Pennock Creek Watershed Assessment Update

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

2010

2010 Pennock Creek Watershed Assessment Update

September 2010

Written and Published by:

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

Prepared by:
Dan Brazeau (Assistant Water Resource Technologist)
Scott Drebit (GIS Technician/Planner)

Acknowledgements

The 2010 Corbett Creek Watershed Assessment Update was completed by Dan Brazeau, Water Resources Technician Assistant and Scott Drebit, GIS Technician/Planner of the Lakehead Region Conservation Authority. Tammy Cook, Watershed Manager, provided guidance, input and revisions towards the completion of this report.

Executive Summary

The Pennock Creek Watershed is located within the Municipality of Oliver Paipoonge and the City of Thunder Bay. The 2010 Pennock Creek Watershed Update Assessment was completed as an update to the 1996 Pennock Creek Watershed Report completed by the Lakehead Region Conservation Authority.

The 2010 Pennock Creek Watershed Assessment Update included water quality analysis, as well as documentation of the physical and biological attributes of six sampling locations. Surface water sampling, photo documentation and comprehensive field notes were completed for each sampling location.

Each site was chosen based upon accessibility and the proximity to any natural and manmade features which may have affected surface water quality. Site selection was also completed considering sampling locations from the 1996 Pennock Creek Watershed Report. Of the nine locations sampled in 1996 four were re-sampled (i.e. Sites 1, 2, 3 and 7) during the 2010 sampling period.

Water quality analysis completed for the 2010 Pennock Creek Watershed Assessment indicated that the Pennock Creek Watershed was in good condition, with minimal exceedances of the Provincial Water Quality Objectives (PWQO) at the time of sampling. The 2010 laboratory results reported three parameters, aluminum, iron and phosphorus, which exceeded PWQO criteria. Aluminum, iron and phosphorus commonly occur at high concentrations under natural conditions, and concentrations reported from the 2010 study were likely from natural processes within the watershed.

Aluminum exceeded the PWQO criterion (0.075 milligrams per liter) at Site 11, with a concentration of 0.175 mg/L reported on July 19, 2010. The singular occurrence of the aluminum exceedance is likely in response to a point source at or just upstream of the sampling site. Aluminum is the most abundant metal found in nature and its presence may be natural or caused by local land use. Aluminum was not tested for in 1996; therefore no comparison can be made.

Iron concentrations exceeded PWQO criterion (0.3 mg/L) at every site in both the 1996 and the 2010 assessments. Results from 1996 reported iron concentrations which ranged from 0.308 mg/L to 4.94 mg/L with an overall average of 2.14 mg/L. In 2010, iron concentrations ranged from 1.45 mg/L to 2.13 mg/L with an average of 1.60 mg/L. The highest iron concentration reported during 2010 sampling was from Site 3 on July 14, 2010, with a concentration of 2.13 mg/L.

Phosphorus was the only nutrient to exceed PWQO criterion (0.03 mg/L) at both Site 10 (0.0385 mg/L) and Site 2 (0.032 mg/L) which were sampled on July 13, 2010. Site 10 was located in a rural area and the phosphorus concentrations which were reported may be in response to any number of agricultural practices such as fertilizer application, cattle

farming and pesticides. Higher than average phosphorus concentrations may also be caused by large quantities of decaying material.

Both the 1996 and 2010 assessments reported dissolved oxygen concentrations which were below PWQO (minimum of 5 milligrams per litre) from Sites 1 and 3. Flow was not recorded in 1996, but observation in 2010 indicated that both of these locations were stagnant with highly organic substrates. Site 1 did not appear to be disturbed in anyway suggesting that this location naturally has low dissolved oxygen concentrations. Site 3 was observed to have blocked culverts which had caused stagnant conditions. Observations from Site 3 indicated that water quality may be affected by the blockage of two culverts directly upstream and it was noted that the removal of this blockage may be warranted.

Furthermore, comparison of 1996 and 2010 water quality results indicated that between the two study periods there has been negligible change to the water quality within the Pennock Creek Watershed. Average values from 1996 and 2010 reported close correlation, with only some site specific changes observed. Changes in physical parameters were observed between 1996 to 2010 (i.e. conductivity, water temperature and depth) and were likely caused by natural variation.

Based on observed conditions in 2010, the Pennock Creek Watershed continues to be in good condition, with minimal exceedances of PWQO at the time of sampling. A comparison of the 1996 and 2010 water quality results from Pennock Creek indicate that there has been negligible change between the two study periods.

Staff and funding permitting, it is recommended that an update to the 2010 Pennock Watershed Assessment be completed in the next five to ten years to ensure the health of the watershed is maintained. Future sampling should consider the reanalysis of Site 3. To minimize variability in the occurrence of point source contamination, future sampling should consider two sampling periods in which laboratory analysis and field measurements are to be completed. Future sampling should also consider the use of benthic analysis which can indicate water quality over an extended period of time. In addition, future documentation of biological attributes should consider the use of transects to quantify site vegetation.

