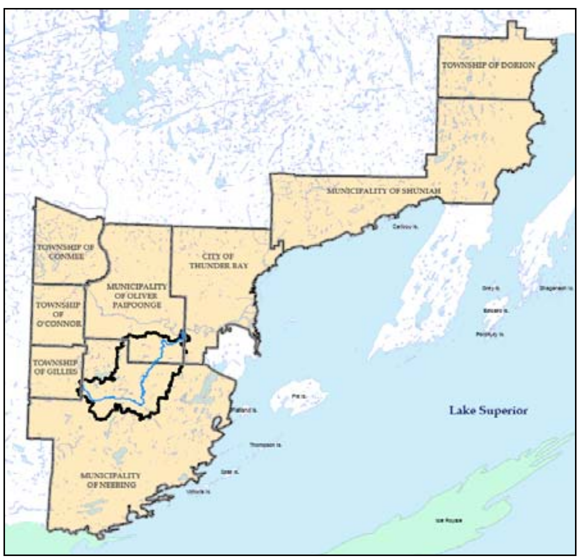
Slate River Watershed Assessment Report



2008

Lakehead Region Conservation Authority

Conserve today...For a better tomorrow

Slate River Watershed Assessment Report

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Written and Published by:

Lakehead Region Conservation Authority
Conserve Today...For A Better Tomorrow

Prepared by:

Cailin Maki (Assistant Water Resource Technologist)
Jennifer Grinstead (Watershed Stewardship Technician Intern)

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The Lakehead Region Conservation Authority would like to acknowledge the residents of the Slate River 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 the Slate River.

This report has been prepared in-house at the Lakehead Region Conservation Authority for internal purposes to document the condition of the Slate River in 2008.

Executive Summary

The Slate River watershed is located within the Township of Gillies, Municipalities of Oliver Paipoonge and Neebing and City of Thunder Bay. The Slate River watershed drains an area of 183 square kilometres including two named tributaries, Otter and Newton Creek. The Slate River runs 50.5 kilometres from its headwaters south of Oliver Lake to its confluence with the Kaministiquia River. The watershed is characterized by two distinct parts, an upper and lower watershed. The upper watershed has rolling hills and gentle slopes; the elevation quickly drops over 100 metres into the lower watershed known as the Slate River valley.

The surficial geology of the Slate River watershed is mainly bedrock from the Rove Formation and glaciolacustrine plain. The Slate River watershed is located within the boundaries of the Great Lakes – St. Lawrence forest region. However, the original forest composition has been changed over the years due to clearing the land for agriculture. In the upper watershed, the forest region is more typical of Boreal.

The majority of the watershed is designated as either Rural or Agricultural land use by the Official Plans of the Municipalities of Oliver Paipoonge and Neebing. Agricultural activity within the watershed is economically important to the Thunder Bay Region and is predominantly dairy farming.

For this Report, seven sample sites located along the Slate River were chosen based on a variety of attributes: accessibility, physical features, land use designation, proximity to made-made features that may alter water quality as well as headwaters used as a base reference.

At each of the seven sample locations, surface water samples and field measurements were collected on August 14 and August 27, 2008. Surface water samples were analyzed by ALS Laboratory Group for conductivity, total dissolved solids, turbidity, total ammonia, nitrate, nitrite, total phosphorus, *Escherichia coli* and a full metal scan. Field measurements included water temperature, pH, conductivity and dissolved oxygen. Field and laboratory results were compared to the Ministry of Environment’s *Provincial Water Quality Objectives* (PWQO).

Aluminum exceeded the PWQO criterion (75 micrograms per litre) at each of the sample sites, except Site 7 closest to the confluence with Kaministiquia River. Aluminum, at Sites 1 to 6 ranged between 110 to 350 micrograms per litre. Iron also exceeded the PWQO criterion (300 micrograms per litre) at each of the sample sites, except Site 7. Iron, at Sites 1 to 6 ranged between 540 to 1550 micrograms per litre. High aluminum and iron levels may be caused by the underlying geology and the natural dissociation of metals from rock. Copper exceeded the PWQO criterion (5 micrograms per litre) at Sites

2 and 7. On August 14, 2008 copper concentrations were 6 and 7 micrograms per litre at Sites 2 and 7, respectively. On August 27, 2008 the copper concentration was 6 micrograms per litre at Site 7. This may also be caused by natural sources.

Total phosphorus exceeded the PWQO criterion (< 30 micrograms per litre) at Sites 2 and 4. On August 14, 2008 the total phosphorus concentration was 32 micrograms per litre at Site 4. On August 27, 2008 the total phosphorus concentration was 45 micrograms per litre at Site 2. High total phosphorus levels may be caused by the natural decomposition of organic matter such as leaves, twigs, grass that is washed into the stream during the winter. There was no evidence that phosphorus levels altered water quality through excessive algae or plant growth and no explicit evidence of agricultural nutrient loading into the Slate River during 2008.

Escherichia coli (*E. coli*) exceeded the PWQO criterion for safe swimming and bathing (< 100 counts of *E. coli* per 100 millilitres of water) at Sites 3, 4 and 5. On August 27, 2008 *E. coli* counts were 150, 820 and 130 counts per 100 millilitres of water for Sites 3, 4 and 5, respectively. High *E. coli* counts may indicate recent fecal contamination of the surface water by human sanitary discharge, livestock or wildlife (geese and beavers).

The field measurement, dissolved oxygen, was below the PWQO recommended range at Site 1 during the assessment. Site 1, with results of 37 percent and 43 percent dissolved oxygen saturation were below the PWQO criteria of 54 percent and 47 percent dissolved oxygen saturation at 15 degrees Celsius for cold and warm water biota, respectively.

The flora and fauna inventory indicated that Slate River supports a healthy population of birds. The stream cover data suggests that the majority of the sampling areas had inadequate vegetation at the shoreline to provide shade for healthy benthic animal and fish populations. The streambanks documented along the Slate River in 2008 were stable and showed little signs of erosion. During the study the water crossings appeared to be functional, however at the time of assessment Culvert 2 was blocked by beaver activity and flow was restricted.

Compared to April-July 1990 water quality results for the Slate River, collected by the Ministry of Enironment, published in the Slate River Watershed Management Plan (Cullis *et al.* 1998), August 2008 results demonstrate improvement in total phosphorus, nitrate, ammonium, and *E. coli* levels using current water quality guidelines.

Although historical development of the Slate River watershed has altered surface water quality and forest composition, it can be concluded that at the time of assessment in August 2008, the Slate River watershed was in good condition for a watershed with sustained agricultural activity.

It is recommended that Slate River be monitored in the future as personnel and funding permit and that voluntary stewardship initiatives are encouraged to rehabilitate the streambanks of the Slate River to improve water quality.

The recommendations are as follows:

- Additional sampling should be conducted in spring to observe the water quality differences between high and low flow seasons
- Additional sampling should be conducted to assess the benthic macroinvertebrate community as an indicator of water quality
- Additional monitoring of nutrient, metal and bacterial levels as indicators of water quality
- A 30 metre riparian buffer zone should be allowed to grow along the Slate River, including its seasonal tributaries to improve water quality
- Fences should be erected to prevent livestock direct access to the water’s edge to improve water quality

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1 Introduction

The Slate River watershed is located within the Township of Gillies, Municipalities of Oliver Paipoonge (Geographic Township of Paipoonge) and Neebing (Geographic Townships of Scoble, Blake and Pearson) and City of Thunder Bay inside the jurisdictional boundary of the Lakehead Region Conservation Authority (LRCA); as shown on the Key Plan Map, M-1. A watershed can be defined as all land and water within the confines of a drainage divide. Essentially, the Slate River watershed is comprised of all the surrounding land that naturally drains its lakes, streams, wetlands and precipitation runoff. Technically, Slate River is a sub-watershed of the Kaministiquia River, which flows into Lake Superior. The Slate River is 50.5 kilometres (km) in length and drains two named tributaries, Otter and Newton Creek. The total drainage area of the watershed is 183 square kilometres (km^2). In the spring the Slate River yields high runoff and suffers from periods of low flow during the summer. Agricultural land comprises a significant portion of the Slate River watershed.

The goal of this Report is to document the conditions of the watershed, especially surface water quality, as observed in the summer of 2008, and ultimately use the information 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 Report are to:

- Summarize the physical, biological and socio-economic features of the watershed
- Document the physical condition of all Slate River water crossings (bridges/culverts)
- Collect surface water quality data
- Collect field measurements
- Identify and classify flora and fauna observed along the watershed
- Document active erosion sites and high water marks
- Interpret results to record the health status of the watershed

Historically, due to concerns about impacts from agricultural practices within the Slate River watershed, the Lake Superior Programs Office produced a Watershed Management Plan for the Slate River in 1998 (Cullis *et al*.).

2 Background

2.1 Physical Features

2.1.1 Topography

The area is described as a mesa (a land formation, less extensive than a plateau, having steep walls and a relatively flat top) highland bordering a flat valley. The range of mesas on the east boundary is known as the Nor'westers, including Squaretop Mountain and Mount Hurlburt. The highest point in elevation of the watershed is Mount Hurlburt at 502 metres above sea level (masl). The lowest point in elevation, at the mouth of the river, is 190 masl. The Slate River originates from a mesa plateau at an elevation of approximately 335 masl. On this plateau the land is characterized by rolling hills and gentle slopes. At the end of the plateau the elevation quickly drops over 100 metres into the Slate River valley. This area is flat compared to the upper watershed. Next, the river flows through the Slate River Gorge to meet the Kaministiquia River. Associated with the mesa landform are talus slopes (large rocks accumulated at the bottom of a cliff), rock walls, a steep-sided ravine (the gorge) and shore terraces representative of a glacial lake. Map M-3 illustrates Slate River watershed topography.

2.1.2 Geology and Soils

Slate River geology and soils originates from the last glacial re-advancement in 11,000 B.P. When this ancient glacier advanced, it created a large moraine arching through Marks and Conmee Township, abutting the Dog Lake Moraine near Lappe (Hartvikensen and Momot 1987). These moraines held up a large post-glacial lake, which drained to the west and covered most of Northwestern Ontario and a portion of Manitoba. Eventually, a breach in the Marks Moraine occurred, spilling very large quantities of sediment into the post-glacial lake to form a delta. The shore of this ancient lake, and all its sediments, now occurs along the Slate River area. Bedrock in the watershed consists of the Rove Formation and diabase (dolerite) igneous rock. The Rove Formation contains predominantly dark-coloured fissile argillites (a metamorphic rock, intermediate between shale and slate that is easily split along close parallel lines) and red and green shales (Moorhouse, 1960). The Slate River derived its name from the outcropping of this bedrock near its mouth, in the gorge. The soil of the Slate River watershed is mostly composed of lacustrine clay or silt deposits, calcareous reddish clay loam, noncalcareous fine sandy loam, and stony glacial till derived from shale (Agriculture Canada, 1981) (Hills & Morwick 1944). The moisture retention is better in Slate River loam soil than in either the heavy clays (poor drainage) or light sands (high drainage). According to the Canada Land Inventory performed in the 1960s, the soils in the Slate River are Class 2 and 3 (Agriculture and Agri-Food Canada 1998). The soil classification ranges from 1 (no limitations in use for crop) to 7 (no capacity for arable culture or pasture). This means

Slate River soils are capable of sustaining agriculture with moderate (Class 2) to moderately severe (Class 3) limitations that restrict the range of crops or require special conservation practices. Map M-4 illustrates Slate River watershed surficial geology; Maps M-5 and M-6 illustrate Slate River watershed soil type.

2.1.3 Climate

The climate in the lower portion of the Slate River watershed is similar to Thunder Bay. The climate in the upper watershed is minimally different because of elevation and distance from Lake Superior. Lake Superior modifies the climate of Thunder Bay and the surrounding regions with prevailing westerly winds. The average monthly temperatures in degrees Celsius (ºC) and precipitation levels in millimetres (mm) for Thunder Bay were recorded at the Thunder Bay Airport from 1971 to 2000 (Environment Canada, 2008).

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 Average (ºC)	-14.8	-12	-5.5	2.9	9.5	14	17.6	16.6	11	5	-3	-11.6
Precipitation												
Total Precip (mm)	31.3	24.9	41.6	41.5	66.5	85.7	89	87.5	88	62.6	55.6	37.5

The average monthly temperatures (ºC) and precipitation levels (mm) for Thunder Bay were recorded at the Thunder Bay Airport for 2008 (Environment Canada, 2008).

Table 2.1-2: Average monthly temperature and precipitation for Thunder Bay, January-August 2008

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Temperature								
Daily Average (ºC)	-12.2	-13.8	-7.4	2.9	7.4	14.5	17.6	17.1
Precipitation								
Total Precipitation (mm)	17	6.5	14	60	76.5	195	46	60

From two weeks prior to sampling to the end of the sampling period (July 31-August 27, 2008), the average daily temperature was 17.2ºC, with a maximum temperature of 32.9ºC and a minimum temperature of 2.2ºC.

In comparison with the historical data, 2008 had significantly more precipitation in June (more than double) and less in July and August (less than half). Environment Canada's Slate River streamflow gauge located on Candy Mountain Drive (48º19'29"North; 89º24'17"West) recorded monthly total precipitation as 133.9 mm, 41.4 mm and 40.2 mm for June, July and August 2008, respectively.

2.1.4 Hydrology

The Slate River is 50.5 km long from the headwater area (south of Oliver Lake; near Union School Road) to the mouth at the Kaministiquia River. The drainage area for the Slate River watershed is 183 square kilometres (km^2). The general slope of the watershed is 0.7 percent (%). Most likely, the majority of Slate River flow comes from surface water runoff during spring melts. The water level is highly variable between seasons with high flow in spring to low flow by the end of summer.

From November 2006 until July 3, 2007, Slate River was in a confirmed Level II Low Water Condition since received precipitation was less than 60 percent of the monthly average. The LRCA issued news releases asking the public to reduce water consumption by 20 percent, especially in rural areas where drinking water comes from wells. Figure 1 shows the extent of the drought.

On June 6, 2008 the LRCA issued a Flood Warning. Slate River received 56.5 mm of rainfall between 10:00 a.m. to 11:00 p.m. on that date and its maximum discharge was 57.1 cubic metres per second (m^3/s) recorded at the streamflow gauge (Environment Canada 2008). However, to put the flood in context, between 56.5 mm and 105 mm of precipitation were recorded at area gauges. Between June 10 to June 12, 2008 the LRCA issued Flood Advisories as waterways were still high from the June 6th event and additional precipitation was forcasted. Slate River received 12.0 mm of rainfall during that time. Figure 2 shows the extent of the flooding.

From July 31-August 27, 2008 (two weeks prior to the end of sampling period) the Slate River discharge declined from 0.1 to 0.02 m^3/s at the Slate River streamflow gauge. Figure 3 illustrates change in discharge over time. Stream discharge refers to the total volume of water in the stream. It is a function of the stream width, depth and velocity. Some stretches of the Slate River have historically had little to no flow as was the case in the summer and fall of 2006 when the LRCA Jurisdiction was in a Level II Low Water Condition.

The watershed contains three named water bodies, the Slate River and its two tributaries Newton and Otter Creek. Newton and Otter Creeks drainage area is 28 km^2 and 22 km^2, respectively. During August 2008, the tributaries were dry. The largest lake, unnamed, in the watershed, is 5.2 hectares (ha) and is located on the south branch of Otter Creek. The Slate River watershed contains 1130 ha of wetlands (Cullis *et al.* 1998). Oliver Lake swamp, located just south of Oliver Lake, is the only wetland area to be assessed by the Ontario Ministry of Natural Resources (OMNR). The wetland was given the highest ranking for its biodiversity (Geomatics International 1991). Since the hydrological component of the wetland was not evaluated it is not known whether or not it is provincially or regionally significant.

2.2 Biological Features

2.2.1 Flora

The Slate River watershed is located within the boundaries of the Great Lakes -St. Lawrence forest region. It is categorized as such due to the original abundance of eastern white pine and red pine and occasionally yellow birch. In the upper watershed, in Scoble and Pearson Townships, the forest region is more typical of the Boreal with tree species such as black spruce, jack pine, white birch and trembling aspen. The original forest composition has been changed over the years by logging practices, forest fires in the late 1800s and early 1900s, and clearing the land for agriculture. According to Cullis *et al*., in 1998 there was 111 km^2 of productive forest in the watershed; 89.4 km^2 deciduous and the remaining 21.6 km^2 coniferous.

Thunder Bay Field Naturalists compiled a list of vascular plants found within the Slate River (Harris 1996). Species are mostly characteristic of wetlands or disturbed areas. Wetland species include sedges, spikerushes, bulrushes and violets. Disturbed area species include goldenrods, thistles, and asters. Plants considered either regionally or provincially significant are found within the Areas of Natural and Scientific Interest (ANSIs).

2.2.2 Fauna

The Slate River watershed provides habitat for 109 different breeding bird populations recorded by Thunder Bay Field Naturalists (Escott 1996). Some of the more common species include cedar waxwings, blue jays, white-breasted nuthatches, and American goldfinches.

There have been historical reports of brook trout in streams throughout the watershed, as well as accounts of walleye spawning prior to 1960. Northern pike, common white sucker and walleye have been observed in the lower reaches of the watershed in the last 3 years (Tozer, Kivi 2008). An electro-fishing study conducted by Momot & Stephenson in 1996 found the most abundant fish species in the Slate River to be the common shiner, longnose dace, Johnny darter, trout perch and creek chub.

2.3 Socio-Economic Features

The hydrological boundaries of the Slate River watershed fall within the municipal boundaries of Oliver Paipoonge, Neebing, Gillies, and City of Thunder Bay. Map M-2, the Site Plan, illustrates the location of the Slate River watershed within the Geographic Township boundaries. The following table, Table 2.3-1, helps to outline the watershed area within each municipal boundary.

Table 2.3-1: Municipal area within the Slate River Watershed

Municipality	Total area (km^2)	Municipal Area within Slate River Watershed (km^2)	Municipal Area within Slate River Watershed (%)
Neebing	875.51	131.18	15
Oliver Paipoonge	350.27	50.25	14
Thunder Bay (City of)	328.48	1.17	0.4
Gillies Township	93.9	1.04	1.1

2.3.1 Land Use Designation/ Zoning

Municipal Official Plans contain long term goals and policies that serve as guidelines for future land use and development. Slate River is affected by three distinct Official Plans; Municipalities of Oliver Paipoonge and Neebing and the City of Thunder Bay.

Map M-7 illustrates the land use designations within the Slate River watershed.

Within the Municipality of Oliver Paipoonge, the Slate River watershed has been designated:

- Agricultural
- Commercial
- Rural
- Hazard Land

Within the Municipality of Neebing, the Slate River watershed has been designated:

- Agricultural
- Hazard Land
- Commercial
- Watershed Reserve
- Rural
- Institutional
- Industrial

Within the City of Thunder Bay, the Slate River watershed has been designated:

- Residential
- Institutional
- Hazard Land

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. The following is a description of each land use designation.

Agricultural

In general, agricultural designation ensures that agricultural activity, which is an important component of the economic base in the region, is given a high degree of certainty with respect to the continued viability of farming by minimizing competition with other non-farm land uses and fragmentation of the land base. Permitted uses include the use of lands, buildings and structures for growing crops, greenhouse, nursery and horticulture operations, raising livestock and other animals, animal kennels and stables. Small scale agriculture related commercial and industrial uses that are required to locate in close proximity to farming operations are also permitted. Forestry, mining, electrical generation and distribution may also be permitted within the agricultural designation. The majority of agricultural zoning is found in the Slate River valley, in the Municipality of Oliver Paipoonge, Geographic Township of Paipoonge.

Rural

A rural land use designation is intended to preserve low density rural residential character for townships and municipalities. Rural designations allow for a variety of compatible land uses, including agriculture, hobby farms, recreation and open spaces, mining, forestry, and commercial. The majority of rural zoning is found in the upper reaches of the Slate River, in the Municipality of Neebing, Geographic Townships of Scoble, Pearson and Blake.

Hazard Lands

Hazard Lands/Areas of Use Limitation are those lands which because of their physical characteristics or location may be susceptible to flooding, eroding or instability which conditions may result in loss of life or destruction of property. The uses permitted in hazard lands are limited to agriculture, conservation, forestry, wildlife management areas, public or private parks and other outdoor recreational uses. No buildings or structures are permitted in these areas except where such are intended for flood or erosion control or water course protection or bank stabilization projects. Hazard lands are found throughout the Slate River watershed around rivers, lakes, wetlands and steep slopes.

Commercial

The intent of commercial designation is to ensure local residents have ready access to a variety of commercial facilities that are located on or near major traffic arteries with adequate parking. Permitted uses include convenience or retail stores, gasoline stations, automobile service stations, restaurants, recreational and tourism commercial uses such as hotels, ski areas and marinas.

Industrial

The intent of industrial designation is to permit the expansion of the Municipality's industrial base to provide for improved employment opportunities within the Municipality while having regard for residential uses and other sensitive land uses. Permitted uses include warehouses, automotive service stations, dealerships or manufacturing, asphalt, cement or concrete plants, salvage yards, sawmill or planing mills, pits and quarries for extracting gravel, peat, minerals, etc., aggregate crushing plants, waste disposal sites and any other buildings/business offices/commercial outlets associated with the permitted uses. The one industrial designation within the Slate River watershed is the waste disposal site on Oliver Lake Road, Municipality of Neebing, Geographic Township of Scoble.

Institutional

The intent of institutional designation is to provide for appropriately located public and private institutions that are accessible to the people they serve, while not having an adverse affect on the surrounding area. Permitted institutional uses include government buildings, public service facilities, churches, schools, libraries, cemeteries, fire stations, community halls and similar buildings. Within the Slate River watershed, there is Kamview Nordic Centre and Thunder Bay Correctional Centre, in the City of Thunder Bay, Community Fire Halls on Hwy 608 and Hwy 61 and a Boy Scout Camp in the Municipality of Neebing. The lagoon ponds for Thunder Bay Correction Centre lie outside the watershed boundary, on the south side of Highway 61.

Residential

Within the City of Thunder Bay, Slate River watershed is designated both residential estate zone and residential suburban zone. These areas are intended to accommodate single detached low density dwellings on lots sufficiently large enough to accommodate private waste disposal systems. Certain types of minor institutional uses are also permitted including parks and nursing homes. In residential estate zones, permitted uses also include greenhouses, garden nurseries, personal farms and pits or quarries.

Watershed Reserve

The watershed reserve area surrounds Loch Lomond and is intended to protect the water supply and provide a buffer between Loch Lomond and development. No development, buildings or structures are permitted in the area except if they are to be used for watershed management and protection. Only a small portion of the watershed reserve designation falls within the Slate River watershed in the Municipality of Neebing, the Geographic Township of Blake.

2.3.2 Forestry

At present there is no large scale forestry operation within the watershed. Forest resources are scarce in the lower watershed due to the large amount of agricultural lands. Harvesting is minimal in parts of the upper watershed that do have abundant forest coverage because most of this land is privately owned.

