)	0.108	0.140	0.0566		
	Molybdenum (Mo)-Total (mg/L)	0.000985	0.000589	0.00105		
	Nickel (Ni)-Total (mg/L)	0.00267	0.00186	0.00299		
	Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050		

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1639120-1	L1639120-2	L1639120-3	L1639120-4	L1639120-5
	Description	GRAB	GRAB	GRAB	GRAB	GRAB
	Sampled Date	07-JUL-15	07-JUL-15	08-JUL-15	08-JUL-15	08-JUL-15
	Sampled Time	13:40	14:35	09:30	10:15	10:45
	Client ID	MC8 - MOSQUITO CREEK - SITE #8	MC7 - MOSQUITO CREEK - SITE #7	MC6 - MOSQUITO CREEK - SITE #6	MC5 - MOSQUITO CREEK - SITE #5	MC4 - MOSQUITO CREEK - SITE #4
Grouping	**Analyte**					
WATER						
Total Metals	Potassium (K)-Total (mg/L)	0.933	1.85	2.76	1.74	1.57
	Rubidium (Rb)-Total (mg/L)	0.00077	0.00101	0.00167	0.00079	0.00090
	Selenium (Se)-Total (mg/L)	0.000172	0.000220	0.000106	0.000162	0.000193
	Silicon (Si)-Total (mg/L)	3.34	6.16	10.1	5.21	3.39
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	2.20	24.1	130	32.5	15.3
	Strontium (Sr)-Total (mg/L)	0.0378	0.0796	0.204	0.0948	0.0574
	Sulfur (S)-Total (mg/L)	<0.50	0.55	12.2	0.90	0.62
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Total (mg/L)	0.00491	0.00178	0.00165	0.00082	0.00456
	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Uranium (U)-Total (mg/L)	0.000117	0.000235	0.00127	0.000586	0.000241
	Vanadium (V)-Total (mg/L)	0.00160	0.00220	0.00085	0.00113	0.00173
	Zinc (Zn)-Total (mg/L)	0.0034	<0.0030	0.0048	0.0031	<0.0030
	Zirconium (Zr)-Total (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1639120-6	L1639120-7	L1639120-8		
	Description	GRAB	GRAB	GRAB		
	Sampled Date	08-JUL-15	08-JUL-15	08-JUL-15		
	Sampled Time	11:30	12:45	13:20		
	Client ID	MC3 - MOSQUITO CREEK - SITE #3	MC2 - MOSQUITO CREEK - SITE #2	MC1 - MOSQUITO CREEK - SITE #1		
Grouping	**Analyte**					
WATER						
Total Metals	Potassium (K)-Total (mg/L)	2.00	1.19	1.97		
	Rubidium (Rb)-Total (mg/L)	0.00139	0.00088	0.00163		
	Selenium (Se)-Total (mg/L)	0.000133	0.000129	0.000159		
	Silicon (Si)-Total (mg/L)	4.31	6.03	4.98		
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010		
	Sodium (Na)-Total (mg/L)	48.9	21.4	42.6		
	Strontium (Sr)-Total (mg/L)	0.152	0.0628	0.124		
	Sulfur (S)-Total (mg/L)	2.72	2.83	3.88		
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020		
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	0.000015		
	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Titanium (Ti)-Total (mg/L)	0.0100	0.00253	0.0150		
	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Uranium (U)-Total (mg/L)	0.000717	0.000314	0.000691		
	Vanadium (V)-Total (mg/L)	0.00266	0.00106	0.00369		
	Zinc (Zn)-Total (mg/L)	0.0039	<0.0030	0.0048		
	Zirconium (Zr)-Total (mg/L)	0.00036	<0.00030	0.00047		

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

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Total Kjeldahl Nitrogen	MS-B	L1639120-1, -2
Matrix Spike	Ammonia, Total (as N)	MS-B	L1639120-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Ammonia, Total (as N)	MS-B	L1639120-1, -2, -3, -4, -5, -6, -7, -8

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit adjusted for required dilution
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-TB	Water	Alkalinity	APHA 2320

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.

CL-L-IC-N-TB	Water	Chloride in Water by IC (Low Level)	EPA 300.1 (mod)

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

EC-TITR-TB	Water	Conductivity	APHA 2510 B

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

ETL-HARDNESS-TOT-ED	Water	Hardness (from Total Ca and Mg)	APHA 2340 B-Calculation
MET-T-CCMS-ED	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

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.