Table of Contents

List of Tables

List of Maps

List of Appendices

1 Introduction

The Pennock Creek watershed is located within the Municipality of Oliver Paipoonge and the City of Thunder Bay. The majority of the watershed lies within the rural and agricultural land of Oliver Paipoonge. Municipal and jurisdictional boundaries of the Pennock Creek watershed are shown on map M-1: Key Plan. The general features found within the Pennock Creek watershed are shown on map M-2: Site Plan. The entire watershed resides within the Lakehead Region Conservation Authority (LRCA) Area of Jurisdiction. Map M-7: Approximate Regulated Areas shows the area considered to be regulated by the LRCA under the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Ontario Regulation 180/06.

The Thunder Bay Region contains a diverse array of watersheds each composed of a unique assemblage of ecological communities. A watershed, also simply known as a catchment or drainage basin, is essentially the area of land drained by a river system. A watershed is composed of tributaries (i.e. streams and creeks) which join together into a main channel and then into a lake. Pennock Creek drains into the Neebing River, which then empties into Lake Superior.

The goal of this report is to document the physical and chemical conditions of the Pennock Creek watershed as observed in July 2010, and compare observations to the Pennock Creek Assessment completed by the LRCA in 1996. Ultimately the information gained will be used to maintain programs 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 and biological attributes of the watershed
- Collect surface water quality samples
- Collect field measurements
- Conduct an inventory of the flora and fauna observed at each sampling location
- Conduct an inventory of soil, streambed substrate and stream bank cover observed within the watershed
- Interpret results to record the health status of the watershed
- Compare and contrast 2010 results with results observed from the 1996 Pennock Creek Watershed Assessment

2 Background

2.1 Physical Attributes

2.1.1 Topography

The Thunder Bay Region's varied topography and hydrology is largely owing to previous glaciations which have molded and transformed the landscape into what it is today. The watershed boundary spans 52.26 square kilometres and is located mostly within the Municipality of Oliver Paipoonge. The southeast portion of the watershed and confluence with the Neebing River is found within the City of Thunder Bay. The elevation of the watershed ranges from 188 metres to 326 metres above sea level, for a total drop in elevation of 138 metres throughout the watershed. The topography of the region is illustrated on map M-3: Topography.

2.1.2 Geology and Soils

Bedrock

The Thunder Bay Region lies within a 3,219,000 square kilometre area known as the Canadian Shield. The Canadian Shield is composed of ancient sedimentary, igneous and metamorphic rocks of Precambrian age. The Precambrian era comprises two main divisions: the 'Archaean Period' composed of rocks greater than 2,470 million years old (McGlynn, 1970), and the 'Proterozoic Period' which includes rocks aged from 570 million years (Stockwell, 1964) to 2,480 million years. The Thunder Bay area hosts rocks from both Proterozoic and Archean age groups, with the youngest rocks being about 1,100 million years old (LRCA, 1985). These parent materials are the substance from which the soils in the area are formed. The Pennock Creek watershed is composed entirely of sedimentary rock formation of the Paleoproterozoic era, as shown on map M-4: Bedrock Geology. This sedimentary rock is composed of an assemblage of animikie grey-pan; graywackes, iron formations, shale and limestone.

Surficial Geology and Deposits

Surface deposits in the Thunder Bay region are the result of glacial ice and water. Kame moraines and eskers, often flattened by subsequent lake action are found throughout the area and commonly consist of gravelly, sandy, outwash deposits, especially in the Kaministiqua River Valley. The watershed regions surficial geology is composed of glaciolacustrine plain, moraine, organics and man made topographic features, as shown on map M-5: Surficial Geology. Glaciolacustrine outwash is the dominant deposit of the watershed covering 25.54 square kilometres. Moraine deposits account for the second largest deposit covering 23.75 square kilometres. Organic deposits cover 2.9 square kilometres, while man made deposits cover 0.06 square kilometres.

Soils

The Pennock Creek watershed region is composed of a variety of soil types. Each soil type has a unique structure and properties potentially producing varied effects of drainage and bank stability within the watershed. The importance of soil in ecosystem structure makes it of great importance when assessing watershed quality. The distribution of soils throughout the watershed is illustrated on map M-6: Soils.

The Pennock watershed region is composed predominately of the Nolalu soil type. Found in the northwestern region of the study site Nolalu soils cover approximately 28.73 square kilometres of the total watershed area. Nolalu soils are characterized by non-calcareous fine sandy loam and stony glacial till derived from shale. Nolalu soil provides good drainage overall.

Pennasen soils found in the southern region of the watershed cover approximately 6.91 square kilometres of the study area. Pennasen soils provide very poor drainage, and are made of partially decomposed organic material derived from hypnum moss and reeds 40 to 90 centimetres thick. This layer is underlain by lacustrine clay.

Muck which covers 6.44 square kilometres of the study area is chiefly organic material, silt and clay.