2.3.3 Mining

Rock deposits within the mesa plateaus of the watershed are suitable for crushed aggregate but are regarded as inaccessible and non-workable. There has been past mining operations, for example Lily of the Valley silver mine in Paipoonge Township, but there are currently no active mines in the watershed.

2.3.4 Fisheries

During 2008 site visits, several 183 centimetre (cm) (6 foot) circular dip nets to trap bait fish were observed in a creek along Highway 608. Personal communication with a local resident on Turkey Trail Road revealed that personal use mudminnow traps are common in the spring near the headwaters. At present there is no large scale fisheries operation within the watershed.

2.3.5 Recreation

There were two recreational land use designations within the watershed but facilities at both locations have been closed. Candy Mountain Ski Resort is located off Candy Mountain Drive, near the headwaters of Newton Creek. Big Thunder Ski Resort is located off Little Norway Road, abutting Square Top Mountain.

2.3.6 Industrial/Disposal

There is one area within the Slate River watershed designated as industrial/disposal, an active landfill. The original landfill, now closed, does not have an industrial land use designation. Both landfills are located north off Highway 608, on Oliver Lake Road. Even after they are closed, leaching from landfills has the potential to negatively impact both surface and groundwater.

2.3.7 Rural Residential

Activities related to rural residential land use and pressure to increase residential development can contribute to the degradation of water quality and wildlife habitat. Some of these activities could include malfunctioning septic systems, improper disposal of hazardous waste, drainage of wetlands, use of contaminated fill or the removal of buffer strips along streambanks.

The Municipality of Neebing’s population increased by 6.6 percent (%) from 2001-2006 with the total number of private dwellings being 1,151. Its population density is 2.5 people per square kilometre. The Municipality of Oliver Paipoonge’s population decreased by 1.8% from 2001-2006 with a total number of private dwellings being 2,155. The population density is 16.4 people per square kilometre (Statistics Canada 2006).

The population of Gillies Township within the Slate River watershed boundary (west of Union School Road) is most likely to have a negligible impact on the watershed. The population of the City of Thunder Bay within the Slate River watershed boundary (east of West Riverdale Road) is also most likely to have a negligible impact on the watershed since development has been and will continue to be restricted by hazard land zoning.

2.3.8 Agriculture

Agriculture is a predominant land use in the Slate River watershed. Map M-7 illustrates the land use designations in the watershed. As seen in Table 2.3-2, the economic value of Slate River farming to the Regional District of Thunder Bay (from Atikokan to Marathon) is significant. Dairy and beef cattle are the leading types of farm in the watershed while "pick-your-own" fruit and vegetable ventures are growing in popularity with consumers.

Table 2.3-2: Economic value of Slate River Watershed agriculture to the Thunder Bay District

Municipality	Number of farms	Dairy farms	Farm area (hectares)	Value of products annually ($ million)
Neebing	29	5	3,212	4.2
Oliver Paipoonge	109	24	10,967	17.4
Thunder Bay (District)	252	32	25,030	32.3

(Statistics Canada 2006)

Table 2.3-3: Distribution of farms in the Slate River Watershed

Municipality	Dairy	Beef	Sheep	Horse	Honey	Hay	Vegetable/ Berry	Other Farm Types
Neebing	5	4	3	3	2	2	3	7
Oliver Paipoonge	24	13	3	12	3	19	10	25

(Statistics Canada 2006)

Agricultural development can impact the landscape in many ways. The majority of farms in the Slate River watershed practice conventional tillage. With conventional tillage, the crop residue from the previous year is incorporated into the soil before the winter. During the spring snow melt (with high surface water runoff), conventional tillage can be the main source of soil erosion contributing to sedimentation, nutrient loading and bacterial contamination of the River. Farmers apply either organic (i.e. manure) or chemical fertilizers to replace the nutrients (nitrogen, phosphorus and potassium) in the soil. These nutrients can build up in the soil and leach into the surrounding water. Allowing livestock access to the water's edge is common practice. However, this may lead to bacterial contamination through manure and stream bed erosion through livestock trampling. Improper disposal or storage of manure and milkhouse waste water may contribute to nutrient loading and bacterial contamination. Tile drainage can also disrupt normal hydrology and increase the movement of land inputs (fertilizers, pesticides, lime) from the soil into the nearby water. Tile drainage is the practice of digging and lining subsurface channels that collect excess water when precipitation levels exceed the storage capacity of the soil. They prevent the soil from being over saturated with water. Irrigation is also a necessary practice to grow crops. A Permit to Take Water (PTTW) is required by the Ontario Ministry of the Environment (MOE) when >50,000 litres per day (L/day) is taken from the water source. Two agricultural clients require a PTTW for the Slate River: a fruit orchard allowed a maximum 545,520 L/day from May 15th to August 20th and a field and pasture crop (sod) farm allowed 109,104 L/day.

2.4 Special Considerations

2.4.1 Previous Report

Concerns about impacts from agricultural practices within the Slate River watershed prompted the Lake Superior Programs Office to produce a Watershed Management Plan for the Slate River in 1998 (Cullis *et al*.). The Lake Superior Programs Office was a joint initiative by Environment Canada, the Department of Fisheries and Oceans, the Ministry of Environment and Energy and Ministry of Natural Resources to deliver projects recommended by the Public Advisory Committees for the Remedial Action Plans along the north shore of Lake Superior.

The Report concluded that preliminary surface water quality data indicated levels of total phosphorus, suspended solids (turbidity), total nitrogen and *Escherichia coli (E. coli)* exceeded 1994 *Provincial Water Quality Objectives* (PWQO) at the time of sampling. The data was collected by the MOE during the 1990 spring runoff. Six sampling dates between April 25 and July 30, 1990 were used to test the water at twelve stations along the Slate River and its tributaries. Exact locations of the 1990 sampling stations are not available for comparison to sampling locations in this report.

Total phosphorus exceeded the 1994 PWQO (<30 micrograms per litre, μg/L) for 70 of the 72 water samples collected in 1990 (26 to 150 μg/L). Turbidity exceeded the 1994 referenced PWQO (1 Formazin Turbidity Unit, FTU) for 71 of 72 water samples collected in 1990 (0.9 to 108 FTU). Total nitrogen (expressed as Total Kjeldahl-Nitrogen minus Ammonia-Nitrogen) exceeded the 1994 referenced PWQO (<150 μg/L) for all water samples collected in 1990 (610 to 1750 μg/L). *E. coli* exceeded the 1994 PWQO (<100 counts per 100 millilitres of water) for 11 of 72 water samples collected in 1990 (10 to1200 counts per 100 millilitres of water).

The Report recommended the implementation of a Community Outreach Program to build a cooperative relationship with the farming community since improvements to water quality and wildlife habitat will largely depend upon voluntary stewardship initiatives.

2.4.2 Areas of Natural and Scientific Interest

Areas of Natural and Scientific Interest (ANSIs) are "areas of land and water containing natural landscapes or features which have been identified as having values related to protection, natural heritage appreciation, scientific study or education" (Ontario Ministry of Natural Resources, 1983). The Slate River watershed contains two ANSIs, Square Top Mountain ANSI and Slate River ANSI (as shown on Map M-2, Site Plan).

Square Top Mountain ANSI sits on the watershed boundary within the Nor'wester range. The major part of the ANSI consists of the ravine between Square Top Mountain and Mount McQuaid. This site contains one of the largest existing stands of sugar maple in northwestern Ontario and is at the northern extremity of the species' range. The steep-sided ravine characteristic of the mesa landform provides shelter and a unique warm microclimate favoured by southern species. Most of the Great Lakes-St. Lawrence species are confined to this area, including yellow birch. Plants considered either regionally or provincially significant that are found in this area include spring beauty, jack-in-the-pulpit, wild ginger, provincially rare Braun's holly fern and regionally rare maidenhair spleenwort. Some arctic-alpine species, in particular encrusted saxifrage grow on the cliff faces.

Slate River ANSI consists of two parcels close to the mouth of the Slate River. The Slate River Gorge contains a diverse and abundant collection of carbonate concretations, locally known as kettle rocks. Concretations are composed of concentric layers of black carbonate or black limestone that take on a disc, bowl or blunt cone shape (Figure 7). Many of these concretations are imbedded within the argillite in the 15 metre high walls of the Slate River Gorge. At the confluence of the Slate and Kaministiquia Rivers, a large stand of American elm and black ash occupies the floodplain. Flooding during high water in the spring continues to add alluvial material each year, enriching the moist sandy-silty loam. This site also contains other southern species such as red ash, Manitoba maple, bloodroot, wild ginger and spring beauty.

2.4.3 Erosion Control

In 1989, the Municipality of Paipoonge requested remedial measures to stabilize a portion of the bank along the Slate River. The erosion site was located on Hanna Road, approximately 500 metres south of the intersection at Candy Mountain Drive. The erosion site consisted of a near vertical face approximately 2 metres high and within one metre of the graveled edge of Hanna Road. The remedial measures consisted of a 0.5 metre layer of rip-rap over geotextile (filter fabric). The rip-rap extended up the bank to the 50 year return period storm (approximately 2 metres) with the remainder of the bank that was disturbed or graded re-vegetated with seed and fertilizer. In 2001, the LRCA documented active erosion occurring along the same bank. The erosion site extends for approximately 20 metres beyond the original remediation work. The river bank consists of a silty clay type of material and under moderate rainfall conditions with increased flow volumes, the bank is known to slough and further encroach on the road. Controlling river bank erosion helps protect property and reduce the risk of flooding (by maintaining flow capacity). It also helps to prevent excess sediment (that increases turbidity) and to prevent contaminated sediment (with nutrients, metals, petroleum, etc.) from entering the water. As part of the watershed assessment, bank stability and general slope were observed and reported to determine its susceptibility to erosion.

3 Methods and Materials

3.1 Site Selection

Seven sites were chosen along the Slate River 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 1 was located in the headwaters of the river, above the area of human impact, to represent “baseline” water quality data for comparison. Site 2 was located downstream of Oliver Lake Road landfill. Site 3 was located along Highway 61 in the mid-reaches of the River at the beginning of the agricultural land use designation. Sites 4, 5 and 6 were within the heart of the agricultural land and downstream of the tributaries, Otter Creek and Newton Creek. Site 7 was located as close as possible to the confluence of the Slate River and Kaministiquia River to represent “cumulative” water quality data for the entire watershed. The UTM coordinates and elevation of each site was marked using the Trimble Geo XH GPS unit as shown on Map M-2, Site Plan.

3.2 Quantitative Assessment

Several parameters were measured to assess surface water quality of the Slate River. Sampling was conducted on August 14, 2008 and August 27, 2008. 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 for analysis of conductivity, total dissolved solids (TDS), turbidity, nutrients (ammonia-total nitrogen, nitrate, nitrite and phosphorus), bacteria (*Escherichia coli* and total coliforms) and total metals (notably iron and lead).

The 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 and/or using a reaching pole. Effort was taken to enter the stream downstream of the sampling location to disturb as little sediment as possible. All sample sites were upstream of the water crossing. All samples 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. The samples were collected at a depth of 0.3 metres below the surface of the water. ALS Laboratory provided four collection bottles for each site: routine, nutrient, metal and bacterial analysis. For the first three analyses, the inside of the bottle and underside of the lid was rinsed twice before the actual sample was filled. Sulfuric acid and nitric acid was added as preservative on site to the nutrient and metal bottles, respectively. Bottles for bacterial analysis were pre-charged with sodium thiosulphate preservative and special care was taken not to open the bottle until the actual sample was to be filled.

The field parameters, water temperature, pH, conductivity, and dissolved oxygen were measured using the YSI 556 MPS meter at the same time as water sample collection. The following additional field parameters were also measured: air temperature by mercury thermometer, channel width by measuring-tape reel, channel depth by a weighted fishing line and metre stick and flow rate by timing a stick as it travelled a known distance.

Description of the water quality parameters are attached in Appendix A.

3.3 Applicable Criteria

Surface water quality results 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 2007 were also used for comparison to surface water quality results for the Slate River 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.

3.4 Qualitative Assessment

Watershed health can also be assessed by qualitative (visual) monitoring. The presence of certain flora and fauna, amount of shoreline vegetation, composition of the stream bottom and condition of the stream bank can all effect water quality. Techniques for data collection are attached in Appendix C. Several 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). Each site was assessed in a 10 by 10 metre transect 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 and differences or inconsistencies between the V-types should be expected. Vegetation Types for each site are attached in Appendix D. Common and Latin names of plant species are attached in Appendix E. The following physical characteristics were noted at each sampling site: in-stream material, stream bed description, stream bank stability, stream cover (forest density) and soil type.

An inventory of Slate River water crossings (bridges and culverts) was conducted. Physical dimensions were measured, 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 are shown on Map M-8. The bridge and culvert assessments are attached in Appendices F and G.

Materials

- Maps – road map, topographic map
- Trimble Geo XH GPS
- Sample bottles and preservative provided by ALS Laboratory Group
- Cooler and ice packs
- Reaching pole
- Chest waders
- YSI 556 MPS meter
- Pens and pencils
- Clipboard and observation chart paper
- Digital camera and film
- Mercury thermometer
- Stopwatch
- Fishing pole with lead weights (for measuring depth)
- Measuring tape reel
- 1 metre stick
- Stick (to measure flow rate)
- Dip net
- Scissors
- Bucket
- Ziplock bags
- Hand lens
- Binoculars
- Rubber gloves/ latex gloves
- Work gloves
- Field guides:
    - Field Guide to the Forest Ecosystem Classification for Northwestern Ontario (Sims *et al*. 1997)
    - Field Guide to Trees and Shrubs 2nd Edition (Petrides 1958)
    - Native Trees of Canada 8th Edition (Hosie 1990)
    - ROM Field Guide to Wildflowers of Ontario (Dickinson *et al*. 2004)
    - Wetland Plants of Ontario (Newmaster *et al*. 1997)
    - Atlas of the Breeding Birds of Ontario (Cadman *et al*. 2007)

4 Results and Discussion

Laboratory water quality results and PWQO criteria have been compared and attached in Appendix H. The original Laboratory Certificates of Analysis and Analytical Reports have been attached in Appendix I.

Figures 8-16 graphically represent and compare the following parameters: elevation, water temperature, pH, dissolved oxygen, total dissolved solids, conductivity, turbidity, total phosphorus and *Escherichia coli (E. coli)*.

Results are summarized in the tables below:

4.1 Site 1

Table 4.1-1: Location Reference for Site 1

Location Description	Headwater of Slate River; Turkey Trail Road
UTM Coordinates	5346167.23 metres North / 305332.25 metres East
Altitude/Elevation	367.70 metres above sea level

Table 4.1-2: Field Measurements for Site 1

Field Parameter	Date: August 14, 2008 Time: 10:27	Date: August 27, 2008 Time: 14:40
Water Temperature (ºC)	16.87	15.69
Conductivity (µS/cm)	237.88	300
Dissolved Oxygen (mg/L)	**3.64**	**4.30**
Dissolved Oxygen (%)	**37.62**	**43**
pH	8.49	8.19
Air Temperature (ºC)	23	23
Channel Width (m)	4	4
Channel Depth (m)	1	1
Flow Rate (m/s)	0.0042	No measurable flow

Bold indicates does not meet PWQO guidelines.

Table 4.1-3: Laboratory Water Quality Results for Site 1

Variable	Date: August 14, 2008	Date: August 27, 2008
Conductivity (µS/cm)	283	295
Total Dissolved Solids (mg/L)	210	190
Turbidity (NTU)	7.2	9.3
Ammonia-N, Total (µg/L)	20	<20
Nitrate-N (NO_3-N) (µg/L)	<30	<30
Nitrite-N (NO_2-N) (µg/L)	<20	<20
Phosphorus (P), Total (µg/L)	23	25
Escherichia Coli (MPN/100mL)	41	60
Aluminum (Al) (µg/L)	**150**	**180**
Cadmium (Cd) (µg/L)	<0.09	<0.09
Copper (Cu) (µg/L)	1	1
Iron (Fe) (µg/L)	**1450**	**1090**
Lead (Pb) (µg/L)	<1	<1

Bold indicates exceedance above PWQO guidelines.

Table 4.1-4: Flora and Fauna Observed at Site 1

Terrestrial	Trees	Black spruce, white spruce, white birch, trembling aspen
	Shrubs	Red-osier dogwood, Saskatoon (serviceberry), chokecherry, pin cherry, willow spp., prickly wild rose
	Herbs	Purple vetch, Canada thistle, bull thistle, common burdock, ox-eye daisy, red clover, Canada goldenrod, common yarrow, bird's foot trefoil, aster spp. buttercup, jeweled touch-me-not, narrowleaf spirea, broadleaf spirea, meadow-rue, wood aneome, lily family, violet family
	Ferns/ Mosses	Horsetail (Pteridophyte), feathermoss, plume moss
	Mammals	
	Birds	Blue jay, raven, cedar waxwing, American robin, ovenbird, ruby-throated humming bird, woodpecker, white-breasted nuthatch, American goldfinch, Canadian goose
	Insects	Bees, dragonflies
Aquatic	Plants	Yellow pond lily, broad-leaved arrowhead, common cattail, pondweed, large-fruit burreed, water smartweed, hardstem bulrush
	Animals	Minnow[1], pond skater, leech, snail

Table 4.1-5: Physical Features Observed at Site 1

In-stream Material	Logs, organic debris, lots of aquatic plants
Stream Bed Description	Mixture of silt, clay and decomposing organic material
Bank Stability/Erosion	Stable- bank not steep, channel not well-defined
Stream Cover/ Forest Density	Dense-upstream 100% cover, Partly Open-downstream 50% cover
Soil Type (Texture/Drainage)	Clay- texture Very Poor-Drainage (wet)

Sample Site 1 was closest to the headwater of the Slate River where the stream channel was not well-defined and the area looked more similar to a wetland than a river. Since this part of the watershed was not highly developed, the site was considered to represent baseline water quality data before human alteration. On both sampling dates, this site had dissolved oxygen levels below the PWQO criteria of 57% and 47% DO saturation for cold water biota and warm water biota, respectively. Dissolved oxygen was 37.62% on August 14, 2008 and 43% on August 27, 2008. Low dissolved oxygen levels could have been caused by in-stream organic material being oxidized (metabolized) faster than the aquatic plants could create oxygen through photosynthesis. As well, the stagnant water may prevent mixing of the water column to replenish the dissolved oxygen.

Between the two sampling dates, the aquatic plant species grew at a rate quick enough to encroach on the sampling site. The second sample set was collected 1 metre further into the stream channel. The pH at this site was 8.49 on August 14, 2008 and 8.19 on August 27, 2008. The pH was relatively higher than the other sample sites, however was still within the PWQO guidelines (6.5 to 8.5). Conductivity and total dissolved solids at this site was the lowest of the sample sites. Turbidity was consistent with the other sample

[1] According to personal communication with the local resident, many people set their minnow traps at this location, especially in spring.

sites with readings of 7.2 and 9.3 NTU. Nutrient levels, nitrogen and phosphorus, were within the PWQO and CCREM guidelines. On both sampling dates, aluminum and iron exceeded the PWQO guidelines. Aluminum was 150 micrograms per litre (µg/L) on August 14, 2008 and 180 µg/L on August 27, 2008 (with a PWQO of 75 µg/L). Iron was 1450 µg/L on August 14, 2008 and 1090 µg/L on August 27, 2008 (with a PWQO of 300 µg/L).

4.2 Site 2

Table 4.2-1: Location Reference for Site 2

Location Description	Bailey bridge on Highway 597; just south of Highway 608 before Oliver Lake Road
UTM Coordinates	5344952.53 metres North/ 308899.98 metres East
Altitude/Elevation	313.20 metres above sea level

Table 4.2-2: Field Measurements for Site 2

Field Parameter	Date: August 14, 2008 Time: 11:11	Date: August 27, 2008 Time: 13:45
Water Temperature (ºC)	18.40	16.50
Conductivity (µS/cm)	232.84	297
Dissolved Oxygen (mg/L)	7.47	8.05
Dissolved Oxygen (%)	79.87	82.1
pH	8.04	8.12
Air Temperature (ºC)	29	23
Channel Width (m)	5	5
Channel Depth (m)	1.2	0.8
Flow Rate (m/s)	0.0020	No measurable flow

Table 4.2-3: Laboratory Water Quality Results for Site 2

Variable	Date: August 14, 2008	Date: August 27, 2008
Conductivity (µS/cm)	270	289
Total Dissolved Solids (mg/L)	230	210
Turbidity (NTU)	5.0	13.8
Ammonia-N, Total (µg/L)	20	30
Nitrate-N (NO_3-N) (µg/L)	<30	<30
Nitrite-N (NO_2-N) (µg/L)	<20	<20
Phosphorus (P), Total (µg/L)	21	**45**
Escherichia Coli (MPN/100mL)	2	12
Aluminum (Al) (µg/L)	**120**	**220**
Cadmium (Cd) (µg/L)	<0.09	<0.09
Copper (Cu) (µg/L)	**6**	3
Iron (Fe) (µg/L)	**800**	**1070**
Lead (Pb) (ug/L)	<1	1

Bold indicates exceedance above PWQO guidelines.

Table 4.2-4: Flora and Fauna Observed at Site 2

Terrestrial	Trees	Balsam fir, white spruce, trembling aspen, white birch, balsam poplar, jack pine
	Shrubs	Willow spp. (predominant), wild red raspberry, chokecherry, red-osier dogwood
	Herbs	Fireweed, bird's foot trefoil, common yarrow, common dandelion, Canada thistle, aster spp. common burdock, narrowleaf spirea, mullien, cow parsnip, common strawberry, spotted joe-pye-weed, creeping bellflower
	Mosses	Horsetail (Pteridophyte), feathermoss
	Mammals	Dairy cattle
	Birds	Crow, American goldfinch, red-tailed hawk, white-breasted nuthatch, blue jay, white-throated sparrow, black-capped chickadee, common grackle, heron
		Garter snake
	Insects	Dragonfly, bumblebee, grasshopper
Aquatic	Plants	Broad-leaved arrowhead, pondweed
	Animals	Minnow

Table 4.2-5: Physical Features Observed at Site 2

In-stream Material	Boulders, rubble, mud, sticks, algae and plants
Stream Bed Description	Silt and clay, a deep muddy organic layer
Bank Stability/Erosion	Stable-bank slope is gradual
Stream Cover/ Forest Density	Open- <25% canopy, rural residential
Soil Type (Texture/Drainage)	Silt-texture fair-drainage, had some organic matter

Sample Site 2 was just upstream of Bridge 1 along Highway 597. This site was in the upper reaches of the Slate River and was chosen to indicate any potential impacts from the two landfills (one active, one closed) located off Oliver Lake Road, near tributaries that flow into Slate River upstream of the sample site. The site was downstream of rural residential property that allowed cattle (two were observed) access to the river. The riparian zone did not have many trees, although bank slope was gradual and appeared stabilized by grasses/interspersed shrubs. Dissolved oxygen and pH were both within PWQO guidelines. Total dissolved solids and conductivity were relatively low at this site compared to other sample sites (similar to Site 1). Turbidity, on the second sampling date, was highest of all sites at 13.8 NTU. However, this was still relatively low and below *Canadian Recreational Water Quality* (Health Canada 1992) aesthetic objective of 50 NTU and not more than 10 percent different from the first sampling date reading which is the criterion for the PWQO. This indicates there was little disturbance of sediment upstream. Nitrogen levels were within the PWQO and CCREM guidelines. Phosphorus, however, was the highest of all sites, on the second sampling date at 45 μg/L which exceeded the PWQO criterion of 30 μg/L for rivers and streams. This may have been caused by runoff of fertilizer, pesticides or detergents upstream. *E. coli* counts were very low and within PWQO guidelines. On both sampling dates, aluminum and iron exceeded the PWQO guidelines. Aluminum was 120 μg/L on August 14, 2008 and 220 μg/L on August 27, 2008 (with a PWQO of 75 μg/L). Iron was 800 μg/L on August 14,

2008 and 1070 µg/L on August 27, 2008 (with a PWQO of 300 µg/L). On August 14, 2008, copper
was above the PWQO (criterion of 5µg/L) with a concentration of 6 µg/L. On August 27, 2008, lead met the PWQO criterion of 1µg/L although did not surpass it.