NH3-COL-TB	Water	Ammonia by Discrete Analyzer	APHA 4500-NH3 G. (modified)

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

NO2-IC-TB	Water	Nitrite in Water by IC	EPA 300.1 (mod)

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

NO3-IC-TB	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Anions in aqueous matrices are analyzed using ion chromatography with conductivity and/or UV absorbance detectors.

P-T-COL-TB	Water	Total Phosphorus by Discrete Analyzer	APHA 4500-P B, F, G (modified)

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

PH-TITR-TB	Water	pH	APHA 4500-H

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

SO4-IC-N-TB	Water	Sulfate in Water by IC	EPA 300.1 (mod)

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

TC,EC-QT97-TB	Water	Total Coliform and E.coli	APHA 9223 B

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.

TDS-TB	Water	Total Dissolved Solids	APHA 2540 C (modified)

Aqueous matrices are analyzed using gravimetry and evaporation

TKN-COL-TB	Water	Total Kjeldahl Nitrogen	APHA 4500-Norg (modified)

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

TURBIDITY-TB	Water	Turbidity	APHA 2130 B-Nephelometer

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

Reference Information

** 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:

Laboratory Definition Code	Laboratory Location
ED	ALS ENVIRONMENTAL - EDMONTON, ALBERTA, CANADA
TB	ALS ENVIRONMENTAL - THUNDER BAY, ONTARIO, CANADA

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 based on dry weight of sample.
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) / Analyt Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L1639120-COFC

ere L1639120

COC Number: 14 -

Page 1 of 1

Report To		Report Format / Distribution		Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Lakehead Region Conservation Authority	Select Report Format:	☒ PDF ☐ EXCEL ☐ EDD (DIGITAL)	R ☑ Regular (Standard TAT if received by 3 pm - business days)
Contact:	Tammy Cook	Quality Control (QC) Report with Report	☐ Yes ☒ No	P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	130 Conservation Road PO Box 10427	☐ Criteria on Report - provide details below if box checked		E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
Phone:	807-344-5857 ext 224	Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX	E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
		Email 1 or Fax	tammy@lakeheadca.com	Specify Date Required for E2,E or P:
		Email 2	Scott@lakeheadca.com	

Invoice To	Same as Report To ☑ Yes ☐ No	Invoice Distribution	
	Copy of Invoice with Report ☑ Yes ☐ No	Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Company:		Email 1 or Fax	
Contact:		Email 2	

Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:	Q51234	Approver ID:	Cost Center:
Job #:	Mosquito Creek	GL Account:	Routing Code:
PO / AFE:		Activity Code:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		ALS Contact:	Sampler: SD JH

Analysis Request

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

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Alkalinity, Conductivity, pH	Chloride, Nitrate, Nitrite, Sulphate	TDS, Turbidity	NH3, TKN, TP	Metals, Total & Hardness	TC/EC	Number of Containers
	MC8 - Mosquito Creek - Site #8	07-JUL-15	13:40	grab	X	X	X	X	X	X	5
	MC7 - Mosquito Creek - Site #7	07-JUL-15	14:35	grab	X	X	X	X	X	X	5
	MC6 - Mosquito Creek - Site #6	08-JUL-15	09:30	grab	X	X	X	X	X	X	5
	MC5 - Mosquito Creek - Site #5	08-JUL-15	10:15	grab	X	X	X	X	X	X	5
	MC4 - Mosquito Creek - Site #4	08-JUL-15	10:45	grab	X	X	X	X	X	X	5
	MC3 - Mosquito Creek - Site #3	08-JUL-15	11:30	grab	X	X	X	X	X	X	5
	MC2 - Mosquito Creek - Site #2	08-JUL-15	12:45	grab	X	X	X	X	X	X	5
	MC1 - Mosquito Creek - Site #1	08-JUL-15	13:20	grab	X	X	X	X	X	X	5

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report (client Use)
Are samples taken from a Regulated DW System? ☐ Yes ☒ No	
Are samples for human drinking water use? ☐ Yes ☒ No	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen	☐	SIF Observations	Yes ☐	No ☐	
Ice packs	Yes ☒	No ☐	Custody seal intact	Yes ☐	No ☐
Cooling Initiated	☐				

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
				12.1	

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date: Jul 8/15	Time:	Received By: MM	Date: 7/8/15	Time: 3:49	Received by: MT	Date: 8/7/15	Time: 17:00

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

NA FM-0328e v08 Front/04 January 2014

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

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