Neebing soils account for approximately 4.97 square kilometres of the watersheds soil and are located within the southeastern region. These soils provide imperfect drainage and are made of non-calcareous sand and gravel produced from fluvial outwash.

Wolf River soils cover 1.98 square kilometres of the study area. These soils provide very poor drainage and are largely made of un-decomposed organic material derived from grasses, sedges and mosses greater than 160 centimetres thick.

Passer soils covering 1.75 square kilometres are underlain by coarse textured material and made of partially decomposed organic material derived from hypnum moss and reeds 90 to 130 centimetres thick. Passer soils provide very poor drainage.

The Oskondoga soil type comprises approximately 0.85 square kilometres of the study areas soil. Oskondoga soil has imperfect drainage with calcareous reddish clay loam, clay or silty clay with varved lacustrine.

Paipoonge soils covering 0.46 square kilometres of the watershed are made of a calcareous brownish silt loam and silty clay loam varved lacustrine. This soil is known to provide good drainage.

2.1.3 Climate

Climate of the Thunder Bay Region can be characterized by a continental climate influenced and modified by Lake Superior. Westerly winds predominate from July to March whereas easterly winds predominate the rest of the year. Table 1.0 displays the average daily temperature, total precipitation and extreme max daily temperatures for the Thunder Bay Region from 1971-2000. Table 2.0 displays the average daily temperature and total precipitation for the 1996 sampling year and Table 3.0 displays the average daily temperature and total precipitation for the 2010 sampling year.

Table 1.0: Mean temperature and total precipitation for Thunder Bay, 1971-2000

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature												
Daily (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
Extreme Max. Daily Precip. (mm)	51.6	33.5	41.9	69.3	76.2	49.3	53.8	87.1	131.2	47.8	63	42.7
Date (year / # of days)	1956 /20	1951 /26	1957 /14	1954 /30	1971 /24	1947 /04	1973 /27	1973 /19	1977 /08	1968 /09	1973 /21	1948 /05

Table 2.0: Mean temperature and total precipitation for Thunder Bay, January-July 1996

	Jan	Feb	Mar	Apr	May	Jun	Jul
Temperature							
Daily (ºC)	-18.73	-13.91	-9.59	-0.36	7.46	42.7	16.45
Precipitation							
Total Precipitation (mm)	27.5	36.5	5.5	16.5	40	14.79	110.5

Table 3.0: Mean temperature and total precipitation for Thunder Bay, January-July 2010

	Jan	Feb	Mar	Apr	May	Jun	Jul
Temperature							
Daily (ºC)	-12.09	-9.78	1.4	6.04	11.14	14.41	19.19
Precipitation							
Total Precipitation (mm)	27.0	9.0	18.0	37.5	38.5	83.0	43.0

2.1.4 Hydrology

Pennock Creek has an overall length of 17.29 kilometres with a slope of 0.79 percent. The Pennock Creek watershed drainage area is comprised of 6 sub-catchments, draining an area of 52.26 square kilometres. Pennock Creek flows in a general direction of west to east, originating in the Village of Murillo in the Municipality of Oliver Paipoonge and flowing into the Neebing River just west of the Thunder Bay International Airport.

The watershed is characterized by a relatively high runoff potential, but the numerous small bogs and depressions in the watershed, significantly reduce runoff rates (Dillon, 1982). Extensive flooding along Pennock Creek within the Geographic Township of Paipoonge has occurred several times in the past. These floods were caused, in part by severe snowmelt, rainfall as well as the encroachment of the Pennock Creek's floodplain. Previous developments in the vicinity of Rosslyn Village have changed the characteristics of the drainage area. Pennock Creek, north of Rosslyn Village, frequently overtops its banks subsequently creating extensive overland flow (Dillon, 1975).

The local residents and municipal officials requested that the Lakehead Region Conservation Authority carry out a drainage study on Paipoonge Township in 1975 near Pennock Creek (Dillon, 1975). The Lakehead Region Conservation Authority also authorized M.M. Dillon Limited to proceed with a Flood Plain and Fill Line Study of Pennock Creek in June, 1980. This study was completed from the confluence with the Neebing River upstream to a point about 500 metres north of Highway 11/17; a total area spanning approximately 13 square kilometres (Dillon, 1982).