4.3 Site 3

Table 4.3-1: Location Reference for Site 3

Location Description	On Highway 61; between Boyscout Road and Highway 608
UTM Coordinates	5348945.51 metres North/ 315689.49 metres East
Altitude/Elevation	221.47 metres above sea level

Table 4.3-2: Field Measurements for Site 3

Field Parameter	Date: August 14, 2008 Time: 12:19	Date: August 27, 2008 Time: 13:10
Water Temperature (ºC)	22.13	17.09
Conductivity (µS/cm)	386.37	405.06
Dissolved Oxygen (mg/L)	7.07	5.47
Dissolved Oxygen (%)	81.45	56.79
pH	7.93	8.16
Air Temperature (ºC)	25.0	23.0
Channel Width (m)	6	6
Channel Depth (m)	1.28	1.20
Flow Rate (m/s)	0.0213	0.0204

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

Variable	Date: August 14, 2008	Date: August 27, 2008
Conductivity (µS/cm)	445	481
Total Dissolved Solids (mg/L)	330	320
Turbidity (NTU)	9.7	10.1
Ammonia-N, Total (µg/L)	<20	20
Nitrate-N (NO_3-N) (µg/L)	<30	<30
Nitrite-N (NO_2-N) (µg/L)	<20	<20
Phosphorus (P), Total (µg/L)	29	29
Escherichia Coli (MPN/100mL)	11	**150**
Aluminum (Al) (µg/L)	**210**	**120**
Cadmium (Cd) (µg/L)	<0.09	<0.09
Copper (Cu) (µg/L)	4	3
Iron (Fe) (µg/L)	**1550**	**1100**
Lead (Pb) (µg/L)	<1	1

Bold indicates exceedance above PWQO guidelines.

Table 4.3-4: Flora and Fauna Observed at Site 3

Terrestrial	Trees	Trembling aspen, balsam fir, Manitoba maple, balsam poplar, white birch, 1 red pine, 1 hawthorn
	Shrubs	Willow spp., red-osier dogwood (predominant), wild red raspberry, swamp red currant
	Herbs	Bird's foot trefoil, red clover, white sweet-clover, cow vetch, spotted Joe-pye-weed, Canada goldenrod, false dragonhead, common dandelion, ox-eye daisy, common yarrow, aster spp., fragrant bedstraw, Canada thistle, wild chamomile, prickly wild rose, virgin's bower
	Mosses	
	Mammals	Chipmunk, beaver (dam)
	Birds	American robin, American goldfinch, blue jay, sandpiper, tree swallow, killdear
	Insects	Bumblebee, dragonfly, cricket, grasshopper
Aquatic	Plants	Yellow pond lily, common cattail, hardstem bulrush
	Animals	Minnow

Table 4.3-5: Physical Features Observed at Site 3

In-stream Material	Unsorted stones, algae covered rocks, logs/twigs/mud from beaver dam
Stream Bed Description	Sandy silt
Bank Stability/Erosion	Stable-bank is steep slope with large boulders as fill
Stream Cover/ Forest Density	Open- <25% canopy, rural residential, Partly Open- 50% canopy downstream
Soil Type (Texture/Drainage)	Sandy- texture, good-drainage, soil was dry

Sample Site 3, Bridge 3, was within the mid-reaches of the Slate River in the valley. Upstream, the river slowly meanders through private property, including rural residential and agricultural fields. This site was chosen to represent any impacts from the large portion of the watershed, approximately one-quarter of the Slate River, which is not accessible by public road. As well, this site may represent any influences from Provincial Highway 61 which runs close alongside the Slate River and crosses it at this Sample Site. This site also represents the very beginning of the agricultural land use designation. A beaver dam was restricting flow downstream and created a deeper pool of water at the sample site. Dissolved oxygen at 56.79%, on the second sampling date, was near the threshold of acceptable levels (PWQO guideline of 54% at 15ºC for cold water biota). Total dissolved solids and conductivity were higher than Sites 1 and 2 and comparable to Sites 5, 6 and 7. The pH and nutrients, nitrogen and phosphorus were within PWQO and CCREM guidelines. On August 27, 2008, *E. coli* levels, at 150 counts per 100 mL of water, exceeded the acceptable PWQO criterion of 100 counts per 100 mL of water for safe bathing/swimming. On both sampling dates, aluminum and iron exceeded the PWQO guidelines. Aluminum was 210 µg/L and 120 µg/L on August 14 and August 27, 2008, respectively (above the PWQO criterion of 75 µg/L). Iron was 1150 µg/L and 1100 µg/L on August 14 and August 27, 2008, respectively (above the PWQO criterion of 300 µg/L). On August 14, 2008, hexavalent chromium (Cr VI) met the interim PWQO of

1µg/L although did not surpass it. On August 27, 2008, lead met the PWQO criterion of 1µg/L although did not surpass it.

4.4 Site 4

Table 4.4-1: Location Reference for Site 4

Location Description	On Boundary Road between Falls Road and Farm Road
UTM Coordinates	5351374.03 metres North/ 317556.22 metres East
Altitude/Elevation	218.07 metres above sea level

Table 4.4-2: Field Measurements for Site 4

Field Parameter	Date: August 14, 2008 Time: 13:44	Date: August 27, 2008 Time: 11:55
Water Temperature (ºC)	19.16	17.55
Conductivity (µS/cm)	628.2	800.11
Dissolved Oxygen (mg/L)	8.10	9.06
Dissolved Oxygen (%)	87.76	95.03
pH	8.01	7.97
Air Temperature (ºC)	25	21.5
Channel Width (m)	9.10	9.4
Channel Depth (m)	0.73	0.30
Flow Rate (m/s)	0.00375	0.025

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

Variable	Date: August 14, 2008	Date: August 27, 2008
Conductivity (µS/cm)	693	864
Total Dissolved Solids (mg/L)	550	640
Turbidity (NTU)	13.4	11.1
Ammonia-N, Total (µg/L)	20	70
Nitrate-N (NO_3-N) (µg/L)	<30	<30
Nitrite-N (NO_2-N) (µg/L)	<20	<20
Phosphorus (P), Total (µg/L)	**32**	24
Escherichia Coli (MPN/100mL)	37	**820**
Aluminum (Al) (µg/L)	**350**	**200**
Cadmium (Cd) (µg/L)	<0.09	<0.09
Copper (Cu) (µg/L)	4	3
Iron (Fe) (µg/L)	**880**	**540**
Lead (Pb) (µg/L)	<1	<1

Bold indicates exceedance above PWQO guidelines.

Table 4.4-4: Flora and Fauna Observed at Site 4

Terrestrial	Trees	Manitoba maple (predominant), trembling aspen, wild crab apple
	Shrubs	Chokecherry (predominant), red-osier dogwood, willow spp., wild prickly rose, wild red raspberry
	Herbs	Canada thistle, Canada goldenrod, bird's foot trefoil, Lindley's aster, field sow-thistle, ox-eye daisy, narrowleaf spirea, common strawberry
	Mosses	Grass spp.
	Mammals	Cow, horse
	Birds	White-breasted nuthatch, white-winged crossbill (finch)
	Insects	Dragonfly, snail, water boatman
Aquatic	Plants	Yellow pond lily, broad-leaved arrowhead, hardstem bulrush, burreed
	Animals	Clam

Table 4.4-5: Physical Features Observed at Site 4

In-stream Material	Logs, twigs, grass, rocks, plants, barbed wire fence
Stream Bed Description	Unsorted stones and large boulders covered with algae, silt and clay
Bank Stability/Erosion	Stable-although upstream bank has been trampled by livestock, slope is gradual, floodplain wide
Stream Cover/ Forest Density	Open-<25% canopy although singular small trees/shrubs punctuate the shoreline, agricultural land
Soil Type (Texture/Drainage)	Silt and clay-texture, fair-drainage

Sample Site 4, Bridge 6, was situated within the heart of the agricultural land on Boundary Drive and was directly downstream of a dairy farm. The floodplain was very wide extending approximately 80 metres on the west bank. This site was not given a V-type classification because most of the surrounding land has been cleared for agriculture. The stream bank was dominated mostly by grasses and appeared slightly trampled by livestock that accessed the river. There was a private fence crossing the river to prevent livestock from escaping underneath the bridge. Dissolved oxygen and pH levels were within PWQO guidelines. Total dissolved solids and conductivity were highest at this site; 2-3 times higher than the levels at other sites. TDS were 550 milligrams per litre (mg/L) and 640 mg/L for August 14 and 27, 2008, respectively. Chloride, a major constituent of TDS, also spiked at Site 4; it was 10 times higher than other sites. High TDS levels may indicate runoff from agriculture and/or erosion from exposed soil. The only criteria available for comparison is an aesthetic objective of <500mg/L to prevent unpalatable taste set by the *Canadian Drinking Water Quality* regulations (Health Canada 1996). Turbidity levels were higher than most other sites with values of 13.4 and 11.1 NTU. Nitrogen levels were within PWQO and CCREM guidelines. Phosphorus levels on August 14, 2008, exceeded the PWQO criterion (30 μg/L for rivers and streams) with a value of 32 μg/L. On August 27, 2008, *E. coli* levels exceeded the PQWO guidelines (100 counts per 100mL of water) with a result of 820 counts per 100mL of water. This level was approximately 8 times higher than other sites and indicated possible recent fecal contamination. On both sampling dates, aluminum and iron exceeded the PWQO guidelines. Aluminum was 350 μg/L and 200 μg/L on August 14 and August 27, 2008, respectively (above the PWQO criterion of 75 μg/L). Iron was 880 and 540 on August 14 and August 27, 2008, respectively (above the PWQO criterion of 300 μg/L). On August 14, 2008, hexavalent chromium (Cr VI) met the PWQO criterion of 1 μg/L although did not surpass it. On both sampling dates, the concentration of the metal, barium was 2-10 times higher than the levels at other sites. There are currently no PWQO guidelines limiting exposure to barium. On both sampling dates, the concentration of the metal, strontium was at least 3 times higher than the levels at other sites. There are currently no PWQO guidelines limiting exposure to strontium.

4.5 Site 5

Table 4.5-1: Location Reference for Site 5

Location Description	On Hanna Road; ½ kilometre south of Candy Mountain Drive
UTM Coordinates	5355159.55 metres North/ 318837.56 metres East
Altitude/Elevation	216.43 metres above sea level

Table 4.5-2: Field Measurements for Site 5

Field Parameter	Date: August 14, 2008 Time: 14:53	Date: August 27, 2008 Time: 11:10
Water Temperature (ºC)	21.60	18.61
Conductivity (μS/cm)	439.06	416.7
Dissolved Oxygen (mg/L)	8.66	6.99
Dissolved Oxygen (%)	98.40	74.91
pH	7.97	7.99
Air Temperature (ºC)	29	24
Channel Width (m)	9.5	9.5
Channel Depth (m)	1.38	1.50
Flow Rate (m/s)	No measurable flow	0.00583

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

Variable	Date: August 14, 2008	Date: August 27, 2008
Conductivity (μS/cm)	463	484
Total Dissolved Solids (mg/L)	340	320
Turbidity (NTU)	5.4	7.4
Ammonia-N, Total (μg/L)	20	40
Nitrate-N (NO_3-N) (μg/L)	60	<30
Nitrite-N (NO_2-N) (μg/L)	<20	<20
Phosphorus (P), Total (μg/L)	**30**	26
Escherichia Coli (MPN/100mL)	17	**130**
Aluminum (Al) (μg/L)	**120**	**110**
Cadmium (Cd) (μg/L)	<0.09	<0.09
Copper (Cu) (μg/L)	3	3
Iron (Fe) (μg/L)	**640**	**570**
Lead (Pb) (μg/L)	<1	<1

Bold indicates exceedance above PWQO guidelines.

Table 4.5-4: Flora and Fauna Observed at Site 5

Terrestrial	**Trees**	Manitoba maple (predominant), trembling aspen, speckled alder, white birch, black spruce, 1 tamarack
	Shrubs	Willow spp., red-osier dogwood, chokecherry, currant sp., high-bush cranberry, wild prickly rose
	Herbs	Canada goldenrod, Canada thistle, bird's foot trefoil, cow vetch, field sow thistle, aster spp., red clover, common evening primrose
	Mosses	fowl meadowgrass, grass spp., common reed, lady fern, meadow horsetail
	Mammals	
	Birds	Belted kingfisher, American goldfinch, cedar waxwing, bank swallow, white-breasted nuthatch, song sparrow, duck (box)
	Insects	dragonfly
Aquatic	**Plants**	Yellow pond lily, large-fruit burreed, broad-leaved arrowhead
	Animals	Freshwater sponge

Table 4.5-5: Physical Features Observed at Site 5

In-stream Material	Large boulders, logs
Stream Bed Description	Sandy silt, some boulders covered in algae and sponges
Bank Stability/Erosion	Partly stable- slope was fairly steep, muddy banks were being undercut, road was slumping into the bank
Stream Cover/ Forest Density	Party Open- 25-75% shaded by canopy
Soil Type (Texture/Drainage)	Sandy silt-texture, Fair-drainage, seemed dry and coarse

Sample Site 5 was located near the active erosion remediation work conducted in 1989 on Hanna Road. There was no water crossing structure (bridge/culvert) at this site because the road ran alongside the Slate River. Sloughing of the road into the west stream bank was observed and photo-documented, although the sediment was not reaching the water's edge. High water marks observed indicate that at some point, probably during the June 2008 flood event, the Slate River was at least 1 metre above the Hanna Road elevation at this location. Seasonal high water levels and scouring of the outside bank of the river through the meanders may cause this site to be vulnerable to active erosion in the future. Chunks of asphalt from Highway 61 had traveled down the Slate River, probably during the June 2008 flood event, and landed close to sample Site 5. There were no rural residential buildings or visible agricultural activity directly upstream of the sampling site. The riparian vegetation on the east bank separated the river from agricultural land. Dissolved oxygen and pH levels were within PWQO guidelines. Conductivity and total dissolved solid concentrations were lower than Sites 1 and 2, yet comparable to Sites 3, 6 and 7. Turbidity was lower, in general, than Sites 1 to 4. On August 14, 2008, total phosphorus met the PWQO criterion of 30μg/L for rivers/streams although it did not surpass it. Nitrogen levels were all well below PWQO and CCREM guidelines. On August 27, 2008, *E. coli* levels exceeded the PQWO guidelines (100 counts per 100mL of water) with a result of 130 counts per 100mL of water. On both sampling dates, aluminum and iron exceeded the PWQO guidelines. Aluminum was 120 μg/L and 110 μg/L on August 14 and August 27, 2008, respectively (above the PWQO criterion of 75 μg/L). Iron was 640 μg/L and 570 μg/L on August 14 and August 27, 2008, respectively (above the PWQO criterion of 300 μg/L). A good indication of healthy water quality was the presence of fresh water sponge. Nest boxes for waterfowl were observed close to the sample site.

4.6 Site 6

Table 4.6-1: Location Reference for Site 6

Location Description	On Gillespie Road; ½ kilometre south of Candy Mountain Drive
UTM Coordinates	5354847.45 metres North/ 320886.70 metres East
Altitude/Elevation	213.06 metres above sea level

Table 4.6-2: Field Measurements for Site 6

Field Parameter	Date: August 14, 2008 Time: 15:18	Date: August 27, 2008 Time: 10:35
Water Temperature (ºC)	22.04	16.94
Conductivity (μS/cm)	473.67	382.29
Dissolved Oxygen (mg/L)	9.09	7.16
Dissolved Oxygen (%)	104.10	74.13
pH	7.98	8.13
Air Temperature (ºC)	31	18
Channel Width (m)	14.2	14.2
Channel Depth (m)	0.68	0.45
Flow Rate (m/s)	No measurable flow	0.00666

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

Variable	Date: August 14, 2008	Date: August 27, 2008
Conductivity (μS/cm)	429	447
Total Dissolved Solids (mg/L)	320	290
Turbidity (NTU)	6.5	8.4
Ammonia-N, Total (μg/L)	20	50
Nitrate-N (NO_3-N) (μg/L)	<30	<30
Nitrite-N (NO_2-N) (μg/L)	<20	<20
Phosphorus (P), Total (μg/L)	19	22
Escherichia Coli (MPN/100mL)	35	44
Aluminum (Al) (μg/L)	**140**	**190**
Cadmium (Cd) (μg/L)	<0.09	<0.09
Copper (Cu) (μg/L)	3	3
Iron (Fe) (μg/L)	**590**	**750**
Lead (Pb) (μg/L)	<1	<1

Bold indicates exceedance above PWQO guidelines.

Table 4.6-4: Flora and Fauna Observed at Site 6

Terrestrial	Trees	Speckled alder, black spruce, white birch, trembling aspen, balsam fir, white spruce, 3 mountain ash, 1 tamarack
	Shrubs	Red-osier dogwood, Saskatoon (serviceberry), high-bush cranberry, chokecherry, wild prickly rose, wild red raspberry
	Herbs	Red clover, white sweet clover, Canada goldenrod, bird's foot trefoil, cow vetch, aster spp., common sow-thistle, Lindley's aster, Canada thistle, common yarrow, common burdock, ox-eye daisy, wood anemone, false dragonhead, bull thistle, common strawberry
	Mosses	Meadow horsetail, lady fern, grass spp. sedge spp. rush spp., fowl meadowgrass
	Mammals	Beaver
	Birds	White-breasted nuthatch, red-tailed hawk, crow, American goldfinch, cedar waxwing, least flycatcher
	Insects	
Aquatic	Plants	Yellow pond lily, pondweed, broad-leaved arrowhead, hardstem bulrush, common cattail, green algae
	Animals	Leech, clam

Table 4.6-5: Physical Features Observed at Site 6

In-stream Material	Logs, twigs from beaver, aquatic plants
Stream Bed Description	Sand and silt, muddy
Bank Stability/Erosion	Stable- wide floodplain, slope is gradual, grass and conifer trees down to the water's edge
Stream Cover/ Forest Density	Partly Open- 50% canopy, mature trees on South bank provide shade to middle of river channel
Soil Type (Texture/Drainage)	Sand, coarse- texture fair-drainage, soil was wet and held together

Sample Site 6 was located on Gillespie Road, upstream of Bridge 11. Still within the heart of the agricultural land, this site had more dense riparian vegetation down to the water's edge, including conifer species such as black spruce and balsam fir. The floodplain was wide and stream bank slope was gradual since the river was still within the valley. A beaver was actively building a dam upstream of the sample site and rural residential buildings were observed upstream and downstream. Dissolved oxygen, pH, nitrogen, phosphorus, turbidity and *E. coli* bacterial counts were all within PWQO guidelines for both sampling dates. Conductivity and total dissolved solids were higher than Sites 1 and 2, lower than Site 4, and comparable to Sites 3, 5 and 7. On both sampling dates, aluminum and iron exceeded the PWQO guidelines. Aluminum was 140 μg/L and 190 μg/L on August 14 and August 27, 2008, respectively (above the PWQO criterion of 75 μg/L). Iron was 590 μg/L and 750 μg/L on August 14 and August 27, 2008, respectively (above the PWQO criterion of 300 μg/L).

4.7 Site 7

Table 4.7-1: Location Reference for Site 7

Location Description	Off West Riverdale Road; before Old Pigeon Trail
UTM Coordinates	5356170.721 metres North/ 322930.52 metres East
Altitude/Elevation	193.98 metres above seal level

Table 4.7-2: Field Measurements for Site 7

Field Parameter	Date: August 14, 2008 Time: 16:00	Date: August 27, 2008 Time: 10:00
Water Temperature (ºC)	19.48	14.68
Conductivity (µS/cm)	371.75	352.95
Dissolved Oxygen (mg/L)	9.59	9.83
Dissolved Oxygen (%)	104.49	97.06
pH	8.09	8.31
Air Temperature (ºC)	33	15.5
Channel Width (m)	15	15
Channel Depth (m)	0.7	0.3
Flow Rate (m/s)	No measurable flow	0.00333

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

Variable	Date: August 14, 2008	Date: August 27, 2008
Conductivity (µS/cm)	445	540
Total Dissolved Solids (mg/L)	330	360
Turbidity (NTU)	0.47	0.94
Ammonia-N, Total (µg/L)	20	30
Nitrate-N (NO_3-N) (µg/L)	<30	<30
Nitrite-N (NO_2-N) (µg/L)	<20	<20
Phosphorus (P), Total (µg/L)	6	10
Escherichia Coli (MPN/100mL)	20	2
Aluminum (Al) (µg/L)	10	20
Cadmium (Cd) (µg/L)	**0.13**	**0.17**
Copper (Cu) (µg/L)	**7**	**6**
Iron (Fe) (µg/L)	110	130
Lead (Pb) (µg/L)	<1	<1

Bold indicates exceedance above PWQO guidelines.