3 Methods and Materials

3.1 Site Selection

Six sampling sites were chosen to assess the overall health of the Pennock Creek watershed. Each site was chosen based upon accessibility and proximity to any natural and/or man made features that may affect surface water quality. The site selection was also organized in relation to the previous study completed in 1996. Though all sites from the previous study could not be re-sampled for reasons of accessibility and practicality four of the nine sites sampled in 1996 were sampled in 2010. The location of sites sampled in 1996 and 2010 are shown on map M-2: Site Plan. Site 1 was previously sampled in 1996 and was chosen for the 2010 update due to the need for a headwater sample. Site 1 was located off of the railway in the Village of Murillo. Site 2 located off of Vibert Road, was previously sampled in 1996 and was chosen for the 2010 update. Site 2 had ideal access with public parking just upstream of the sampling site. Site 3, also sampled in 1996 and chosen for the 2010 update, had easy access on public property at the end of Cooper Road. Site 7 previously sampled in 1996 was chosen for the 2010 update. Site 7 was located off of 25th Side Road, downstream of an irrigation pond. This site required parking up the road on a public lot and walking to the site. Site 10, located off Pole Line Road, was only sampled in 2010, and was chosen in part for easy accessibility and to assess the effect of local land-use upon overall stream health. Site 11, located off of 20th Side Road, was also only sampled in 2010 and although not located at the Neebing River confluence is meant to represent the site closest to it.

3.2 Quantitative Assessment

Several parameters were measured to assess the surface water quality of the Pennock Creek watershed. Surface water samples were collected for laboratory analysis in new clean bottles provided by ALS Laboratory Group, 1081 Barton Street, Thunder Bay, Ontario. Laboratory analysis was completed for the following: conductivity, total dissolved solids, turbidity, nutrients (nitrate, nitrite, ammonia and total phosphorus), bacteria (Escherichia coli and total coliforms) and total metals.

Methodology for water sample collection was based on the Provincial Water Quality Monitoring Network (PWQMN), Ministry of Environment Protocol (2006). Grab samples were collected away from the stream bank (facing upstream) within the main current either by wading or by using a reaching pole. In order to avoid disturbing as little sediment as possible, effort was taken to enter the river downstream of the sampling location.

ALS Laboratory Group provided four collection bottles for each site: routine, nutrient, metal and bacterial analysis. Sulfuric acid and nitric acid were added as preservative on site to the nutrient and metal bottles, respectively. Bottles for bacterial analysis were pre-charged with sodium thiosulphate preservative and care was taken not to open the bottle

until the true sample was to be filled. All sample bottles were transported using a cooler and ice packs.

Field parameters of water temperature, pH, conductivity and dissolved oxygen were measured using an YSI 600 MDS multi parameter water quality sampler at the same time and location as water sample collection. Other standard field measurements were also taken. Air temperature was measured by mercury thermometer; channel width using a measuring tape and channel depth using a metre stick. Velocity was measured using a floatation device, measuring tape, stop watch and appropriate calculations. This was only employed for use in water which was running in the downstream direction (not in ponds producing only windblown results). Techniques for data collection are outlined 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 Ministry of the Environment and Energy (MOEE), July 2004. 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 Pennock Creek watershed. The information in these guidelines and supporting text is used to compliment the PWQO and Interim Objectives. The applicable criteria published in the PWQO and CCREM water quality guidelines are attached in Appendix C. There are no current PWQO standards for total coliforms and fecal coliforms, however, recreational water quality guidelines published by the Ontario Ministry of Health in 1992 were used. These objectives were 1000 counts per 100 ml (based on a geometric mean density for a series of water samples) for total coliforms and 100 counts per 100 ml for fecal coliforms.

3.4 Qualitative Assessment

Watershed health can also be assessed by qualitative monitoring (visual inspection). The composition of in-stream substrate, forest soil and the stream bank riparian community can affect surface water quality. The presence or absence of certain flora and fauna may indicate the ability of a watershed to provide suitable habitat.

Site flora was assessed using the Field Guide to Forest Ecosystem Classification for Northwestern Ontario (Sims et al. 1997). Each site was evaluated based on a 50 metre proximity to the creek. Each site which had significant forest vegetation was given a vegetation type or FEC V-Type. Common and scientific names are located within Appendix G.

Fauna was assessed by identifying the species and number of individuals observed at each site. This process did not utilize netting of any kind and therefore fish species and insect species are only described generally (i.e. minnows, water striders, etc.). Physical dimensions were measured, UTM (Universal Transverse Mercator) coordinates and pictures were taken and general observations were noted including any barriers to flow.

Erosion potential, slope stability and culverts were documented only where outstanding cases could be observed. This was documented using a camera and short hand notes on the field sheet. Soil observations were completed by digging a small pit approximately 30 x 30 x 30 centimeters. Due to the lack of in depth data, (which can be provided only through more extensive testing) only general descriptions of the soil characteristics were noted. Documentation of culverts throughout the Pennock Creek watershed was completed for the 1996 Pennock Creek watershed assessment. Wherever possible, 1996 photos were compared to photos taken in 2010 and significant physical changes were noted. Photo documentation of each site is located within Appendix H.