Table 4.7-4: Flora and Fauna Observed at Site 7

Terrestrial	Trees	Balsam fir (predominant), eastern white cedar, white birch, trembling aspen, white spruce, speckled alder, black spruce, mountain maple, black ash
	Shrubs	Willow spp., wild red raspberry, red-osier dogwood
	Herbs	Spotted joe-pye-weed, bird's foot trefoil, lupine, red clover, cow vetch, crown-vetch, yellow clover, square stemmed monkey flower, false dragonhead, wild mint sp., ox-eye daisy, wood anemone, common strawberry, aster spp., buttercup, water parsnip, marsh cinquefoil
	Mosses	Lady fern, sensitive fern, meadow horsetail, grass, sedge and rush spp., plume moss, common fern moss, central peat moss
	Mammals	Bear (scat), deer (tracks), raccoon
	Birds	Sandpiper, white-breasted nuthatch, raven, red-tailed hawk, song sparrow, woodpecker, Canadian goose, crow, ruby-throated humming bird, dark-eyed junco
	Insects	Grasshopper, dragonfly, predacious diving beetle, bumblebee, spider
Aquatic	Plants	Broad-leaved arrowhead, green algae, black algae
	Animals	American toad, wood frog, water strider, crayfish, clam, painted turtle, mudminnow, sucker, rock bass[2]

Table 4.7-5: Physical Features Observed at Site 7

In-stream Material	Large boulders (especially concretations) emerging above the water surface
Stream Bed Description	Shale pebbles
Bank Stability/Erosion	Stable-although it was in the gorge so there was some evidence of large boulders dislodging from walls, very steep banks
Stream Cover/ Forest Density	Dense-75-100% shaded by canopy, the ravine walls provided more shade than vegetation did
Soil Type (Texture/Drainage)	Coarse gravel-texture, good-drainage, the top substrate was gravel size shale pieces

Site 7 was off West Riverdale Road, 18 metres down a shale terraced waterfall, in the Slate River Gorge. The sample site was located within the Slate River ANSI and had many biological and physical features that were distinctly unique to the area. Eastern white cedar and black ash were observed. There was an abundance of crayfish, clams, mudminnows and small (10 centimetre) rock bass. The stream bed substrate was shale pebbles instead of silty mud observed at the other sample sites. This was the only sample location where the stream was 100% shaded by canopy although it was mostly the rock walls that provided shade with dense forest 15 metres above. Dissolved oxygen, pH, nitrogen and phosphorus levels were within PWQO and CCREM guidelines. Total phosphorus, at Site 7, was lowest out of all sample sites with concentrations of 6 µg/L and 10 µg/L (where PWQO is 30 µg/L for streams/rivers). Conductivity and total dissolved solids were higher than Sites 1 and 2, lower than Site 4 and comparable to Sites 3, 5 and 6. Turbidity was the lowest out of all sample sites, with readings of 0.94 NTU and 0.47 NTU. Extremely clear water permitted observation of the streambed (maximum

[2] According to personal communication with local residents, within the last three years a juvenile walleye, a northern pike, a snapping turtle and a minx have been observed.

one metre depth). *E. coli* bacterial counts were well below the PWQO criteria. Cadmium was highest at this site. On August 14, and August 27, 2008, cadmium concentrations were 0.13 μg/L and 0.17 μg/L, respectively. Cadmium levels were below the PWQO criterion of 0.20 μg/L although it may be worth noting that an interim objective of 0.10 μg/L (when hardness at $CaCO_3$ is 0-100 mg/L) is being researched and developed by the MOE. Copper was above the PWQO criterion of 5 μg/L on both sampling dates, with concentrations of 7 μg/L and 6 μg/L on August 14 and August 27, 2008, respectively. This was the only site where aluminum and iron levels were below the PWQO criteria.

5 Overall Discussion

The highest point of elevation sampled was at Site 1, which was 367.7 metres above mean sea level. Elevation dropped off quickly from the mesa highland into the Slate River valley. At Site 3, elevation dropped over 100 metres to 221.47 metres above mean sea level. The Slate River meandered through the flat terrain until it reached the confluence. Site 7, closest to the confluence, was 193.98 metres above mean sea level. Between Sites 1 to 7, elevation dropped 173.72 metres. Elevation plays an important role in direction of water drainage and stream velocity. The Slate River has an average gentle slope at 0.7%.

The stream widened from 4 metres across at the headwaters (Site 1) to 15 metres across near the confluence (Site 7). Stream depth ranged from 0.3 metres to 1.5 metres, however it was 1 metre on average. Stream velocity was, on average, 0.008 m/s. Flow rate was so slow in the Slate River during August 2008 that in some cases it was not observable. Prevailing wind direction highly influenced the direction of surface water current.

On August 14, 2008 the average air temperature was 28ºC and average water temperature was 19.95ºC. Conditions were sunny with minimal cloud cover. On August 27, 2008 the average air temperature was 21ºC and average water temperature was 16.72ºC. The second sampling date was colder with more cloud cover and stronger winds.

The pH for all sites fell within the PWQO criteria of 6.5 to 8.5 for healthy aquatic life.

Dissolved oxygen was within the PWQO guidelines for all sites except for Site 1. Site 1, with results of 37.62% and 43% DO saturation, were below the criteria of 54% and 47% DO saturation at 15ºC for cold and warm water biota, respectively. This is most likely due to the large amount of dead organic material in the stream bed requiring oxidative processes to decompose.

Total dissolved solids (TDS) were lowest at Sites 1 and 2 at approximately 200 mg/L; TDS increased at Sites 3, 5, 6 and 7 to approximately 300 mg/L and spiked to approximately 600 mg/L at Site 4. Conductivity readings exhibited a similar pattern. These results may indicate a disturbance at Site 4. Possible sources of high TDS could be agricultural runoff or erosion of the stream bank. Since TDS is highly variable to due the underlying geology, the only objective in place is <500 mg/L for drinking water published in the *Canadian Drinking Water Quality* guidelines to prevent unpalatable tastes and excessive scaling in water pipes and boilers (Health Canada 1996).

Turbidity in the Slate River ranged from 0.74 to 13.8 NTU. All sites were well below the *Canadian Recreational Water Quality* guidelines of 50 NTU (Health Canada 1992). The lowest values were recorded from Site 7 where the water was so clear that the streambed was observed one metre below the surface. PWQOs state that there should be no more than 10% change in Secchi disk (depth) reading. When comparing each site to itself between the two sampling dates, Slate River water quality fell within this criterion.

Nitrogen was analyzed in three biologically-useable forms: nitrate (NO_3), nitrite (NO_2) and ammonia. All three forms of nitrogen in the Slate River were below the maximum concentrations published in the PWQO and CCREM guidelines. All, except one, nitrate concentrations in Slate River were <30 μg/L (with a CCREM criterion of 2900 μg/L). All nitrite concentrations in Slate River were <20 μg/L (with a CCREM criterion of 60 μg/L). Total ammonia ranged from 20-70 μg/L. Total ammonia does not have a singular criterion because its speciation between the un-ionized (NH_3) and (NH_4^+) forms is dependant 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 Slate River were <3 μg/L (with a PWQO criterion of 20 μg/L). These guidelines were put in place for protection from direct toxic effects; [they] do not consider indirect effects due to eutrophication (large algae blooms).

Total phosphorus exceeded the PWQO criterion of 30 μg/L for rivers/streams at Site 2 and Site 4. Site 2, on August 28, 2008 resulted in a concentration of 45 μg/L; Site 4 on August 14, 2008 resulted in a concentration of 32 μg/L; and Site 5 on August 14, 2008 was exactly at 30 μg/L. 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.

There was no evidence of nitrogen or phosphorus levels altering water quality through excessive algal /plant growth and no explicit evidence of agricultural nutrient loading into the Slate River during August 2008.

PWQOs recommend *Escherichia coli (E. coli)* bacteria levels below 100 counts per 100mL of water for safe swimming and bathing. On August 14, 2008, all sample sites were below the PWQO criterion. On August 27, 2008, Sites 3, 4 and 5 were above the criterion with 150, 820 and 130 counts per 100 mL of water. *E. coli* is present in the intestines of warm-blooded animals such as humans, livestock and wildlife and is indicative of recent fecal contamination. Many studies have shown that the presence of cattle grazing near a stream can significantly influence bacteria counts. *E. coli* could also be entering the Slate River from leaking residential septic tanks, leaking manure or milkhouse waste storage facilities, or from manure application to fields. The presence of *E. coli* can cause skin and eye irritation and when ingested can cause severe gastro-intestinal disorders. One such strain is *E. coli* O157:H7, which is found in the digestive tract of cattle.

Prior to 1994, the MOE also monitored and enforced total coliform bacteria counts. To monitor any long-term trends in water quality, total coliforms were analyzed in August 2008 for comparison to the 1990 MOE water quality results for Slate River. The past PWQO criterion for total coliforms was 1000 counts per 100 mL of water. In August 2008, all total coliform results for Slate River were above this criterion, except for one instance. The majority of results were >2420 counts per 100 mL of water. In comparison, the majority of results from the 1990 MOE study were <1000 counts per 100 mL of water. Although total coliform bacteria include relatively harmless microorganisms, they are commonly used to indicate that some pathway exists for bacteria from warm and cold-blooded animals to enter the river.

All sites, except Site 7, were above the PWQO criterion of 75 μg/L for aluminum. Aluminum, at Sites 1-6, ranged between 110 to 350 μg/L and had an average concentration of 180 μg/L. All sites, except Site 7, were above the PWQO criterion of 300 μg/L for iron. Iron, at Sites 1-6, ranged between 540 to 1550 μg/L and had an average concentration of 920 μg/L. High aluminum and iron levels may be caused by the underlying geology. These metals may natural dissociate from mineral-rich rocks.

Copper was above the PWQO of 5 μg/L at Sites 2 and 7. On August 14, 2008, copper concentrations were 6 μg/L and 7 μg/L for Site 2 and 7, respectively. On August 27, 2008, the copper concentration was 6 μg/L for Site 7. High copper levels could be from natural sources as copper occurs in nature as a metal or an ore (sulphide, oxide or carbonate minerals in rock). Copper is also used extensively in pesticide formulation and as an anti-fungal, anti-microbial agent for treated wood.

Lead concentrations on August 27, 2008 at Sites 2 and 3 were at the PWQO criterion of 1 μg/L. Although lead can occur naturally from the weathering of rock ores, lead in watercourses may come from human sources such as historical atmospheric emissions from leaded gasoline, batteries, alloys, pigments and chemicals and solid and liquid waste discharge (usually from landfills).

Cadmium concentrations on August 14 and August 27, 2008 at Site 7 were 0.13 μg/L and 0.17 μg/L, respectively. Cadmium levels were below the PWQO criterion of 0.20 μg/L although it may be worth noting that an interim objective of 0.10 μg/L (when hardness at CaCO3 is 0-100 mg/L) is being researched and developed by the MOE. According to Health Canada’s technical documents on water quality, surface water containing in excess of a few micrograms of cadmium per litre have probably been contaminated by cadmium-stabilized plastics, nickel-cadmium batteries or sewage treatment effluent.

Forest composition was characteristic of the Boreal region. Each sample site had similar species identified. The most common tree species observed include black spruce, balsam fir, trembling aspen, white birch, speckled alder and Manitoba maple. Manitoba maple is not native to Northwestern Ontario Boreal forest region and is considered an opportunistic weed species that adapts readily to disturbed areas. The shrub layer was dominated by red-osier dogwood, serviceberry, chokecherry and willow species. Dogwood and willow are characteristic of wetland/riparian zone habitat and are most valuable in controlling stream bank erosion. The prevalence of berry-producing shrubs may help to encourage healthy bird populations. The herb layer was dominated by species characteristic of disturbed areas (such as roadsides and ditches), open fields, wet meadows, stream banks or marshes. The most common herb species include Canada goldenrod, aster, purple vetch, red clover, Canada thistle, bird's foot trefoil, common yarrow and spotted-Joe-pye-weed.

The most common observed aquatic species included hardstem bulrush, yellow pond lily, broad-leaved arrowhead, large-fruit burreed, snails, clams and mudminnows. The presence of freshwater sponge and clam are good indicators of healthy water quality, although more data needs to be collected on the benthic macroinvertebrate community since its composition changes in response to ecosystem stress faster than other members of the aquatic community. Fish populations lacked abundance and diversity but physical water quality parameters are healthy enough to support such a population. Lack of fish may be due to the natural variability in water level and flow. Water level was so low in August 2008 that in some cases flow was nothing more than a trickle. Migration of fish would be prevented by numerous beaver dams and dry portions of the stream bed.

The Slate River watershed has a diverse population of birds. The most common species identified include cedar waxwing, white-breasted nuthatch, blue jay, and American goldfinch. The presence of a belted kingfisher and a great blue heron show the Slate River watershed is important habitat for nesting waterbirds.

The contrasting vegetative cover (forest versus farmland) can provide suitable habitat for species that favour both dense cover (upper watershed) and open edges (in the agricultural fields).The forest density along the riparian buffer zone (up to 5 metres back from the water's edge) was low. The canopy was open; less than 25% of the stream was shaded by the canopy. The riparian zone was mostly mixed grasses and herb species, with shrubs interspersed. According to Cullis *et al.* (1998), the Slate River watershed met most of the wildlife habitat targets identified in the Great Lakes remedial action plans (RAPs) except for: a lack of 30 metre wide buffer zones along first to third order streams and a lack of wetlands in the watershed. These buffer zones are important to improve water quality. Riparian vegetation will uptake excess nutrients/other contaminants before it reaches the river; it will reduce erosion and increase bank stability and provide shade for potential fish populations. Wetlands act as a natural reservoir for contaminants and sediment to prevent them entering the river. Wetlands are also important to reduce the impact from flooding.

Overall, the stream banks documented along the Slate River were stable. The gentle slope of the stream bank and its composition of silty clay soil gave the area low erosion potential. Although, there were some documented sites of minor erosion mostly from undercut banks as the river meandered and from the trampling of the stream bank from livestock access to the water's edge.

Bridges that cross the Slate River appeared to be in good structural condition in August 2008. Fill was mostly composed of boulders (imported blast rock) and appeared stable. Fill often went down to the water's edge with little vegetation growing along it. Height from the bottom of the bridge to the water surface varied from 2.3 to 6.5 metres at the time of assessment. High water marks from the June 2008 flood indicate that the Slate River water level met the height of several bridges. Structural integrity did not appear comprised by the high water levels. The pair of culverts (Culverts 1a and 1b) that cross the Slate River (at the headwaters) were in good condition although high water marks indicate the water level was above the elevation of the culverts and the road surface. At the time of assessment Culvert 2 was blocked with mud and twigs as a result of beaver activity. Flow was restricted through the culvert and the downstream end of the culvert appeared to be crushed.

Compared to April-July 1990 water quality results for the Slate River, collected by the MOE, published in the Slate River Watershed Management Plan (Cullis *et al.* 1998), August 2008 results demonstrate improvement in total phosphorus, nitrate, ammonium, and *E. coli* levels using current PWQO and CCREM guidelines. Most notable improvement were total phosphorus levels which had an average concentration of 83 μg/L in 1990 and 24 μg/L in 2008 sampling sessions; levels were reduced by 29%.

6 Conclusion

Slate River watershed has been impacted by historical development which has resulted in surface water quality and forest composition being altered. Although, an improvement in agricultural best management practices has translated into an improvement in overall watershed health in the past two decades as indicated by comparison of August 2008 water quality results to 1990 MOE results. The majority of parameters analyzed by the ALS Laboratory Group in 2008 were below the PWQO guidelines. During the 2008 assessment, disturbance was highest at sample Site 4 in the center of the region's agricultural activities; disturbance was lowest at sample Site 7 downstream of agricultural activity and closest to the Slate River and Kaministiquia River confluence. The highest diversity of flora and fauna was observed at Site 7. The improvement of water quality and forest composition near the confluence may indicate that the Slate River was, in general, a healthy contributing tributary within the Lake Superior watershed in 2008. It can be concluded that at the time of assessment in August 2008, the Slate River watershed was in good condition for a watershed with sustained agricultural activity.

7 Recommendations

Slate River watershed was in good health at the time of study during August 2008, however additional testing is recommended to create a more thorough assessment. Time and resources permitting, the Slate River watershed should be reassessed by the LRCA within ten years to monitor changes to water quality. Similar to the previous report, it is recommended that voluntary stewardship initiatives are encouraged to rehabilitate the streambanks of the Slate River.

A copy of this Report should be made available to the residents of the Municipalities of Oliver Paipoonge and Neebing and be kept on file at the LRCA administrative office for review by interested parties.

The recommendations are as follows:

- Additional sampling should be conducted in spring to observe the water quality differences between high and low flow seasons
- Additional sampling should be conducted to assess the benthic macroinvertebrate community as an indicator of water quality
- Additional monitoring of nutrient, metal and bacterial levels as indicators of water quality
- A 30 metre riparian buffer zone should be allowed to grow along the Slate River, including its seasonal tributaries to improve water quality
- Fences should be erected to prevent livestock direct access to the water's edge to improve water quality

8 References

Agriculture and Agri-Food Canada. (1998). Canada Land Inventory, National Soil DataBase. [online] Available: http://sis.agr.gc.ca/cansis/nsdb/cli/intro.html

Agriculture Canada (1981). Cartography by the Land Resource Research Institute, Research Branch, Agriculture Canada. Thunder Bay 52A. Soils of the Thunder Bay Area. Soil Survey Report No. 48.

Breukelman, E. (2008). Slate River Resident. Personal communication (August 2008)

Cadman, M., Sutherland, D., Beck, G., Lepage, D. & A. Couturier (eds.) (2007). Atlas of the Breeding Birds of Ontario, 2001-2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources and Ontario Nature: Toronto, Ontario.

Canadian Council of Ministers of the Environment (CCREM) (2007). Canadian water quality guidelines for the protection of aquatic life: Summary table. Updated September, 2007. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

Cullis, K., Brigham, D., Graham, J., Oldale, J., Tyuis, R. (1998) Watershed Management Plan For The Slate River. Lake Superior Programs Office. Ontario Ministry of Natural Resources: Thunder Bay, Ontario.

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

Environment Canada. (2008). *Canadian Daily Climate Data* (CDCD). [online] Available: http://www.climate.weatheroffice.ec.gc.ca [September 02, 2008].

Environment Canada. (2008). Slate River Streamflow Gauge data. Released by Environment Canada to the LRCA.

Escott, N. (1996). Breeding Birds of the Slate River Valley. Thunder Bay Field Naturalists.

Geomatics International (1991). Northern Ontario Wetland Evaluation, Wetland Data Record and Scoring, Oliver Lake Swamp. Ministry of Natural Resources: Thunder Bay, Ontario

Hardy, J., Pakylak, A. (2004) Pearl River Watershed assessment Report. Lakehead Region Conservation Authority.

Harris, A. (1996). Collection of Plant Records from Lakehead University Herbarium. The Thunder Bay Field Naturalists: unpublished [located in Cullis et al.]

Hartvicksen, C. and W. Momot. (1989) Fishes of The Thunder Bay Area of Ontario. Wildwood Publications.

Health Canada. (1992). *Guidelines for Canadian Recreational Water Quality*. Ministry of National Health and Family Welfare. Ottawa: Supply and Services Canada. [online] Available: http://www.hc-sc.gc.ca [September 02, 2008].

Health Canada. (1996). *Guidelines for Canadian Drinking Water Quality* (6th Edition). Ministry of National Health and Family Welfare. Federal-Provincial Subcommittee on Drinking Water. Ottawa: Supply and Services Canada. [online] Available: http://www.hc-sc.gc.ca [September 02, 2008].

Hills, G.A. and F.F. Morwick (1944). Reconnaissance Soil Survey of Parts of NW Ontario. Report No. 8. Experimental Farm Service, Ontario Agricultural College: Guelph, Ontario [located in LRCA library].

Hosie, R. (1990). Native Trees of Canada. 8th Edition. Canadian Forestry Service (Environment Canada). Fitzhenry & Whiteside Ltd.: Canada.

Kivi, K (2008). Slate River Resident. Personal communication (August 2008)

Lakehead Region Conservation Authority (LRCA). Photocopies of OMNR ANSIs for Thunder Bay Area. ANSI Policy, Slate River and Squaretop Mountain Sections.

LRCA. (1989). TOE. *Slate River Erosion Project* . (1989: Cabinet 11, Drawer 4, File # 30). TOE Protection (2001: Cabinet 11, Drawer 4, File # 31)

Ministry of the Environment and Energy (MOEE). (1994). *Provincial Water Quality Objectives*. Ontario: Queen’s Printer. [online]. Available: http://www.ene.gov.on.ca/envision/gp/3303e.htm#AppA

Momot, W. and S. Stephenson (1996). Atlas of the Distribution of Fish within the Canadian Tributaries of Western Lake Superior. Lakehead University: Thunder Bay, Ontario.

Moorhouse, W.W. (1960). Gunflint Iron Range in the Vicinity of Port Arthur. Ontario Department of Mines. VLXIX, Part 7. Toronto, Ontario.

Nelson, L. & M. Norris (2006). Welch Creek Watershed Assessment Report. Lakehead Region Conservation Authority: Thunder Bay, Ontario.

Newmaster, S., Harris, A., & L. Kershaw. (1997). Wetland Plants of Ontario. Lone Prine Publishing and Queen's Printer for Ontario: Canada.

Ontario Ministry of Natural Resources (OMNR) (1983). Policy for Areas of Natural and Scientific Interest. Policy No. PM 11.08. Ontario Parks, NRMD: Field Services Division, Planning & Research Section. Excerpted from Appendix D, Backgrounder Land Use Guidelines.

OMNR. *Understanding Natural Hazards.* (2001) Queen's Printer for Ontario.

Petrides, G. (1958). A Field Guide to Trees and Shrubs. 2nd Edition. The Peterson Field Guide Series. Hougton Mifflin Company, Boston, USA.

Shankie, S. & T. Villa (2007). Brule Creek Watershed Assessment. Lakehead Region Conservation Authority: Thunder Bay, Ontario.

Sims, R., Towill, W., Baldwin, K. & G. Wickware. (1989). Forest Ecosystem Classification for Northwestern Ontario. Ontario Ministry of Natural Resources and Forestry Canada. Twin Offset Ltd: Thunder Bay, Ontario.

Statistics Canada. (2006). 2006 Agricultural Community Profiles, for Neebing, Oliver Paipoonge and Thunder Bay, Ontario. [online]. Available: http://www26.statcan.ca:8080/AgrProfiles/cp06/PlaceSearch.action [October 1, 2008].

Statistics Canada (2006). 2006 Community Profiles, for Neebing, Oliver Paipoonge and Thunder Bay, Ontario. [online]. Available: http://www12.statcan.ca/english/census06/data/profiles/community/Index.cfm?Lang=E [October 1, 2008].

Tozer, R. (2008). Slate River Resident. Personal communication (August 2008).

Appendix A: Water Quality Parameters

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. Some examples of the importance of temperature are: 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.

Dissolved Oxygen

Like terrestrial animals, fish and other aquatic species require oxygen to breath. Its not the mere presence of dissolved oxygen, the gas has to be above a certain concentration 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. PWQOs have an acceptable range for dissolved oxygen in water dependant 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.

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.

Conductivity

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

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 and 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 indicate soil erosion.

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

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. Milkhouse waste from dairy farms is also a large source of phosphorus and has become one of the main environmental issues surrounding dairy farming.

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).

Bacteria
Escherichia coli is 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. Sources of *E. coli* could be 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.

Metals

The following is a complete list of the total metal scan performed on the water samples:

Aluminum (Al)	Molybdenum (Mo)
Antimony (Sb)	Nickel (Ni)
Arsenic (As)	Selenium (Se)
Barium (Ba)	Silicon (Si)
Beryllium (Be)	Silver (Ag)
Bismuth (Bi)	Strontium (Sr)
Boron (B)	Thallium (TI)
Cadmium* (Cd)	Tin (Sn)
Chromium (Cr)	Titanium (Ti)
Cobalt (Co)	Tungsten (W)
Copper (Cu)	Uranium (U)
Iron (Fe)	Vanadium (V)
Lead (Pb)	Zinc (Zn)
Manganese (Mn)	Zirconium (Zr)

Most of these metals are found naturally within the earth's crust and weathering of rock can transport them into surface water.

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 is 75 μg/L.

Antimony

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

Arsenic
Arsenic is a natural element found widely in 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 discolouration of the skin; nausea and diarrhea; decreased production of blood cells; abnormal heart rhythm and blood vessel damage; or numbness in the hands and feet. Short term exposure (days/weeks) to very high levels of arsenic can result in abdominal pain, vomiting and diarrhea; muscular cramping or pain; weakness and flushing of skin, skin rash; numbness, burning or tingling sensation on the palms of the hands and soles of the feet; or loss of movement and sensory response. The maximum concentration of arsenic under PWQO guidelines is 5 μg/L.

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

Beryllium
Beryllium is a hard grey metal that is extracted from the earth, refined and reduced to a very fine powder. It occurs as a chemical component of certain rocks, coal and oil, soil, and volcanic dust. People exposed to beryllium are at risk of developing serious, debilitating diseases. Chronic beryllium disease (CBD or berylliosis) is a painful scarring of the lung tissue. Less common than CBD, acute (short—term) beryllium disease causes lung inflammation resembling pneumonia. In severe cases, both diseases may be fatal. The maximum concentration of beryllium under PWQO guidelines depends on hardness. If $CaCO_3$ is >75 mg/L the maximum concentration of beryllium is 1100 μg/L and if the $CaCO_3$ is <75 mg/L the maximum concentration of Beryllium is 11 μg/L.

Bismuth
Bismuth is a brittle metal with a pinkish colour, which is 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 non-metallic element that is not found in nature in its elemental form but can be found in a number of compounds. Exposure to boron in small doses may cause irritation

to the nose, throat and eyes. In larger doses, boron can affect the stomach, liver, kidneys and brain and may eventually lead to death. The maximum level of boron under PWQO guidelines is 200 μg/L.

Cadmium
Cadmium is an extremely toxic metal even in low concentrations. It is used commercially as a stabilizer in plastic, in fungicides for golf courses, television picture tube phosphors, nickel–cadmium batteries, motor oils, and curing agents for rubber. Cadmium poisoning can lead to itai-itai disease, which initiates bone softening, joint pain and kidney failure. The maximum concentration of cadmium under PWQO guidelines is 0.2 μg/L. The interim PWQO guideline states if hardness as $CaCO_3$ is 0-100 the maximum cadmium concentration is 0.1 μg/L and if hardness is >100 the maximum cadmium concentration is 0.5 μg/L.

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

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

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

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

Iron
Iron is also an abundant metal found in rock. The precipitation of excessive iron creates an objectionable reddish-brown colour to water. Iron may also stain laundry and plumbing fixtures, produce undesirable tastes in beverages, and promote the growth of

certain iron-bacteria, leading to the deposition of a slimy coating in water distribution pipes.The PWQO guideline stipulates that the levels of iron in the water must be below 300 μg/L.

Lead
Lead is a very toxic metal to all forms of life, causing neurological damage and even death. Although natural occurrences can occur from precipitation and the weathering of ores; the majority of lead in watercourses comes from anthropogenic sources. The PWQO requirement for lead varies with different alkalinity as $CaCO_3$ (mg/L); the maximum lead concentration is 25 μg/L.

Magnesium
Magnesium is very abundant in nature, and is found in important quantities in many minerals. It is a dietary requirement, but too much can lead to muscle weakness, lethargy and confusion. There are currently no currently no PWQO guidelines limiting the intake of 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 limiting the intake of manganese.

Molybdenum
Molybdenum is a by-product of copper and tungsten mining, used as an alloy for various metals, 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 μg/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 μg/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 limiting the intake of 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 μg/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 limiting the intake of 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 at oral uptake it leads to vomiting, dizziness and diarrhea. The maximum concentration of silver under PWQO guidelines is 0.1 μg/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 limiting the intake of 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 μg/L.

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

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

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

Uranium

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

Vanadium

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

Zinc

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

Zirconium

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

Appendix B: Water Quality Guidelines

The following are taken from the Ministry of the Environment water quality guidelines, 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 10C° (18F°). However, in special circumstances, local conditions may require a significantly lower temperature difference than 10C° (18F°). 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 10C° (18F°) or the allowed temperature difference, which ever 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 20µg/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 20°C and pH of 8.0, a total ammonia concentration of 500µg/L would give an un-ionized ammonia concentration of 500 x 3.8/100 = 19µg/L which is less than the un-ionized ammonia Objective of 20µg/L.

The table below is taken from Emerson et al. 197511 but percentages are rounded to two significant figures. The equations given by Emerson et al. may be used to interpolate values between those given in the table:

$f = 1/(10^{pKa-pH} + 1)$, where f is the fraction of NH_3

$pKa = 0.09018 + 2729.92/T$, 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.
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.

Temp.	**pH**								
°C	**6.0**	**6.5**	**7.0**	**7.5**	**8.0**	**8.5**	**9.0**	**9.5**	**10.0**
29	.075	.24	.75	2.3	7.0	19.	43.	70.	88.
30	.081	.25	.80	2.5	7.5	20.	45.	72.	89.

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 20µg/L;

A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration for the ice-free period of 10µg/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 30µg/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 judgement 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 a 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 µg/L.

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

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

Beryllium:
Beryllium amounts should not exceed the following:

Hardness as $CaCO_3$ (mg/L)	Interim PWQO (µg/L)
< 75	11
>75	1100

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

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

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

Hardness as $CaCO_3$ (mg/L)	Interim PWQO (µg/L)
0 - 100	0.1
>100	0.5

Calcium:
There are currently no PWQO guidelines limiting the intake of 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 µg/L.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Location
The sample sites were chosen using a 1:4000 scale topographic map. The sample sites were also described in terms of road access and road crossings.

Latitude, Longitude, and Elevation
The coordinates for each site were measured with a Trimble Geo XH hand held GPS unit.

Channel width & depth
The width was measured with a nylon measuring-tape reel. Channel depth was measured by dropping a weighted fishing line into the river and measuring the released line with a metre stick.

Flow
The velocity of the river was measured by placing a piece of floating debris (stick) in the stream and measuring the amount of time it took to travel a specified distance. The flow was later calculated to metres per second.

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

Water Temperature
Water temperature was measured with the YSI 556 MPS. The readings were taken after the probe was submerged and all variables on the meter were stabilized.

Conductivity
Conductivity was measured with the YSI 556 MPS. 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.

Total Dissolved Solids
The total dissolved solids (TDS) are measured from the conductivity reading.

Dissolved Oxygen
The YSI 556 MPS measured dissolved oxygen for the samples. The readings were recorded once the probe was submerged in the water and all variables were stabilized.

Tree, Shrub & Herb Species
Identification was made in the vicinity of the sample sites, approximately 10 metre by 10 metre transects.

Aquatic Plants
Aquatic plants were determined through careful observation and identification via a field guide.

Benthic/Terrestrial Species

Through the use of dip nets and observations, species was identified by observation and verified by the use of field guides.

In-stream Material

In-stream material refers to logs, rocks and organic/vegetative debris that are found within the river. This is important to record as it greatly affects the diversity of benthic life. The in-stream material was described through observation and recorded for each site.

Stream Bed Description

The bed description was given a set of categories of varying grain sizes.

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 Bank Stability / Erosion

Evidence of erosion or the potential of erosion was observed, categorized as either stable or unstable. A bank was categorized stable if there was little to no erosion present, well vegetated or had a low slope. Unstable was defined as having visible signs of erosion, little to no vegetation on the bank or a steep slope.

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:

Dense	75-100% shaded by canopy
Partly Open	25-74% shaded by canopy
Open	0-25% shaded by canopy

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 table above and its moisture content. For example, clay with poor drainage will have a low erosion hazard.

Appendix D: Forest Ecosystem Classification

Site 1: 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.

Common Overstory Species:

White spruce, balsam fir, trembling aspen, white birch, black spruce, balsam poplar, red maple, jack pine

Common Understory Species:

Shrubs: balsam fir, Acer spicatum, *Rubus pubescens, Corylus cornuta, Sorbus décor, Linnaea borealis, Diervilla lonicera, Rose acicularis, Amelanchier spp., trembling aspen*

Herbs*: Aralia nudicaulis, Cornus Canadensis, Clintonia borealis, Maianthemum canadense, Streptopus roseus, Trientalis borealis, Calium triforum, Aster macrophyllus, Mitella nuda, Viola renifolia, Anemone quinquefolia, Petasites palmatus*

Mosses*: Pleurozium schreberi, Ptilium crista-castrensis, Rhytidiadelphus triquetrus, Plagiomnium cuspidatum*

Forest Floor Cover:

Broadleaf litter: 61 Moss: 16 Conifer litter: 13 Wood: 5

Site 2: V16 Balsam fir – white spruce mixedwood/ feathermoss

Description: A variable mixedwood Type with balsam fir and/or white spruce as the main tree species. The understory generally lacks an abundance of broadleaved species but balsam fir can occur in dense thickets. Extensive feathermoss mats cover the forest floor. Occurring on a broad range of soil and site conditions but primarily on fresh to moist, upland mineral soils.

Common Overstory Species:

Balsam fir, white spruce, white birch, black spruce, trembling aspen, jack pine

Common Understory Species:

Shrubs: *balsam fir, Linnaea borealis, Diervilla lonicera, Vaccinium myrtilloides, Sorbus decora, Acer spicatum, Rubus pubescens, Picea mariana, Rosa acicularis, Gaultheria hispidula*

Herbs: *Cornus Canadensis, Clintonia borealis, Aralia nudicaulis, Maianthemum canadense, Trientalis borealis, Streptopus roseus, Coptis trifolia, Lycopodium annotinum, Voila renifolia*

Mosses: *Pleurozium schreberi, Ptilium crista-castrensis, Dicranum polysetum, Hylocomium splendens, Dicranum fuscescens, Rhytidiadelphus triquetrus*

Forest Floor Cover:

Moss: 64 Broadleaf litter: 19 Conifer litter: 11 Wood: 5

Site 3: V7 Trembling Aspen – balsam fir/balsam fir shrub

Description:
Hardwood mixed woods, typically with a two tiered canopy. In general, trembling aspen constitutes the overstory with balsam fir in the secondary canopy. Understory development is variable with balsam fir, *Aralia nudicaulis* and *Diervilla lonicera* often abundant. This occurs mainly on deep, fresh, well-drained, fine-textured mineral soils.

Common Overstory Species:

Trees: balsam fir, trembling aspen, white birch, white spruce, black spruce, jack pine

Common Understory Species:

Shrubs: *Abies balsamia, Rubus pubescens, Diervilla lonicera, Acer spicatum, Rosa acicularis, Populus tremuloides, Corylus cornuta, Linnaea borealis, Sorbus decora*

Herbs: *Maianthemum canadense, Aralia nudicaulis, Cornus Canadensis, Clintonia borealis, Aster macrophyllus, Streptopus roseus, Trientalis borealis, Viola renifolia, Mitella nuda, Petasites palmatus, Anemone quinquefolia, Gallium triflorum*

Mosses: *Pleurozium schreberi, Rhytidiadelphus triquetrus*

Forest Floor Cover:

Broadleaf litter: 81 Moss: 7 Conifer litter: 6 Wood: 5

Site 4: No V-Type classification

Description: The surrounding landscape is cleared for agricultural activity such as corn, wheat and dairy cattle.

Site 5: V8 Trembling aspen (white birch) / Manitoba maple

Description: Hardwood mixedwood stands with an abundance of broadleaved herbs and shrubs in the understory. Although this V-Type is characterized by dense thickets of Mountain maple (*Acer spicatum*), this location is predominately Manitoba maple (*Acer negundo*). Occurring mainly on deep, fresh to dry, well to rapidly drained mineral soils.

Common Overstory Species:

Trees: trembling aspen, white birch, white spruce, black spruce, jack pine, balsam fir

Common Understory Species:

Shrubs: *Acer spicatum, Rubus pubescens, balsam fir, Corylus cornuta, Diervilla lonicera, trembling aspen, Rosa acicularis, Amelanchier spp., Linnaea borealis, Sorbus decora, Lonicera Canadensis*

Herbs: *Aralia nudicaulis, Streptopus roseus, Clintonia borealis, Maianthemum canadense, Aster macrophyllus, Trientalis borealis, Cornus Canadensis, Voila renifolia, Calium triflorum, Lycopodium clavatum, Mitella nuda, Coptis trifolia*

Mosses: *Pleurozium schreberi, Ptilium crista-castrensis, Rhytidiadelphus triquetrus, Plagiomnium cuspidatum*

Forest Floor Cover:

Broadleaf litter: 84 Moss: 7 Wood: 5

Site 6: V19 Black spruce mixedwood / herb rich

Description: A black spruce mixedwood type with several potential species in the overstory. The understory is typically dominated by a rich herb/dwarf shrub layer. The shrub stratum ranges from dense to open, usually with balsam fir and black spruce as important components. Forest floor cover varies from moss rich to mainly broadleaf litter. Occurring on a range of site conditions although mostly on fresh to moist, mineral soils.

Common Overstory Species:

Trees: black spruce, trembling aspen, jack pine, balsam fir, white birch, white spruce, balsam poplar

Common Understory Species:

Shrubs: *Linnaea borealis, balsam fir, Rubus pubescens, Vaccinium myrtilloides, black spruce, Rosa acicularis, Amelanchier spp., Vaccinium angustifolium, Sorbus decora, Gaultheria hispidula, Diervilla lonicera, Ledum groenlandicum, trembling aspen*

Herbs: *Cornus Canadensis, Maianthemum canadense, Clintonia borealis, Trientalis borealis, Aralia nudicaulis, Coptis trifolia, Petasites palmatus, Aster macrophyllus, Streptopus roseus, Voila renifolia*

Mosses: *Pleurozium schreberia, Ptilium crista-castrensis, Dicranum polysetum, Hylocomium splendens, Rhytidiadephus triquetrus*

Forest Floor Cover:

Moss: 49 Broadleaf litter: 33 Conifer litter: 12

Site 7: V21 Cedar (incl. mixedwood) / Mountain maple

Description: A diverse white cedar Type consisting of both conifer and mixedwood stands. Numerous species combinations are possible in the overstory. The shrub layer is usually dominated by balsam fir, white cedar and Acer spicatum but is rarely dense. Species diversity in the herb layer is often high. Occurring across a range of site and soil conditions from wet, organic lowlands to rich, fresh uplands.

Common Overstory Species:

Trees: white cedar, balsam fir, white birch, white spruce, trembling aspen, black spruce, balsam poplar, black ash

Common Understory Species:

Shrubs: *balsam fir, Acer spicatum, white cedar, Rubus pubescens, Linnaea borealis, Sorbus decora, Lonicera Canadensis, Ribes triste, Corylus cornuta*

Herbs: *Trientalis borealis, Voila renifolia, Mitella nuda, Aralia nudicaulis, Maianthemum canadense, Clintonia borealis, Cornus canadensis, Streptopus roseus, Galium triflorum, Aster macrophyllus, Gymnocarpium dryopteris*

Mosses: *Pleurozium schreberi, Rhytidiadelphus triquetrus, Hylocomium splendens, Ptilium crista-castrensis, Plagiomnium cuspidatum, Drepanocladus uncinatus*

Forest Floor Cover:

Conifer litter: 42 Broadleaf litter: 30 Moss: 18 Wood: 5

Appendix E: Plant Species Common and Latin Names

Common Names	Latin Names
Trees	
American Elm	*Ulmus americana*
Balsam Fir	*Abies balsamea*
Balsam Poplar	*Populus balsamifera*
Black Ash	*Fraxinus nigra*
Black Spruce	*Picea mariana*
Eastern White Cedar	*Thuja occidentalis*
Hawthorn	*Crataegus*
Jack Pine	*Pinus banksiana*
Manitoba Maple	*Acer negundo*
Mountain Ash	*Sorbus americana*
Mountain Maple	*Acer spicatum*
Red Ash	*Fraxinus pennsylvanica*
Red Pine	*Pinus resinosa*
Speckled Alder	*Alnus rugosa*
Sugar Maple	*Acer saccharum*
Tamarack	*Larix laricina*
Trembling Aspen	*Populus tremuloides*
White Birch	*Betula papyrifera*
White Spruce	*Picea glauca*
Wild Crabapple	*Malus coronaria*
Yellow Birch	*Betula alleghaniensis*
Shrubs	
Chokecherry	*Prunus virginiana*
Currant	*Ribes spp.*
High-bush cranberry	*Viburnum trilobum*
Pincherry	*Prunus pensylvanica*
Prickly wild rose	*Rosa acicularis*
Red-osier Dogwood	*Cornus stolonifera*
Saskatoon (serviceberry)	*Amelanchier spp*
Swamp red currant	*Ribes triste*
Wild red raspberry	*Rubus idaeus var. strigosus*
Willow	*Salix spp.*
Herbs	
Aster	*Symphyotrichum spp.*
Bird's foot trefoil	*Lotus corniculata*

Bloodroot	*Sanguinaria canadensis*
Broadleaf spirea	*Spiraea alba*
Bull thistle	*Cirsium*
Buttercup	*Ranunculus repens*
Canada goldenrod	*Solidago canadensis*
Canada thistle	*Cirsium arvense*
Common burdock	*Arctium minus*
Common evening primose	*Oenothera biennis*
Common strawberry	*Fragaria virginiana*
Common yarrow	*Achillea millefolium*
Cow parsnip	*Heracleum lanatum*
Cow vetch	*Vivia cracca*
Creeping bellflower	*Campanula rapunculoides*
Crown vetch	*Coronilla varia*
Dandelion	*Taraxacum officinale*
Encrusted saxifrage	*Saxifraga aizoon*
False dragonhead	*Physostegia virginiana*
Field sow-thistle	*Sonchus arvensis*
Fireweed	*Epilobium angustifolium*
Fragrant bedstraw	*Galium triflorum*
Jack-in-the-pulpit	*Arisaema triphyllum*
Jeweled touch-me-not	*Impatiens capensis*
Lily	*Liliaceace spp.*
Lindley's aster	*Symphyotrichum ciliolatum*
Lupine	*Lupinus polyphyllus*
Marsh cinquefoil	*Potentilla palustris*
Meadow-rue	*Thalictrum dioicum*
Mullien	*Verbascum thapsus*
Narrowleaf spirea	*Spiraea alba*
Ox-eye daisy	*Chrysanthemum leucanthemum*
Red clover	*Trifolium pratense*
Spotted Joe-pye-weed	*Eupatorium maculatum*
Spring Beauty	*Claytonia caroliniana*
Square-stemmed-monkey-flower	*Mimulus ringens*
Violet	*Viola spp.*
Virgin's bower	*Clematis virginiana*
Water parsnip	*Sium suave*
White sweet-clover	*Melilotus alba*
Wild chamomile	*Anthemis arvensis*
Wild ginger	*Asarum canadensis*
Wild mint	*Mentha arvensis*

Wood aneome	*Anemone quinquefolia*
Yellow Clover	*Melilotus officinalis*

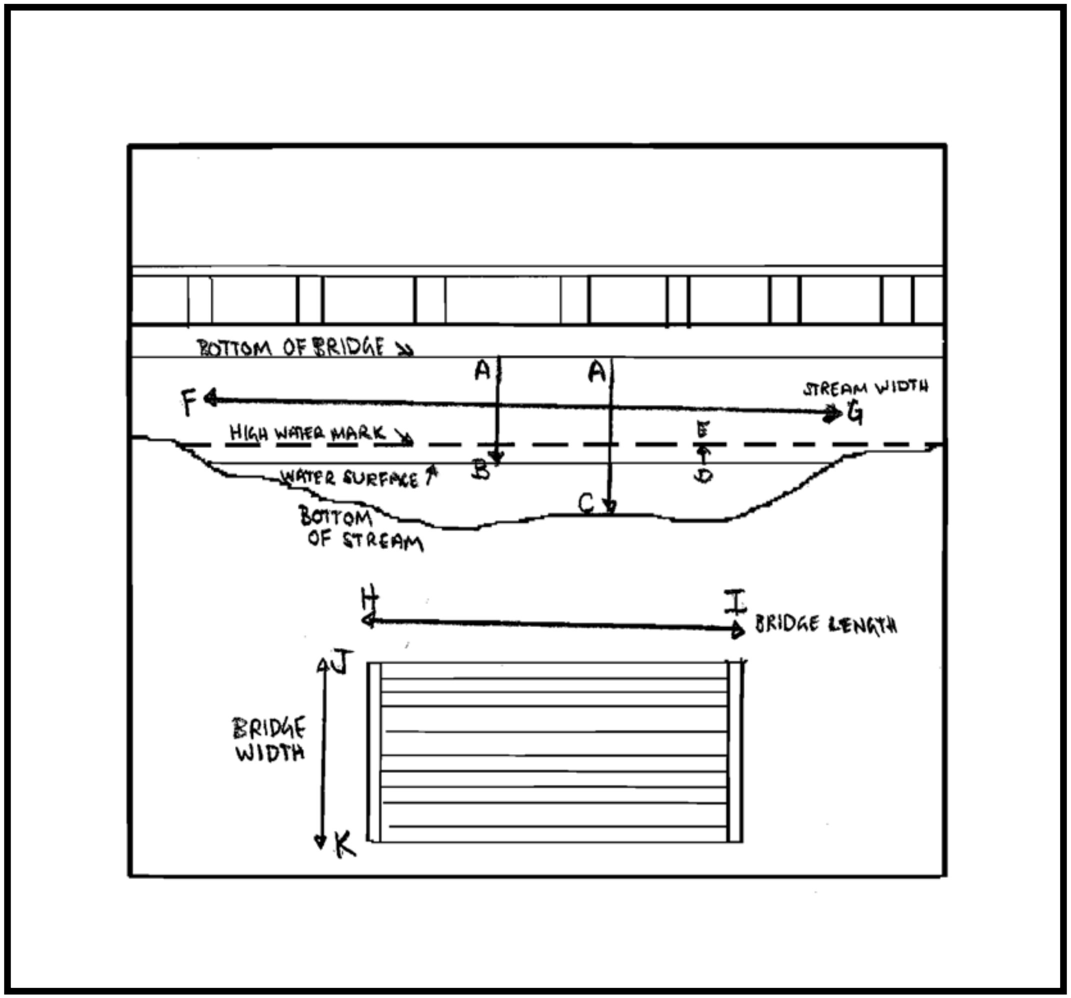
Ferns/Mosses

Braun's holly fern	*Polystichum braunii*
Central peat moss	*Sphagnum centrale*
Common fern moss	*Thuidium delicatulum*
Feathermoss	
Horsetail	*Equisetaceae spp.*
Lady fern	*Athyrium filix-femina*
Maidenhair spleenwort	*Asplenium trichomanes*
Meadow horsetail	*Equisetum pratense*
Plume moss	*Ptilium crista-castrensis*
Sensitive fern	*Onoclea sensibilis*

Aquatic Plants

Black algae	*Cyanobacteria*
Broad-leaved arrowhead	*Sagittaria latifolia*
Burreed	*Sparganium spp.*
Common cattail	*Typha latifolia*
Green algae	*Chlorophyta*
Hardstem bulrush	*Scirpus acutus*
Large-fruit burreed	*Sparganium eurycarpum*
Pondweed	*Potamogeton spp.*
Water smartweed	*Polygonum amphibium*
Yellow pond lily	*Nuphar variegatum*

Appendix F: Bridges



Bridge Number	A – B Bottom of Bridge to Water Surface (m)	A – C 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	2.3	3.1	2.87	5.9	24.2	5.6
2	5.1	6.1	3	8.0	22.0	9.8
3	6.5	7.8	3.5	9.0	28.8	12.0
4	3.5	4.0	3	8.6	22.4	6.3
5	4.3	4.6	2.4	4.5	17.7	5.9
6	4.3	4.3	1.25[1]	9.1	20.9	5.8
7	3.0	3.3	2.22	6.9	14.0	10.75
8	5.3	5.85	1.6	11.1	34.6	12.0
9	4.7	5.3	3.5	16.4	30.1	6.4
10	3.85	5.6	1	19.2	34.2	6.0
11	4.45	5.6	1.69	13.1	30.8	5.8
12	4.5	4.9	1	10.2	16.4	3.7
Maximum Value	6.5	7.8		19.2		
Minimum Value	2.3	3.1		4.5		
Average	4.3	5.0		10.2		

[1] According to personal communication with Ed Breukelman from Breukside Dairy Farm, the floodplain extends 84.4 metres in springtime (from the water's edge on August 28, 2008 to a property line fence)

Bridge 1

Location: On Highway 597; just south of Highway 608 before Oliver Lake Road

GPS Coordinates: 5344952.53 m North/ 308899.20 m East; 313.20 metres above sea level

Description: This bridge was a Bailey Bridge design: lattice steel designed for rapid assembly from prefabricated standard parts and it was in good condition. The foundation was supported with concrete beams and the road surface was steel grating. Having an open road surface may be beneficial during times of high water (spring flooding) because the road surface will not wash away or collapse. The fill was mainly large boulders that were stabilized by opportunistic species. The riparian zone slope was gradual and there was no evidence of active erosion. Both upstream and downstream had no/minimal stream cover. Further up the floodplain, the vegetation was dominated by Balsam fir and White spruce. Upstream, cattle had access to the river on the adjacent rural residential property.