3.5 Materials

- Chest waders
- Cooler
- Underwater digital camera
- GPS Camera
- Field guides
- Fluorescent Orange Vests
- Ice packs
- Knife
- Latex gloves
- Life Jackets
- Measuring tape reel
- Mercury thermometer
- Meter stick
- Paper towel
- Pens and pencils
- Reaching pole
- Road map
- Sampling bottles provided by ALS Laboratory Group
- Shovel
- Squeeze Bottles
- Stopwatch
- Topographic map
- Trimble Geo XH GPS
- Whistle
- Work gloves
- YSI 600 MDS multi parameter water quality sampler
- Ziploc © bags

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)
- Newcombs Wildflower Guide (Newcomb, 1977)
- ROM Field Guide to Wildflowers of Ontario (Dickinson *et al.* 2004)
- Wetland Plants of Ontario (Newmaster *et al.* 1997)
- Forest Plants of Northeastern Ontario (Legasy et al. 1995)

4 Results

All results from the 1996 assessment are attached in Appendix E and all laboratory results from ALS Laboratories for the 2010 assessment are located in Appendix D. Photo documentation from all 2010 sampling locations is located in Appendix H.

4.1 Site 1: Headwaters - Murillo

Location Reference for Site 1	
Location Description	Headwaters in the Village of Murillo. Located adjacent to train tracks off of Oliver Road.
UTM Coordinates	Northing 5365249/ Easting 314978
Altitude/Elevation	288.022 metres above sea level

Field Measurements for Site 1						
Parameter	Unit	Date: July 17, 1996 Time: 3:15 pm	Date: August 2, 1996 Time: 9:15 am	Date: August 15, 1996 Time: 9:05 am	Average of 1996 Data	Date: July 13, 2010 Time: 10:20 am
Water Temperature	ºC	20.5	16.6	15.4	17.5	16.32
Conductivity	µS/cm	200	355	NA	277.5	316
Dissolved Oxygen	mg/L	**3.8**	**3.90**	**3.2**	**3.63**	**0.68**
Dissolved Oxygen	%	NA	NA	NA	NA	7.1
pH		7.25	7.30	7.05	7.2	6.98
Air Temperature	ºC	31.0	21.5	15.0	22.5	24
Channel Width	m	NA	NA	NA	NA	0.7
Channel Depth	m	0.42	0.38	0.38	0.39	0.6
Velocity	m/s	NA	NA	NA	NA	No flow

* Bold #'s indicate exceedance of PWQO guidelines

Laboratory Water Quality Results for Site 1				
Parameter	Unit	Date: August 9, 1996	Date: August 20, 1996	Date: July 13, 2010 Time: 10:20 am
Bacteriological				
Escherichia Coli	MPN/100mL	NA	NA	5
Total Coliforms	MPN/100mL	NA	NA	**2000**
Physical				
Conductivity (EC)	µS/cm	NA	NA	303
Total Dissolved Solids	mg/L	NA	NA	261
Turbidity	NTU	1.5	3.5	1.92
Nutrients and Anions				
Ammonia-N, Total	mg/L	NA	NA	<0.020
Chloride (Cl)	mg/L	NA	NA	18.9
Nitrate-N (NO3-N)	mg/L	NA	NA	<0.030

Nitrite-N (NO2-N)	mg/L	NA	NA	<0.020
Phosphorus (P)-Total	mg/L	0.07	0.26	0.0245
Sulphate (SO4)	mg/L	NA	NA	<0.30
Metals				
Aluminum (Al)	mg/L	NA	NA	0.011
Cadmium (Cd)	mg/L	<0.005	<0.001	<0.000090
Copper (Cu)	mg/L	NA	NA	<0.0010
Iron (Fe)	mg/L	**0.843**	**1.06**	**1.45**
Lead (Pb)	mg/L	<0.005	<0.005	<0.0010

* Bold #'s indicate exceedance of PWQO guidelines

Flora Observed at Site 1	
FEC V-Type: V-23 Tamarack (Black Spruce) / Speckled Alder / Labrador Tea	
Dominant Species *	
Species	
Trees	Slender Willow* Black Spruce White Spruce Tamarack
Shrubs	Speckled Alder Bog Laurel
Ground Cover	Wild Raspberry* Canada Blue Joint Red Top Grass* Wool Grass Early Meadow-Rue
Aquatic Macrophytes and Algae	Cattail Wild Calla

Fauna Observed at Site 1		
Species		**# Observed**
Birds	-	-
Mammals	-	-
Amphibians	-	-
Fish	Sticklebacks	>10
Mollusca	-	-
Crustaceans	-	-
Insects	Water Striders	>20
Other	Leech	1

Substrate Observations for Site 1		**Soil Pit Observations**	
Percentage Shaded	0-25%	**Soil Characteristics**	Very moist soil with cobble likely from railway construction. Within cobble the soil was dominated by silt and clay with <50 % sand.
Substrate Classification	Muck, with cobble banks.		
Abundance of aquatic vegetation	Abundant cattails, as well as wild calla.		

General Observations

Site 1, previously sampled in 1996 was located directly adjacent to the CN railway in the Village of Murillo. Access to the site was available by following the tracks from an entrance off of Oliver Road northwest. The sampling site was approximately two to three metres from the railway and there was relatively high railway traffic with two trains passing the site during sampling.