Upstream

Downstream

Bridge 2

Location: On Highway 608; ½ kilometre west of Highway 61 intersection

GPS Coordinates: 5348103.44 m North/ 315230.57 m East; 226.62 metres above sea level

Description: The bridge was built in 1975 and was supported by two concrete pillars on either side of the streambed and several wooden posts with cross beams that stand in the streambed. There was no visible high water marks on the wooden posts, yet high water marks were visible on the west side upstream bank 3 metres above the water surface. Underneath the bridge, there was a significant pile of woody debris (logs, branches) but it was not restricting flow. The fill was mostly boulders. Higher up on the west side downstream bank, sand/silt fill was sloughing but it did not appear to reach the water's edge. Further downstream, there was evidence of active erosion from bank undercutting as the river meanders. The original farming settlement property line down to the river's edge was marked by an old fence and mature trees (birch, spruce) separating the road from the field.

Upstream

Downstream

Bridge 3

Location: On Highway 61; between Boyscout Road and Highway 608

GPS Coordinates: 5348945.51 m North/ 315689.49 m East; 221.47 metres above sea level

Description: This bridge was built in 1994 and carried a significant amount of two-lane highway traffic. It was built with reinforced concrete and steel and appeared in good condition. It was the highest bridge above the water surface documented at 6.5 metres. Large blast rock/boulders were used as fill that extends down to the water's edge with little riparian vegetation or streamcover. Upstream on the north bank, there was an extra cement block retaining wall which created a very steep slope from the road surface to the water. The bridge did not appear to restrict flow in any way, the high water mark being approximately 3.5 metres from the water surface as the time of assessment. However, a beaver dam downstream has prevented the river from flowing (below the dam the streambed was dry/exposed).

Upstream

Downstream

Bridge 4

Location: On Boyscout Road; less than ½ kilometre from Highway 61; before Farm Road

GPS Coordinates: 5349682.81 m North/ 316177.61 m East; 221.79 metres above sea level

Description: This concrete bridge supported single-lane dirt road traffic. The corrugated steel wrapped around the concrete support pillars was cracked. Underneath the bridge, there were large boulders on the east bank right down to the water's edge. Upstream, the riparian zone was well established with approximately a 10 metre buffer between the river and a farmer's field. As well, downstream, there was a significant amount of stream cover (mixed hardwood trees/shrubs) right to the water's edge. A nest of new-born cedar waxwing chicks and a woodpecker were documented at this site.

Upstream

Downstream

Bridge 5

Location: On Farm Road; between Boundary Drive and Boyscout Road; downstream of the Otter Creek and Slate River confluence

GPS Coordinates: 5350971.09 m North/ 317316.47 m East; 219.84 metres above sea level

Description: This was the only wooden bridge documented. It may require some repair since one support beam was broken and the wooden beams in the riverbed had lost some of their tar sealant. Upstream, there was a lot of vegetation along the river (mixed conifer/ shrubs/grasses) and it appeared like the river channel was obstructed by some mound of land (perhaps a beaver dam that has vegetation growing upon it). Downstream, a barbed-wire fence crossed the river channel and had collected a significant amount of debris which indicated the high water mark was at least 2 metres above the current water level. Downstream, there was evidence that livestock had access to the water's edge and the banks on both sides showed some minor erosion. In the picture below, the three tiered undercut bank may indicate different water levels.

Upstream

Downstream

Bridge 6

Location: On Boundary Road between Falls Road and Farm Road

GPS Coordinates: 5351374.03 m North/ 317556.23 m East; 218.07 metres above sea level

Description: This bridge supported one lane local traffic on a dirt road and was built with reinforced concrete. It was in the heart of the area's agricultural activity. Upstream, a private barbed wire fence ran across the river to prevent livestock from escaping underneath the bridge. However, there was no fence preventing access of livestock to the river. There was not very much imported fill and slope was gradual. Upstream, there was minimal vegetative buffer or stream cover. The potential for erosion may be high as livestock can trample the bank and grass was predominant rather than trees/shrubs. Downstream, the riverbank had more stability with mostly deciduous trees and plenty of aquatic grasses. As well, there was a cornfield on the eastern bank which the river cuts through with its large meanders. There was evidence of bear and fox from droppings and a field mouse, a herd of cattle and a horse were observed. According to personal communication with the adjacent landowner, the floodplain extended 84 metres on the west side of the river during flooding.

Upstream

Downstream

Bridge 7

Location: On Hanna Road between Highway 61 and Boundary Drive

GPS Coordinates: 5352247.79 m North/ 318393.51 m East; 219.33 metres above sea level

Description: The newly constructed Pipe Arch was composed of corrugated steel with wooden railings. Fill, on both sides, was large blast rock. Many fill boulders were more than 1 metre in diameter. Currently there are no sites of active erosion; however there is potential for erosion in the future as the fill was not stabilized by a vegetative buffer zone. The fill went to the water's edge, and upstream on the south bank the exposed soil was so dry that it was cracking. The water level was low and turbid and the flow appeared to be going in the opposite direction probably due to a greater influence by wind direction. The high water mark appeared to be at the same elevation as the road surface. The in-stream fill was sand and/or small pebbles that were iron-rich giving a reddish-brown colour. The river was bordered by mixed hardwood trees and grasses.

Upstream

Downstream

Bridge 8

Location: On Highway 61 heading east to Thunder Bay

GPS Coordinates: 5353359.03 m North/ 319049.90 m East; 219.99 metres above sea level

Description: This bridge was approximately 5 metres above the river's surface and was characterized by reinforced concrete with steel support beams that appeared to be stable. The width and height of the structure did not appear to alter natural channel characteristics. A significant amount of large blast-rock boulders were used as fill and appeared to be stable. Downstream, the streambank had a gradual slope with vegetation right to the water's edge. Upstream, there was a small creek (diversion channel) running parallel to the bridge on the east side. There was not a lot of visible aquatic life activity. The streambank had mostly conifer species with bulrushes, buttercups, goldenrod and Labrador tea bushes noted.

Upstream

Downstream

Bridge 9

Location: At the Candy Mountain Drive and Hanna Road intersection

GPS Coordinates: 5355376.32 m North/ 318990.01 m East; 219.44 metres above sea level

Description: The materials used in building this bridge were cement, iron, and wood. The bridge was 4.7 metres above the water surface level at the time of assessment, and appeared to be in good condition. This bridge was considered a high traffic bridge as many vehicles and tractors were noted passing over it. The waters around the bridge were turbid and stagnant but harbored a variety of wildlife. Many birds such as White Throated Sparrows, Finches, Swallows and Ravens were documented. Aquatic wildlife included a large amount of fresh water clams, water striders and fry. Various shrubs and deciduous trees stabilized the river banks.

Upstream

Downstream

Bridge 10

Location: Halfway down Candy Mountain Dr. before Hanna Road.

GPS Coordinates: 5355366.96 m North/ 319494.03 m East; 216.72 metres above sea level

Description: This bridge was mostly concrete and cement with corrugated support beams. The support beams appeared to be filled with concrete. The bridge was in good condition and supported the large amount of traffic passing over it. The fill underneath the bridge was a collection of small to medium boulders and shale. The height of the bridge was 3.85 metres above the water level at the time of assessment. Downstream of the bridge had very little stream cover. The river bank was occupied by many low lying shrubs. The upstream banks were characterized by many wild raspberries and Dogwood shrubs. The water height at the stream bank was approximately 1.3 metres deep; as well the waters were very slow-moving and turbid. Wildlife observed included an Oven Bird, juvenile Chipmunk, fry, Water boatmen and various Bees and Wasps.

Upstream

Downstream

Bridge 11

Location: On Gillespie Road; ½ kilometre south of Candy Mountain Drive

GPS Coordinates: 5354847.45 m North/ 320886.70 m East; 213.06 metres above sea level

Description: This bridge was built mainly of iron, cement and wood. The bridge was approximately 5 metres above the surface of the water at the time of assessment. The fill slopes around the bridge were not very steep and the ecosystem around the bridge was very lively. A variety of wildlife was observed including a Blue heron, a Brown duck, nuthatches, as well as two beavers at work. The water near the riverbank was approximately 1.3 metres deep and very turbid.

Upstream

Downstream

Bridge 12

Location: At the start of Candy Mountain Drive; right after West Riverdale Road becomes Old Pigeon Trail

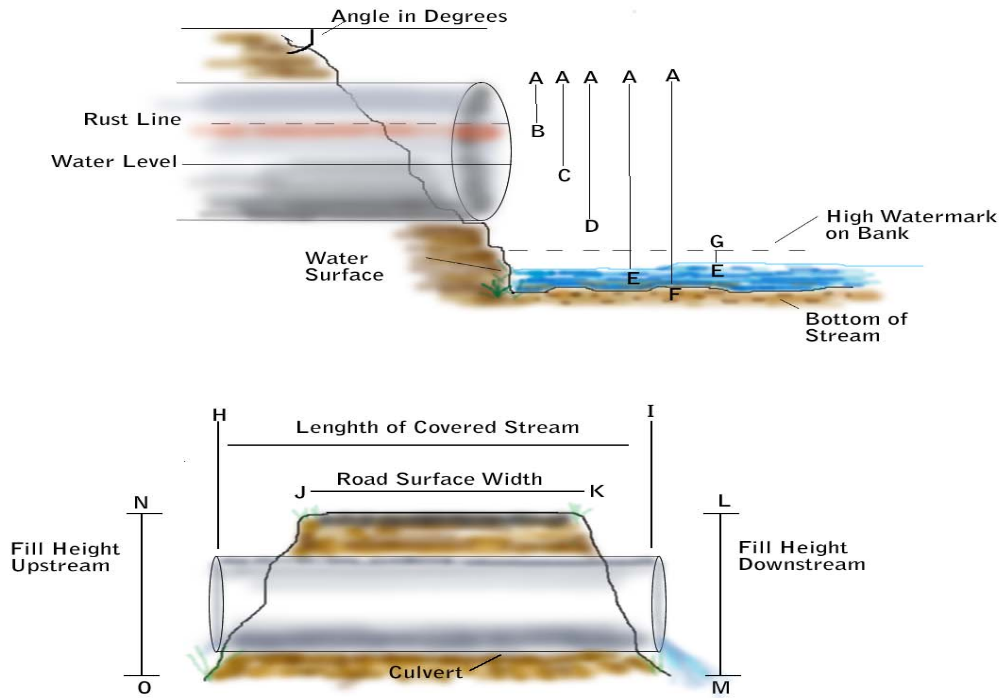
GPS coordinates: 5355313.37 m North/ 321767.57 m East; 213.19 metres above sea level

Description: This bridge was the location of the Environment Canada and LRCA stream flow and precipitation gauge. The bridge was constructed with concrete and iron and appeared to be in good condition. Upstream, flow was significantly low with most of the in-stream material (boulders and pebbles) exposed. On both sides of the bridge the riparian zone was in good condition with at least 2-5 metres of vegetative border (mixed hardwood). Comparatively, the west side bank had a more gradual slope to the water's edge than the east side. A freshwater clam, minnows and snails were documented.

Upstream

Downstream

Appendix G: Culverts



Culvert 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 (cm)	A – B Inside Top to High Water Rustline (cm)	A – C Inside Top to Water Surface (cm)	A – E Height above Outlet Pool (cm)	E – G Water Surface to High Water Mark (cm)	A – F Inside Top to Bottom of Stream (cm)
1a	12.77	22.65	2.06	2.33	Upstream	130	25	32	32	40	126
					Downstream	100	n/a rust over top	8	8	80	115
1b	12.77	22.65	2.06	2.33	Upstream	96	15	38	38	35	130
					Downstream	n/a submerged				80	90
2	6.86	10.39	n/a submerged	0.95		41	20	30	30		48
3	8	32	6.7	8		65	41	62	200		1825.5

*Culverts 1a and 1b were the only culverts used as a water crossing rather than a bridge along the Slate River. The other two culvert locations documented in this report were at small creeks that drained into Slate River where erosion or flooding is considered an immediate issue.

Culvert 1a, 1b

Location: Turkey Trail Road; 1 kilometre west of West Oliver Lake Road

GPS Coordinates: 5346167.23 m North/ 305332.25 m East; 367.70 metres above sea level

Description: Culverts 1a and 1b were located at the headwater of the Slate River where the river channel was fairly un-established; the area looked more similar to a wetland than a river. The culverts did not appear to have any damage or clogging that would restrict flow, although the current water level was high enough to completely submerge culvert 1b downstream. As shown in the photograph, the downstream end of the culverts were hard to locate because they did not extend beyond the fill; fill had slumped on to the top of the metal culverts and plants were established there. The private property owner whose land was adjacent to this site reported that, during the spring 2008 flood event, the water level was well above the road surface. The high water marks along the bank were higher than both the top of the culverts and the elevation of the road. The culverts ran on a diagonal underneath the road surface and covered 22.65 metres of stream. Flow rate was stagnant and the surrounding vegetation was dominated by aquatic plants, such as cattail, arrowhead and pondweed.

1a Upstream

1a Downstream

Culvert 2

Location: On Hanna Road; ½ kilometre north of Highway 61

GPS Coordinates: 5353809.79 m North/ 318440.31 m East; 224.37 metres above sea level

Description: Before Highway 61 on Hanna Road there was evidence that a beaver had blocked a culvert coming off of a small tributary. The upstream end had been completely covered in thick mud with plenty of twigs and small logs. The waters of the tributary had overflowed on to the road and into the surrounding forest as a result of the blockage. In the event of heavy rains, this could result in road erosion. Frogs and water spiders were observed in the overflowed tributary. On the downstream end of the culvert the water was a few centimetres deep and stagnant. This end of the culvert appeared to be crushed with a large sharp fragment sticking up. This culvert was in need of repair do to safety and erosion concerns.

Upstream

Upstream

Downstream

Culvert 3

Location: West Riverdale Road between Old Pigeon Trail and 20th Side Road

GPS Coordinates: 5356155.91 m North/ 322976.75 m East; 212.24 metres above sea level

Description: This culvert drained a small wetland to the east into the Slate River. The upstream end of the culvert was slightly blocked by woody debris. The blockage did not appear to be caused by a beaver (likely debris collection from the June 2008 flood event) and was not restricting flow. Unlike the upstream side of the culvert that was flush with the streambed, the downstream side of the culvert was perched at least 2 metres above the outlet pool. The outlet pool became a shale terraced waterfall that dropped 18 metres to reach the Slate River gorge. The photograph below documented that unsupported fill was slumping. Fill height over the culvert was significant; 6.7 metres upstream and 8 metres downstream. The fill slope was greater than a 45º angle and had not been stabilized by vegetation.

Upstream

Downstream

Downstream (west side of road)

Laboratory Water Quality Results for Sample Site 1

	PWQO	August 14, 2008	August 27, 2008
Conductivity (µS/cm)	N/A	283	295
Total Dissolved Solids (mg/L)	N/A	210	190
Turbidity (NTU)	<10% of natural	7.2	9.3
Ammonia – N (Total) (µg/L)	N/A	20	<20
Ammonia- N (Un-ionized) (µg/L)	20	1.82*	<0.54*
Nitrate-N (µg/L)	N/A	<30	<30
Nitrite-N (µg/L)	N/A	<20	<20
Phosphorus (Total) (µg/L)	30	23	25
Chloride (mg/L)	N/A	10.2	10
Sulphate (mg/L)	N/A	<0.3	0.3
Escherichia Coli (MPN/100mL)	100	41	60
Total Coliforms (MPN/100mL)	1000 (prior to 1994)	**>2420**	**>2420**
Aluminum (µg/L)	75	**150**	**180**
Antimony (µg/L)	20	<5	<5
Arsenic (µg/L)	5 (interim)	1	1
Barium (µg/L)	N/A	20	20
Beryllium (µg/L)	11	<1	<1
Bismuth (µg/L)	N/A	<1	<1
Boron (µg/L)	200	50	<50
Cadmium (µg/L)	0.1 (interim)	<0.09	<0.09
Chromium (µg/L)	1 for Chromium (VI)	<1	<1
Cobalt (µg/L)	0.9	0.6	<0.5
Copper (µg/L)	5 (interim)	1	1
Iron (µg/L)	300	**1450**	**1090**
Lead (µg/L)	1 (interim)	<1	<1
Manganese (µg/L)	N/A	257	124
Molybdenum (µg/L)	40	<1	<1
Nickel (µg/L)	25	3	3
Selenium (µg/L)	100	<0.4	<0.4
Silicon (µg/L)	N/A	900	1000
Silver (µg/L)	0.1	<0.1	<0.1
Strontium (µg/L)	N/A	67	80
Thallium (µg/L)	0.3	<0.3	<0.3
Tin (µg/L)	N/A	<1	<1
Titanium (µg/L)	N/A	5	6
Tungsten (µg/L)	30	10	<10
Uranium (µg/L)	5	<5	<5
Vanadium (µg/L)	6	1	1
Zinc (µg/L)	20 (interim)	5	<3
Zirconium (µg/L)	4	<4	<4

Bold indicates above PWQO guidelines.
* indicates calculation using table provided in PWQO guidelines. See Appendix C.

Laboratory Water Quality Results for Sample Site 2

	PWQO	August 14, 2008	August 27, 2008
Conductivity (µS/cm)	N/A	270	289
Total Dissolved Solids (mg/L)	N/A	230	210
Turbidity (NTU)	<10% of natural	5.0	13.8
Ammonia – N (Total) (µg/L)	N/A	20	30
Ammonia- N (Un-ionized) (µg/L)	20	0.66*	0.93*
Nitrate-N (µg/L)	N/A	<30	<30
Nitrite-N (µg/L)	N/A	<20	<20
Phosphorus (Total) (µg/L)	30	21	**45**
Chloride (mg/L)	N/A	5.4	5.7
Sulphate (mg/L)	N/A	0.5	0.8
Escherichia Coli (MPN/100mL)	100	2	12
Total Coliforms (MPN/100mL)	1000 (prior to 1994)	**>2420**	**1600**
Aluminum (µg/L)	75	**120**	**220**
Antimony (µg/L)	20	<5	<5
Arsenic (µg/L)	5 (interim)	2	2
Barium (µg/L)	N/A	20	20
Beryllium (µg/L)	11	<1	<1
Bismuth (µg/L)	N/A	<1	<1
Boron (µg/L)	200	<50	<50
Cadmium (µg/L)	0.1 (interim)	<0.09	<0.09
Chromium (µg/L)	1 for Chromium (VI)	1	<1
Cobalt (µg/L)	0.9	<0.5	<0.5
Copper (µg/L)	5 (interim)	**6**	3
Iron (µg/L)	300	**800**	**1070**
Lead (µg/L)	1 (interim)	<1	1
Manganese (µg/L)	N/A	88	114
Molybdenum (µg/L)	40	2	2
Nickel (µg/L)	25	4	4
Selenium (µg/L)	100	0.5	0.6
Silicon (µg/L)	N/A	3800	3000
Silver (µg/L)	0.1	<0.1	<0.1
Strontium (µg/L)	N/A	68	79
Thallium (µg/L)	0.3	<0.3	<0.3
Tin (µg/L)	N/A	<1	<1
Titanium (µg/L)	N/A	4	8
Tungsten (µg/L)	30	<10	<10
Uranium (µg/L)	5	<5	<5
Vanadium (µg/L)	6	1	2
Zinc (µg/L)	20 (interim)	3	<3
Zirconium (µg/L)	4	<4	<4

Bold indicates above PWQO guidelines.
* indicates calculation using table provided in PWQO guidelines. See Appendix C.

Laboratory Water Quality Results for Sample Site 3

	PWQO	August 14, 2008	August 27, 2008
Conductivity (µS/cm)	N/A	445	481
Total Dissolved Solids (mg/L)	N/A	330	320
Turbidity (NTU)	<10% of natural	9.7	10.1
Ammonia – N (Total) (µg/L)	N/A	<20	20
Ammonia- N (Un-ionized) (µg/L)	20	<0.82*	0.62*
Nitrate-N (µg/L)	N/A	<30	<30
Nitrite-N (µg/L)	N/A	<20	<20
Phosphorus (Total) (µg/L)	30	29	29
Chloride (mg/L)	N/A	63.1	71.5
Sulphate (mg/L)	N/A	5.8	5.1
Escherichia Coli (MPN/100mL)	100	11	**150**
Total Coliforms (MPN/100mL)	1000 (prior to 1994)	**1700**	**1600**
Aluminum (µg/L)	75	**210**	**120**
Antimony (µg/L)	20	<5	<5
Arsenic (µg/L)	5 (interim)	4	3
Barium (µg/L)	N/A	80	80
Beryllium (µg/L)	11	<1	<1
Bismuth (µg/L)	N/A	<1	<1
Boron (µg/L)	200	<50	<50
Cadmium (µg/L)	0.1 (interim)	<0.09	<0.09
Chromium (µg/L)	1 for Chromium (VI)	1	<1
Cobalt (µg/L)	0.9	<0.5	<0.5
Copper (µg/L)	5 (interim)	4	3
Iron (µg/L)	300	**1550**	**1100**
Lead (µg/L)	1 (interim)	<1	1
Manganese (µg/L)	N/A	121	132
Molybdenum (µg/L)	40	2	2
Nickel (µg/L)	25	4	4
Selenium (µg/L)	100	1.2	1.1
Silicon (µg/L)	N/A	4200	4000
Silver (µg/L)	0.1	<0.1	<0.1
Strontium (µg/L)	N/A	260	270
Thallium (µg/L)	0.3	<0.3	<0.3
Tin (µg/L)	N/A	<1	<1
Titanium (µg/L)	N/A	8	5
Tungsten (µg/L)	30	<10	<10
Uranium (µg/L)	5	<5	<5
Vanadium (µg/L)	6	3	2
Zinc (µg/L)	20 (interim)	4	<3
Zirconium (µg/L)	4	<4	<4

Bold indicates above PWQO guidelines.
* indicates calculation using table provided in PWQO guidelines. See Appendix C.

Laboratory Water Quality Results for Sample Site 4

	PWQO	August 14, 2008	August 27, 2008
Conductivity (µS/cm)	N/A	693	864
Total Dissolved Solids (mg/L)	N/A	550	640
Turbidity (NTU)	<10% of natural	13.4	11.1
Ammonia – N (Total) (µg/L)	N/A	20	70
Ammonia- N (Un-ionized) (µg/L)	20	0.72*	2.31*
Nitrate-N (µg/L)	N/A	<30	<30
Nitrite-N (µg/L)	N/A	<20	<20
Phosphorus (Total) (µg/L)	30	**32**	24
Chloride (mg/L)	N/A	133	176
Sulphate (mg/L)	N/A	4.8	5.0
Escherichia Coli (MPN/100mL)	100	37	**820**
Total Coliforms (MPN/100mL)	1000 (prior to 1994)	**>2420**	**>2420**
Aluminum (µg/L)	75	**350**	**200**
Antimony (µg/L)	20	<5	<5
Arsenic (µg/L)	5 (interim)	4	5
Barium (µg/L)	N/A	200	220
Beryllium (µg/L)	11	<1	<1
Bismuth (µg/L)	N/A	<1	<1
Boron (µg/L)	200	<50	<50
Cadmium (µg/L)	0.1 (interim)	<0.09	<0.9
Chromium (µg/L)	1 for Chromium (VI)	1	<1
Cobalt (µg/L)	0.9	0.6	0.6
Copper (µg/L)	5 (interim)	4	3
Iron (µg/L)	300	**880**	**540**
Lead (µg/L)	1 (interim)	<1	<1
Manganese (µg/L)	N/A	384	496
Molybdenum (µg/L)	40	3	3
Nickel (µg/L)	25	5	6
Selenium (µg/L)	100	2.3	2.9
Silicon (µg/L)	N/A	3300	2800
Silver (µg/L)	0.1	<0.1	<0.1
Strontium (µg/L)	N/A	761	1030
Thallium (µg/L)	0.3	<0.3	<0.3
Tin (µg/L)	N/A	<1	<1
Titanium (µg/L)	N/A	12	8
Tungsten (µg/L)	30	<10	<10
Uranium (µg/L)	5	<5	<5
Vanadium (µg/L)	6	3	2
Zinc (µg/L)	20 (interim)	4	<3
Zirconium (µg/L)	4	<4	<4

Bold indicates above PWQO guidelines.
* indicates calculation using table provided in PWQO guidelines. See Appendix C.

Laboratory Water Quality Results for Sample Site 5

	PWQO	August 14, 2008	August 27, 2008
Conductivity (µS/cm)	N/A	463	484
Total Dissolved Solids (mg/L)	N/A	340	320
Turbidity (NTU)	<10% of natural	5.4	7.4
Ammonia – N (Total) (µg/L)	N/A	20	40
Ammonia- N (Un-ionized) (µg/L)	20	0.88*	1.44*
Nitrate-N (µg/L)	N/A	60	<30
Nitrite-N (µg/L)	N/A	<20	<20
Phosphorus (Total) (µg/L)	30	30	26
Chloride (mg/L)	N/A	51.3	56.3
Sulphate (mg/L)	N/A	7.0	0.026
Escherichia Coli (MPN/100mL)	100	17	**130**
Total Coliforms (MPN/100mL)	1000 (prior to 1994)	**>2420**	**>2420**
Aluminum (µg/L)	75	**120**	**110**
Antimony (µg/L)	20	<5	<5
Arsenic (µg/L)	5 (interim)	2	2
Barium (µg/L)	N/A	70	70
Beryllium (µg/L)	11	<1	<1
Bismuth (µg/L)	N/A	<1	<1
Boron (µg/L)	200	<50	<50
Cadmium (µg/L)	0.1 (interim)	<0.09	<0.09
Chromium (µg/L)	1 for Chromium (VI)	<1	<1
Cobalt (µg/L)	0.9	<0.5	<0.5
Copper (µg/L)	5 (interim)	3	3
Iron (µg/L)	300	**640**	**570**
Lead (µg/L)	1 (interim)	<1	<1
Manganese (µg/L)	N/A	79	67
Molybdenum (µg/L)	40	1	1
Nickel (µg/L)	25	4	4
Selenium (µg/L)	100	1	1.1
Silicon (µg/L)	N/A	2600	2000
Silver (µg/L)	0.1	<0.1	<0.1
Strontium (µg/L)	N/A	241	261
Thallium (µg/L)	0.3	<0.3	<0.3
Tin (µg/L)	N/A	<1	<1
Titanium (µg/L)	N/A	4	4
Tungsten (µg/L)	30	<10	<10
Uranium (µg/L)	5	<5	<5
Vanadium (µg/L)	6	2	2
Zinc (µg/L)	20 (interim)	<3	<3
Zirconium (µg/L)	4	<4	<4

Bold indicates above PWQO guidelines.
* indicates calculation using table provided in PWQO guidelines. See Appendix C.

Laboratory Water Quality Results for Sample Site 6

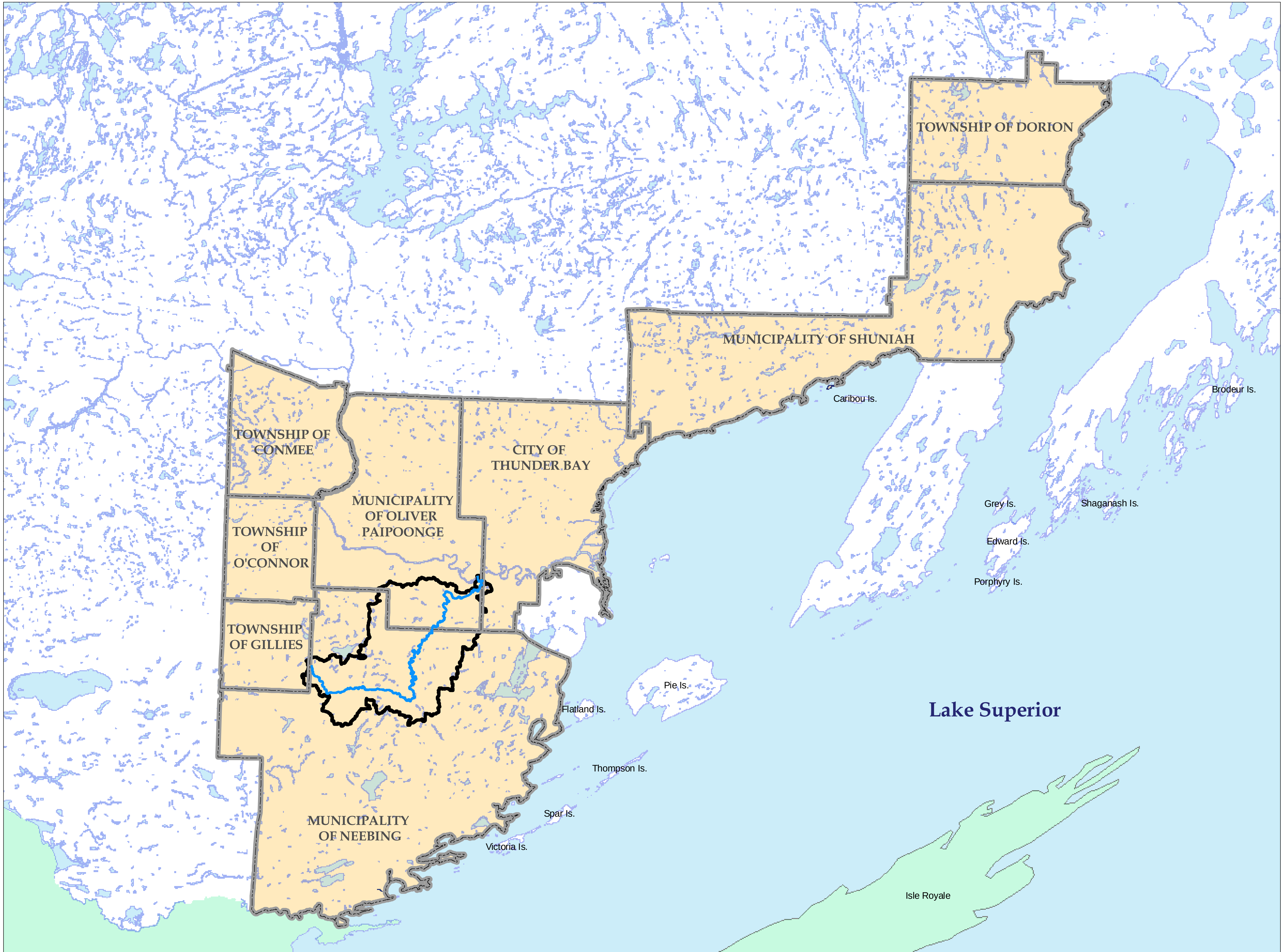
	PWQO	August 14, 2008	August 27, 2008
Conductivity (µS/cm)	N/A	429	447
Total Dissolved Solids (mg/L)	N/A	320	290
Turbidity (NTU)	<10% of natural	6.5	8.4
Ammonia – N (Total) (µg/L)	N/A	20	50
Ammonia- N (Un-ionized) (µg/L)	20	0.88*	1.55*
Nitrate-N (µg/L)	N/A	<30	<30
Nitrite-N (µg/L)	N/A	<20	<20
Phosphorus (Total) (µg/L)	30	19	22
Chloride (mg/L)	N/A	44.5	47.6
Sulphate (mg/L)	N/A	7.7	8
Escherichia Coli (MPN/100mL)	100	35	44
Total Coliforms (MPN/100mL)	1000 (prior to 1994)	**>2420**	**>2420**
Aluminum (µg/L)	75	**140**	**190**
Antimony (µg/L)	20	<5	<5
Arsenic (µg/L)	5 (interim)	2	2
Barium (µg/L)	N/A	60	60
Beryllium (µg/L)	11	<1	<1
Bismuth (µg/L)	N/A	<1	<1
Boron (µg/L)	200	<50	<50
Cadmium (µg/L)	0.1 (interim)	<0.09	<0.09
Chromium (µg/L)	1 for Chromium (VI)	<1	<1
Cobalt (µg/L)	0.9	<0.5	<0.5
Copper (µg/L)	5 (interim)	3	3
Iron (µg/L)	300	**590**	**750**
Lead (µg/L)	1 (interim)	<1	<1
Manganese (µg/L)	N/A	56	99
Molybdenum (µg/L)	40	2	2
Nickel (µg/L)	25	4	4
Selenium (µg/L)	100	1	0.9
Silicon (µg/L)	N/A	2400	2000
Silver (µg/L)	0.1	<0.1	<0.1
Strontium (µg/L)	N/A	221	221
Thallium (µg/L)	0.3	<0.3	<0.3
Tin (µg/L)	N/A	<1	<1
Titanium (µg/L)	N/A	5	7
Tungsten (µg/L)	30	<10	<10
Uranium (µg/L)	5	<5	<5
Vanadium (µg/L)	6	2	2
Zinc (µg/L)	20 (interim)	3	<3
Zirconium (µg/L)	4	<4	<4

Bold indicates above PWQO guidelines.
* indicates calculation using table provided in PWQO guidelines. See Appendix C.

Laboratory Water Quality Results for Sample Site 7

	PWQO	August 14, 2008	August 27, 2008
Conductivity (µS/cm)	N/A	445	540
Total Dissolved Solids (mg/L)	N/A	330	360
Turbidity (NTU)	<10% of natural	0.47	0.94
Ammonia – N (Total) (µg/L)	N/A	20	30
Ammonia- N (Un-ionized) (µg/L)	20	0.76*	2.4*
Nitrate-N (µg/L)	N/A	<30	<30
Nitrite-N (µg/L)	N/A	<20	<20
Phosphorus (Total) (µg/L)	30	6	10
Chloride (mg/L)	N/A	47.2	28.8
Sulphate (mg/L)	N/A	18.2	32.3
Escherichia Coli (MPN/100mL)	100	20	2
Total Coliforms (MPN/100mL)	1000 (prior to 1994)	**1200**	980
Aluminum (µg/L)	75	10	20
Antimony (µg/L)	20	<5	<5
Arsenic (µg/L)	5 (interim)	1	1
Barium (µg/L)	N/A	40	50
Beryllium (µg/L)	11	<1	<1
Bismuth (µg/L)	N/A	<1	<1
Boron (µg/L)	200	<50	<50
Cadmium (µg/L)	0.1 (interim)	**0.13**	**0.17**
Chromium (µg/L)	1 for Chromium (VI)	<1	<1
Cobalt (µg/L)	0.9	<0.5	<0.5
Copper (µg/L)	5 (interim)	**7**	**6**
Iron (µg/L)	300	110	130
Lead (µg/L)	1 (interim)	<1	<1
Manganese (µg/L)	N/A	27	142
Molybdenum (µg/L)	40	3	3
Nickel (µg/L)	25	7	8
Selenium (µg/L)	100	1.3	1.6
Silicon (µg/L)	N/A	2200	2500
Silver (µg/L)	0.1	<0.1	<0.1
Strontium (µg/L)	N/A	197	212
Thallium (µg/L)	0.3	<0.3	<0.3
Tin (µg/L)	N/A	<1	<1
Titanium (µg/L)	N/A	<2	<2
Tungsten (µg/L)	30	<10	<10
Uranium (µg/L)	5	<5	<5
Vanadium (µg/L)	6	<1	<1
Zinc (µg/L)	20 (interim)	10	8
Zirconium (µg/L)	4	<4	<4

Bold indicates above PWQO guidelines.
* indicates calculation using table provided in PWQO guidelines. See Appendix C.



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N

Slate River Watershed Key Plan M-1

Legend

- Slate River
- Municipal Boundary
- LRCA Jurisdiction Boundary
- Water
- Island
- Slate River Watershed

1:400,000

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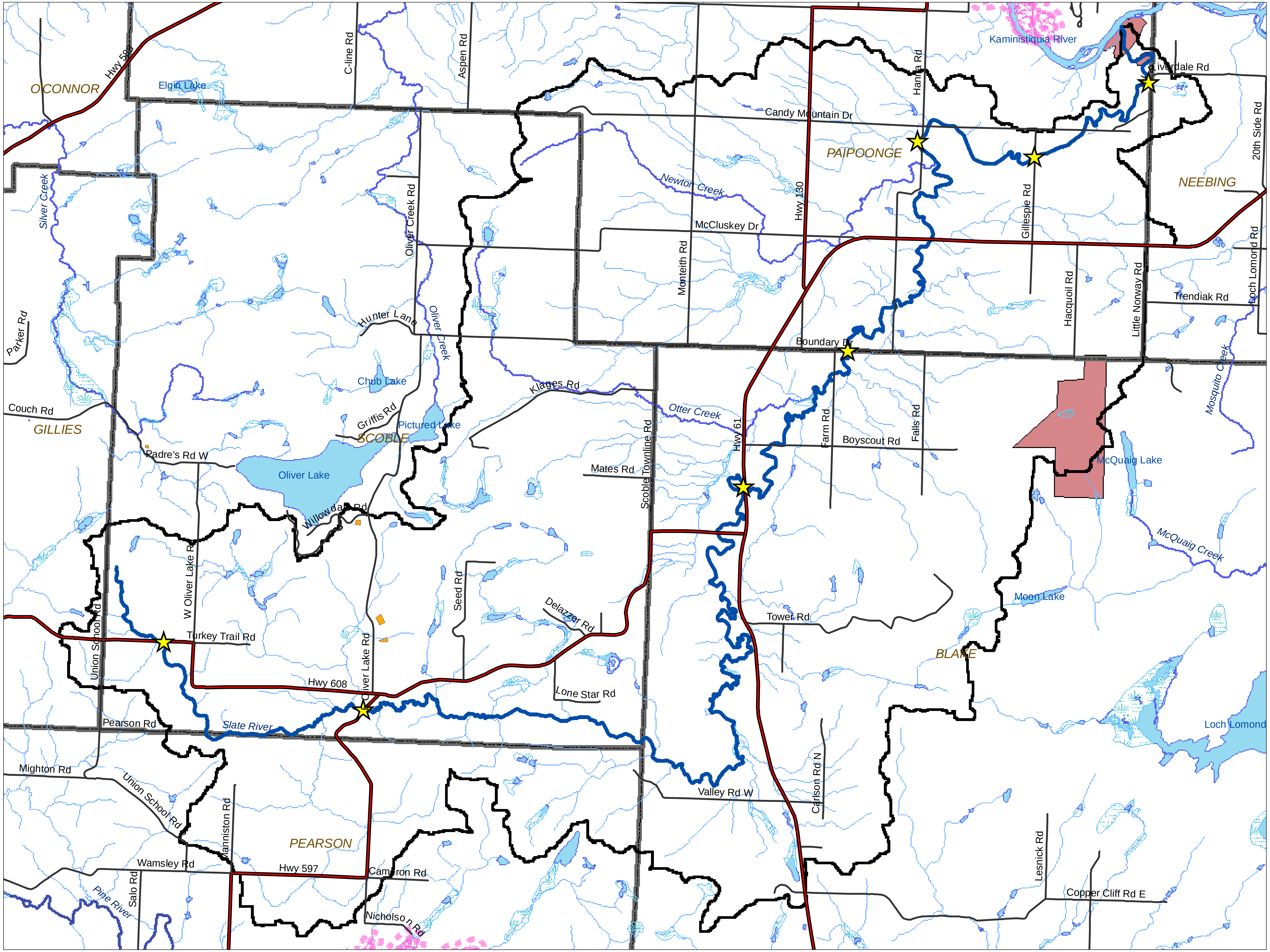
Created by: A. Finlay



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Slate River Watershed Site Plan M-2

Legend

- Sample Site
- Highway
- Road
- Slate River
- River
- Creek
- Stream
- Water Body
- Wetland
- Slate River Watershed
- ANSI
- Landfill Site
- Provincially Significant Wetland (PSW)
- PSW 120 Metre Regulated Area
- Township Boundary

1:65,000

0 1 2 3 km

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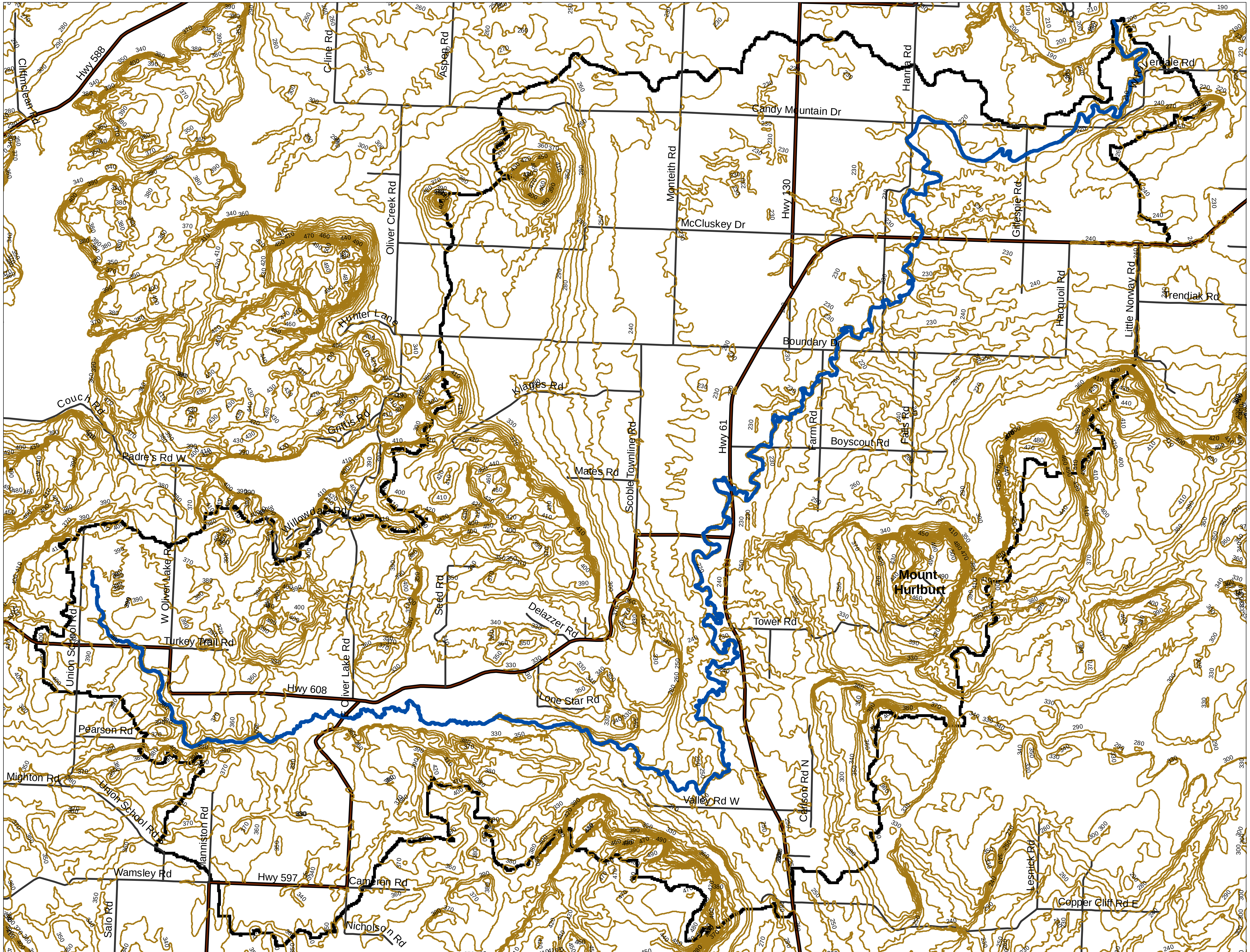