A large pile of woody debris, which appeared to be a removed beaver dam, was observed on the culvert. The water showed no surface flow and appeared to be stagnant. Soil at this site contained large cobble and was fragmented by silty-clay soil. This large cobble may have been from railroad construction, with the same appearance as cobble on the rail bed.

Vegetation reported from Site 1 consisted largely of grasses and cattails, with a conifer stand located approximately 40 metres north. Only a single aquatic plant, wild calla, was located at the site. The substrate was varied with cobble and gravel along the banks of the creek and the center of the creek bed was largely composed of organic muck. This muck was greater than 30 centimetres in depth, making sampling somewhat difficult. Fewer fish relative to the other sites were observed, with sticklebacks present as well as a swimming leech approximately six inches in length.

When compared to the photo taken in 1996 (Appendix H), some change to the site location is apparent. The culvert in 1996 did not have a grating to prevent beaver activity and similarly no beaver activity adjacent to the culvert was evident. The predominately herb vegetation observed in 2010 appears to be consistent with the vegetation shown in the 1996 photo.

Results and Discussion

Results from sampling on July 13, 2010 indicated that Site 1 was in reasonably good condition, exceeding three PWQO criteria. Total coliforms were in exceedance of the pre-1994 PWQO guideline of 1,000 counts per 100 millilitres of water (MPN/100 mL), with a concentration of 2,000 MPN/100 mL. Dissolved oxygen (DO) exceeded PWQO criterion (minimum of 5 mg/L) with a concentration of 0.68 milligrams per litre (mg/L). Iron exceeded PWQO criterion (0.3 mg/L) with a concentration of 1.45 mg/L. The reddish brown colour characteristic of iron rich water was prominent at Site 1.

Low DO concentrations observed in 2010 may have been caused by the relatively thick organic layer and stagnant water observed at the time of sampling. From 1996 to 2010, DO from Site 1 changed significantly, with an average DO concentration of 3.63 mg/L recorded in 1996 and a DO concentration of 0.68 mg/L recorded in 2010. This difference may be accounted for by spatial and temporal variations in weather, equipment accuracy, stream flow and time of year.

Temperature is inversely correlated with dissolved oxygen; increasing temperatures decrease the ability of water to hold dissolved oxygen. Water temperatures reported from 1996 and 2010 were relatively similar and do not indicate that water temperature lead to lower DO concentrations. Greater depth also decreases surface area relative to volume, decreasing the exchange between water and the atmosphere in stagnant water. In a relatively deeper, more stagnant water body, the DO would naturally occur at lower levels. A depth of 0.6 metres was observed in 2010 while the greatest depth observed in 1996 was 0.42 metres. The thick muck substrate composed largely of organic matter, and high levels of decomposition along with stagnant water are two potential causes to the lower DO concentrations. Although velocity was not recorded in 1996, there was no flow observed during the sampling in 2010.

An increase in iron concentrations was reported from 1996 to 2010. The 1996 iron concentrations observed on August 9, 1996 and on August 20, 1996 were 0.843 mg/L and 1.06 mg/L respectively, where the iron concentration reported in 2010 was 1.46 mg/L.

The 2010 and 1996 vegetation inventory of Site 1 reported similar findings. Grasses, cattails, willow and speckled alder were observed during both sampling periods. Approximately 40 metres north of the sampling site was abundant white and black spruce as well as tamarack which were identified in both 2010 and 1996. A complete list of species identified for Site 1 in 1996 is summarized within Appendix E. Both the 2010 and 1996 reports, using the Forest Ecosystem classification for North Western Ontario (FEC), classified the nearby forest as a V-23 Tamarack (Black spruce).

4.2 Site 2: Vibert Road, Upstream

Location Reference for Site 2	
Location Description	Located just downstream of Highway 11/17 and upstream of Vibert Road. Access available directly from Vibert Road.
UTM Coordinates	Northing 5361293/ Easting 319144
Altitude/Elevation	222.338 metres above sea level

Field Measurements for Site 2						
		Date: July 17, 1996	Date: August 2, 1996	Date: August 15, 1996	Average of 1996 Data	Date: July 13, 2010
Parameter	Unit	Time: 2:45 pm	Time: 9:45 am	Time: 9:30 am		Time: 2:00 pm
Water Temperature	ºC	21.5	15.0	14.5	17.0	19.2
Conductivity	µS/cm	200	448	NA	398.0	548
Dissolved Oxygen	mg/L	9.9	7.5	5.1	7.50	6.64
Dissolved Oxygen	%	NA	NA	NA	NA	74
pH		6.45	7.40	7.15	7.00	7.57
Air Temperature	ºC	30.0	21.5	15.0	22.2	27
Channel Width	m	NA	NA	NA	NA	2.6
Channel Depth	m	0.62	0.51	0.25	0.46	0.52
Velocity	m/s	NA	NA	NA	NA	No flow

Laboratory Water Quality Results for Site 2		
		Date: July 13, 2010
Parameter	Unit	Time: 2:00 pm
Bacteriological		
Escherichia Coli	MPN/100mL	59
Total Coliforms	MPN/100mL	**1700**
Physical		
Conductivity (EC)	µS/cm	511
Total Dissolved Solids	mg/L	400
Turbidity	NTU	5.24
Nutrients		
Ammonia-N, Total	mg/L	<0.020
Chloride (Cl)	mg/L	52.1
Nitrate-N (NO3-N)	mg/L	<0.030
Nitrite-N (NO2-N)	mg/L	<0.020
Phosphorus (P)-Total	mg/L	**0.0320**
Sulphate (SO4)	mg/L	0.49
Metals		
Aluminum (Al)	mg/L	0.030
Cadmium (Cd)	mg/L	<0.000090
Copper (Cu)	mg/L	0.0013
Iron (Fe)	mg/L	**1.26**
Lead (Pb)	mg/L	<0.0010

* Bold #'s indicate exceedance of PWQO guidelines

Flora Observed at Site 2	
FEC V-Type: V-2 Black Ash Hardwood and Mixedwood	
Dominant Species *	
Species	
Trees	Black Ash
Shrubs	Red Osier Dogwood* Willow spp.* Currant
Ground Cover	Wild Raspberry Goldenrod Cow Vetch Tall Manna Grass Reed Canary Grass* Marsh Timothy Swamp Thistle Narrow Leaved Meadow Sweet
Aquatic Macrophytes and Algae	Alternate Leaved Pondweed Broad-leaved Arrowhead, Wapato Water Plantain Submerged Water Starwort Floating Leaved Burreed
	Water Arum, Wild Calla Sago Pondweed Northern Water Milfoil Common Bladder Wort

Fauna Observed at Site 2		
Species		**# Observed**
Birds	Warblers	3
	Crows	Multiple (auditory identification)
Mammals	Chipmunk	1
Amphibians	Frogs	3
Fish	Minnows	>10
Mollusca	-	-
Crustaceans	-	-
Insects	Water striders	>100
	Butterfly	1
	Bumble bee	1

Substrate Observations for Site 2		Soil Pit Observations	
Percentage Shaded	25-50%	Soil Characteristics	Construction gravel adjacent to sampling site and organics underlying thick matted vegetation.
Substrate Classification	Largely cobble with abundant organics throughout.		
Abundance of aquatic vegetation	Abundant submergent and emergent plants. Much of the substrate was completely covered in sampling location.		

General Observations

Site 2, located off of Vibert Road just downstream of the new Highway 11/17 was previously sampled in 1996. Field measurements were recorded from this site in 1996 but laboratory analysis was not completed. The Site 2 location had undergone considerable highway construction since the 1996 assessment, with a portion of the Trans-Canada Highway realigned.

The vegetation from Site 2 was characterized by reeds and grasses with a few small black ash, with no trees observed greater than five metres. The substrate was predominately cobble with organics and abundant aquatic vegetation which covered much of the substrate. Although surface flow could not be recorded because of a combination of wind and slow flow, flow was apparent from suspended sediment flowing within the channel. The soil pit was dug through a thick layer of matted reeds, yielding only organics. Farther up the edge of the bank, the roadside was predominately gravel with the soil profile yielding only road construction materials. Photo documentation of Site 2 was not completed in 1996.

Results and Discussion

Laboratory results from sampling on July 13, 2010 indicated that Site 2 was in good condition exceeding three PWQO parameters at the time of sampling. Total coliforms exceeded pre-1994 PWQO criterion (1,000 MPN/100 mL) with a value of 1,700 MPN/100 mL; a significant decrease from upstream sites. Phosphorus exceeded PWQO (0.03 mg/L), with a concentration of 0.032 mg/L and iron exceeded PWQO criterion (0.3 mg/L) with a concentration of 1.26 mg/L.

Laboratory analysis was excluded from Site 2 in the 1996 report. In relation to the field measurements there were no significant change between 1996 and 2010 observations.

Vegetation reported from the 2010 and 1996 reports was comparable, with grasses, black ash and fireweed reported for both sampling periods. A FEC of V-2 Black Ash Hardwood was used to classify both 2010 and 1996 observations. The complete list of species identified in 1996 for Site 2 is summarized in Appendix E.