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N

Slate River Watershed Topographic Map M-3

Legend

- Slate River
- Contours (10m Interval)

Roads

- Highway
- Road
- Slate River Watershed

1:65,000

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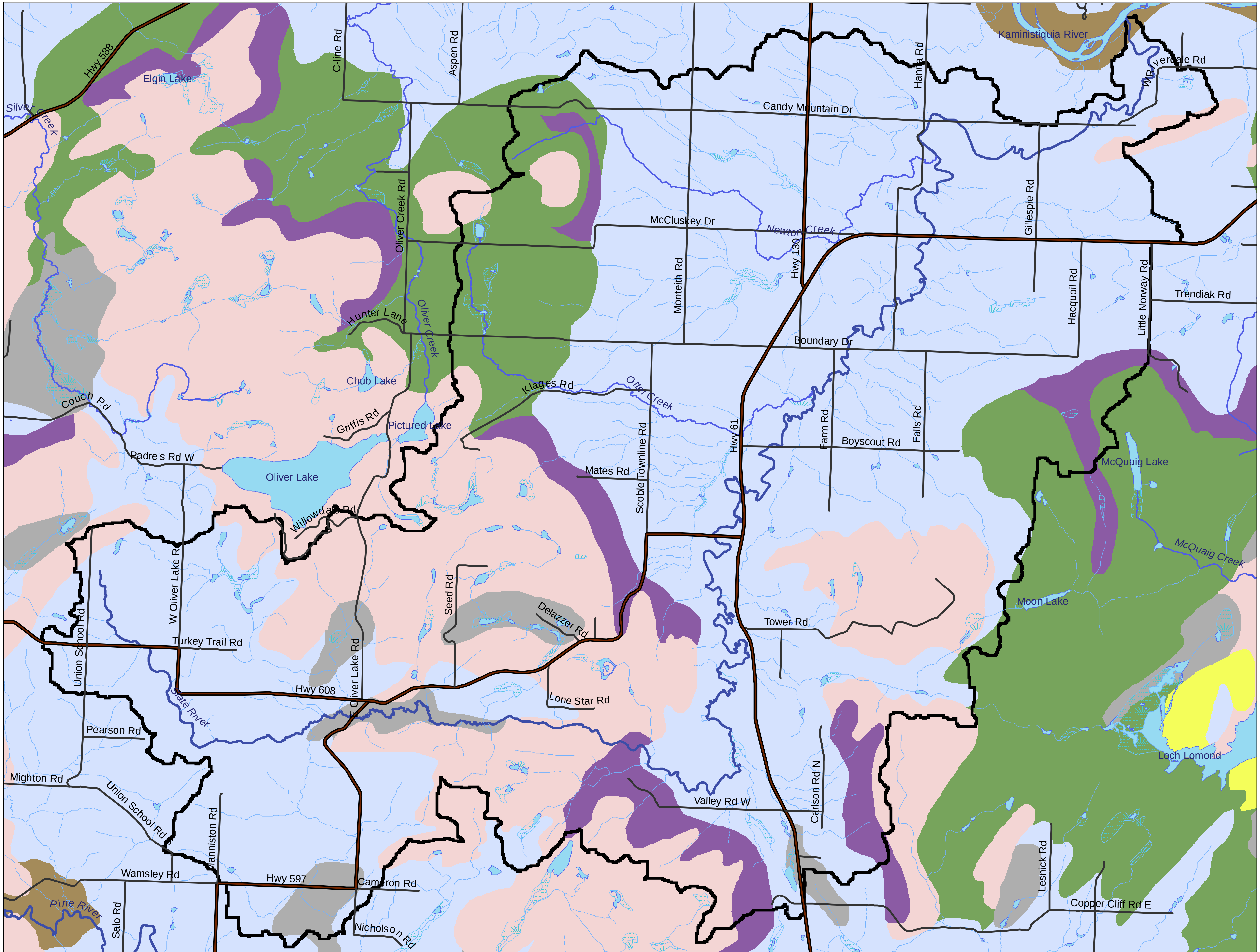

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N

Slate River Watershed
Surficial Geology
M-4

Legend

Roads

- Highway
- Road

Permanent Watercourse

- River
- Creek
- Stream
- Water Body
- Wetland
- Slate River Watershed
- Moraine
- Esker/Kame/Outwash plain
- Glaciolacustrine plain
- Alluvial
- Slope/Talus pile
- Organics
- Bedrock

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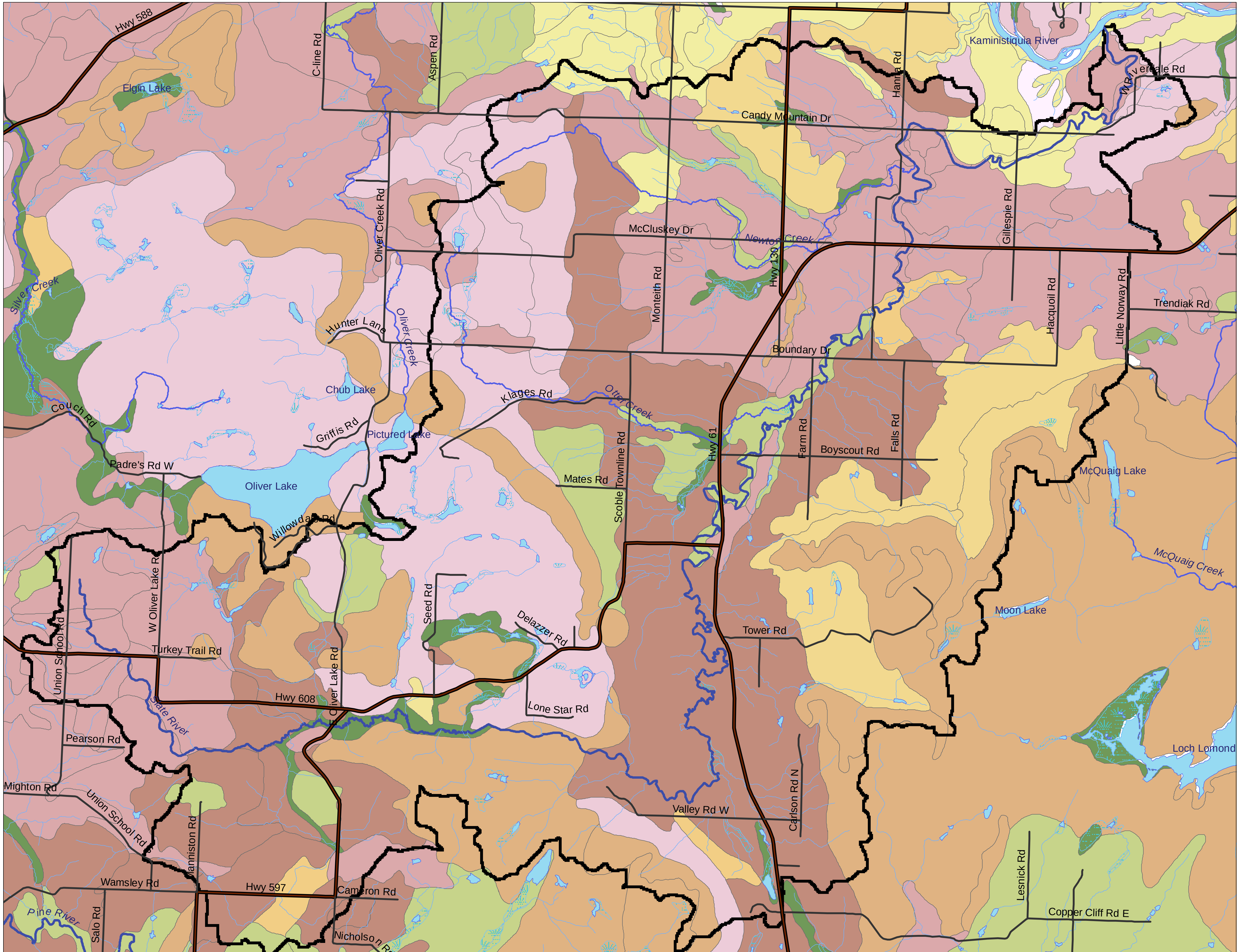

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N

Slate River Watershed Soils
M-5

Legend

Roads
- Highway
- Road

Permanent Watercourse
- River
- Creek
- Stream
- Water Body
- Wetland
- Slate River Watershed

Soils
- Organic
- Clay
- Clay Loam
- Fine Sandy Loam
- Gravelly Sand Loam
- Medium to Moderately Fine Loam
- Peaty Phase
- Rock
- Coarse Sand and Loamy Sand
- Silty Clay Loam
- Silt Loam
- Moderately Coarse Sandy Loam
- Very Fine Sandy Loam

1:65,000

0 1 2 3 km

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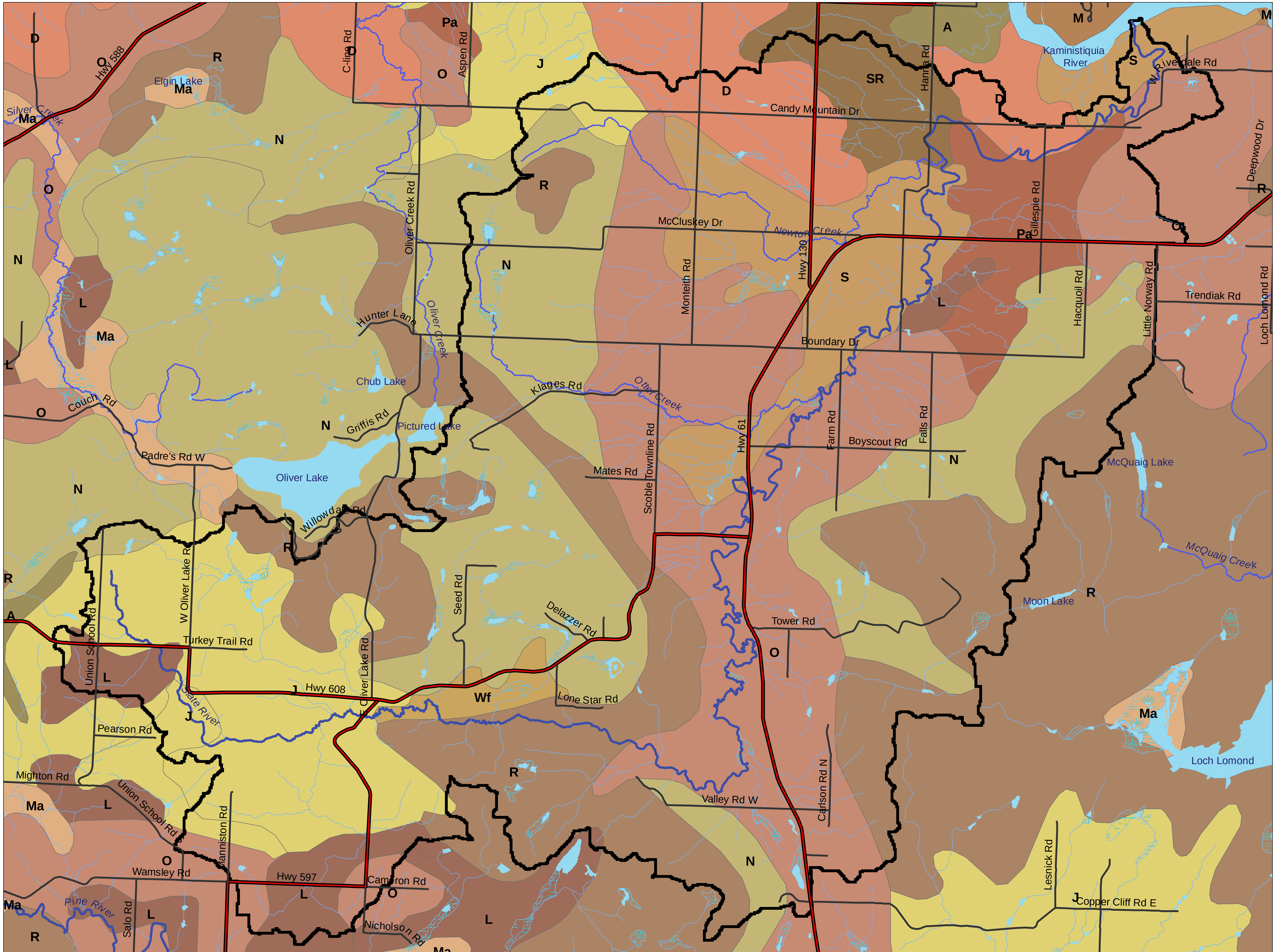
N

Slate River Watershed Thunder Bay Soils M-6



Legend

Roads
- Highway
- Road

Permanent Watercourse
- River
- Creek
- Stream
- Waterbody
- Wetland
- Slate River Watershed

Thunder Bay Soils
- ARTHUR, (A)
- DORION,(D)
- JARVIS RIVER, (J)
- LAPPE, (L)
- MARSH, (Ma)
- MUCK, (M)
- NOLALU, (N)
- WOLF RIVER, (Wf)
- OSKONDOGA, (O)
- PAIPOONGE, (Pa)
- ROCKLAND, (R)
- SLATE RIVER, (SR)
- STRAWBERRY, (S)
- WATER
- WATER - LAKE SUPERIOR

1:65,000

0 1 2 3 km

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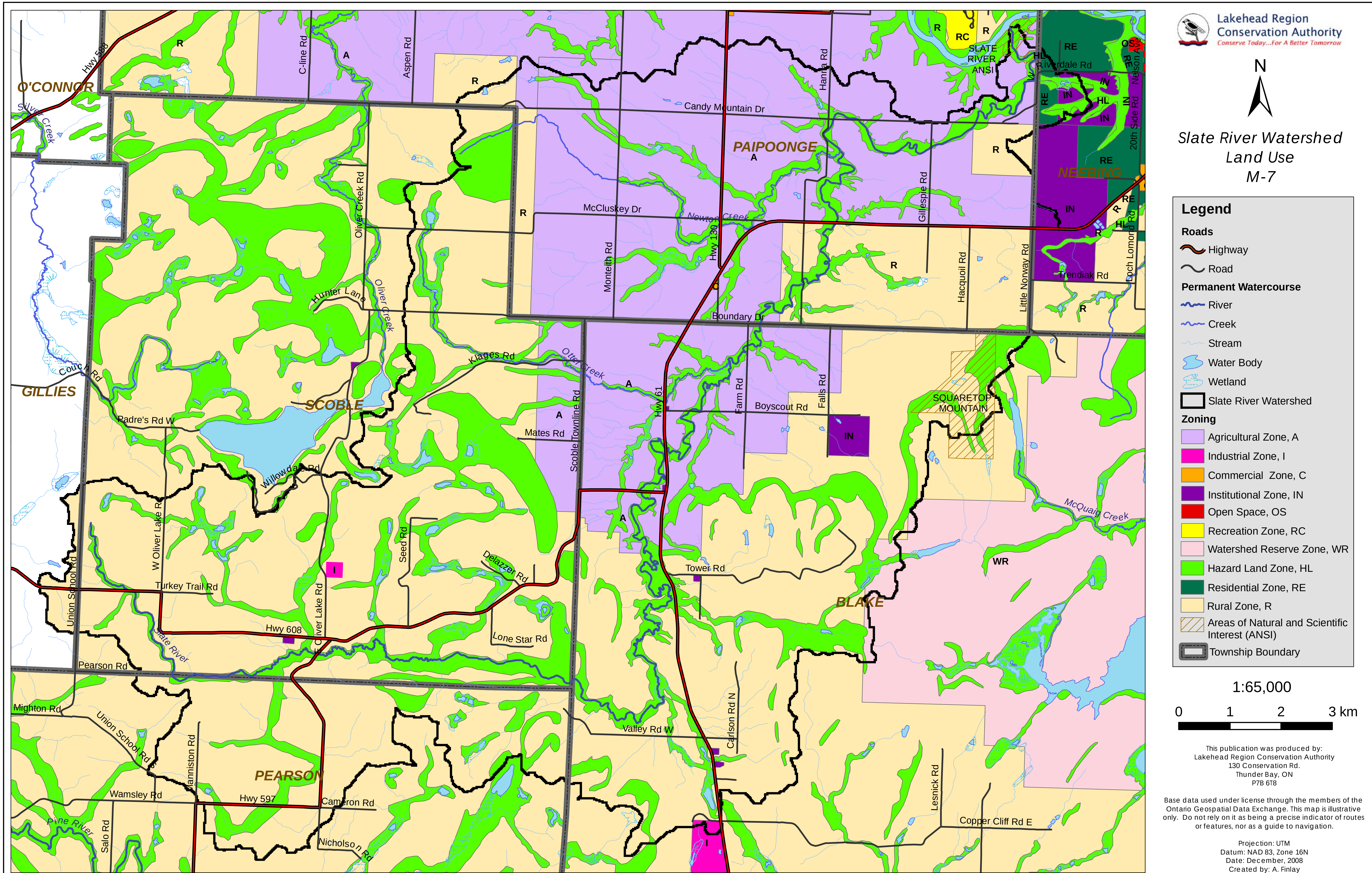
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N
Slate River Watershed
Land Use
M-7
Legend
Roads
Highway
Road
Permanent Watercourse
River
Creek
Stream
Water Body
Wetland
Slate River Watershed
Zoning
Agricultural Zone, A
Industrial Zone, I
Commercial Zone, C
Institutional Zone, IN
Open Space, OS
Recreation Zone, RC
Watershed Reserve Zone, WR
Hazard Land Zone, HL
Residential Zone, RE
Rural Zone, R
Areas of Natural and Scientific Interest (ANSI)
Township Boundary
1:65,000
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3 km
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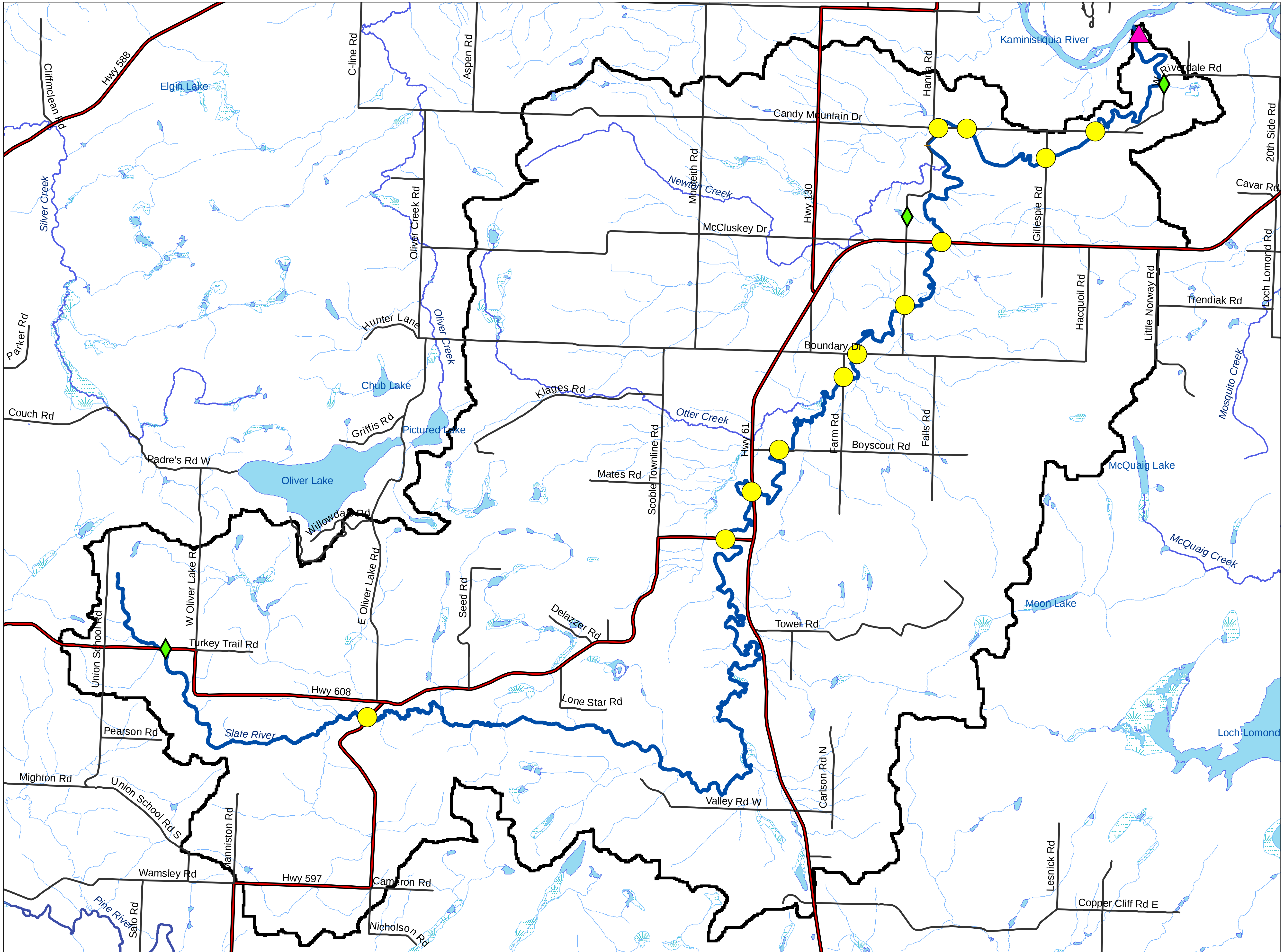
O'CONNOR
GILLIES
SCOBLE
PAIPOONGE
NEEBING
BLAKE
PEARSON
SLATE RIVER ANSI
SQUARETOP MOUNTAIN
Hwy 588
Hwy 130
Hwy 61
Hwy 608
Hwy 597
Silver Creek
Oliver Creek
Otter Creek
Newton Creek
McQuaig Creek
Slate River
Pine River
C-line Rd
Aspen Rd
Candy Mountain Dr
Hanna Rd
Riverdale Rd
Nelson Ave
20th Side Rd
McCluskey Dr
Montieth Rd
Gillespie Rd
Hacquoil Rd
Little Norway Rd
Loch Lomond Rd
Trendiak Rd
Boundary Dr
Oliver Creek Rd
Hunter Lane
Klages Rd
Couch Rd
Padre's Rd W
Willowdale Rd
Mates Rd
Scoble Townline Rd
Farm Rd
Boyscout Rd
Falls Rd
W Oliver Lake Rd
Union School Rd
Turkey Trail Rd
E Oliver Lake Rd
Seed Rd
Delazzer Rd
Lone Star Rd
Tower Rd
Pearson Rd
Mighton Rd
Union School Rd S
Manniston Rd
Wamsley Rd
Cameron Rd
Salo Rd
Nicholson Rd
Valley Rd W
Carlson Rd N
Lesnick Rd
Copper Cliff Rd E
WR



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N

Slate River Watershed Bridge and Culvert Sites M-8

Legend

- Bridge
- Confluence
- Culvert
- Highway
- Road
- Slate River
- River
- Creek
- Stream
- Water Body
- Wetland
- Slate River Watershed

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