4.3 Site 3: Cooper Road, Downstream

Location Reference for Site **3**	
Location Description	Located at the end of Cooper Road with public access. Industrial park in local area.
UTM Coordinates	Northing 5360766/ Easting 320297
Altitude/Elevation	220.7 metres above sea level

Field Measurements for Site 3						
Parameter	Unit	Date: July17, 1996 Time: 2:30 pm	Date: August 2, 1996 Time: 10:00 am	Date: August 15, 1996 Time: 9:45 am	Average of 1996 Data	Date: July 14, 2010 Time: 9:45 am
Water Temperature	ºC	19.5	15.5	15.0	16.7	17.5
Conductivity	µS/cm	375	428	NA	401.5	541
Dissolved Oxygen	mg/L	6.8	**3.2**	**3.7**	**4.57**	**1.60**
Dissolved Oxygen	%	NA	NA	NA	NA	17.4
pH		7.5	7.55	7.25	7.43	7.31
Air Temperature	ºC	30.0	22.0	15.0	22.3	23
Channel Width	m	NA	NA	NA	NA	5.5: pool 0.7: channel
Channel Depth	m	0.17	0.13	0.14	0.15	0.48
Velocity	m/s	NA	NA	NA	NA	No flow

*Bold #'s indicate exceedance of PWQO guidelines

Laboratory Water Quality Results for Site 3				
Parameter	Unit	Date: August 9, 1996	Date: August 20, 1996	Date: July 14, 2010 Time: 9:45 am
Bacteriological				
Escherichia Coli	MPN/100mL	NA	NA	25
Total Coliforms	MPN/100mL	NA	NA	**>2420**
Physical				
Conductivity (EC)	µS/cm	NA	NA	513
Total Dissolved Solids	mg/L	NA	NA	395
Turbidity	NTU	1.2	NA	8.93
Nutrients and Anions				
Ammonia-N, Total	mg/L	NA	NA	0.085
Chloride (Cl)	mg/L	NA	NA	55.5
Nitrate-N (NO3-N)	mg/L	NA	NA	<0.030
Nitrite-N (NO2-N)	mg/L	NA	NA	<0.020
Phosphorus (P)-Total	mg/L	0.09	0.26	0.0261
Sulphate (SO4)	mg/L	NA	NA	0.31

Metals				
Aluminum (Al)	mg/L	NA	NA	<0.010
Cadmium (Cd)	mg/L	<0.001	<0.001	<0.000090
Copper (Cu)	mg/L	NA	NA	<0.0010
Iron (Fe)	mg/L	**0.425**	**0.308**	**2.13**
Lead (Pb)	mg/L	0.013	<0.005	<0.0010

* Bold #'s indicate exceedance of PWQO guidelines

Flora Observed at Site 3	
FEC V-Type: V-17 Jack Pine Mixedwood/ Shrub Rich	
Dominant Species *	
Species	
Trees	Jack Pine Willow Saskatoon
Shrubs	Red Osier Dogwood Speckled Alder* Willow spp. Mountain Ash
Ground Cover	Cow Vetch Jewel Weed Wild Mint Fragrant Bedstraw Fireweed Reed Canary Grass Timothy Grass Wire Grass Redtop Grass Swamp Milkweed
Aquatic Macrophytes and Algae	Algae Alternate Leaved Pondweed Broad-Leaved Arrowhead Water Plantain Duckweed Coontail Common Bladderwort Wild Calla Floating Bulrush Floating Arrowhead Large Leaved Pondweed Small Yellow Water Crowfoot

Fauna Observed at Site 3		
Species		**# Observed**
Birds	Crows	1
	Savanna Sparrow	1
Mammals	Chipmunk	1
Amphibians	Frog	1
Fish	Minnows	>10
Mollusca	-	-
Crustaceans	-	-
Insects	Mosquitoes	Abundant

Substrate Observations for Site 3		Soil Pit Observations	
Percentage Shaded	25-50%	Soil Characteristics	-High sand content with ~10% silt and clay. -Sandy loam
Substrate Classification	Cobble, boulders and muck throughout.		
Abundance of aquatic vegetation	Abundant submergent and emergent plants of varied species.		

General Observations

Site 3, located at the south end of Cooper Road was previously sampled in 1996. Cooper Road provides traffic access to an industrial park (concrete and culvert manufacturers). The weather observed during sampling was overcast with a light breeze. There were two large culverts under a gravel roadbed which narrowed after the culverts and continued south. During the 2010 sampling, both culverts at the site were blocked by a beaver dam, forming a nearly stagnant pool at the sampling location downstream. The pool flowed into a narrow, shallow channel which was obstructed by fallen woody debris. The water column was highly turbid, with the bottom of the pool (which was less than one metre in depth) not visible. Some of the fill surrounding the culverts had eroded exposing landscape fabric and causing the road to narrow. This erosion was not severe and did not appear to compromise road safety, but may require further investigation. Upstream of the culverts and Cooper Road the channel was wide and differed significantly from the sampling site in regard to colour, flow and vegetation. Floating mats of orange stained foam (likely iron bacteria) and water with a dark orange tinge were observed; shown in Plate F of Appendix H. High iron concentrations can be caused by industrial activity and more commonly from natural causes of geologic origin.

Aquatic flora of Site 3 was abundant relative to the other site locations, with submergent aquatics including common bladderwort and coontail in abundance. There appeared to be a high abundance of wildlife utilizing the site as well. Water striders and minnows were numerous and a frog (unidentified) was also seen. Small mammals and birds were abundant in the lower canopy and deer and beaver tracks were adjacent to and within the pool. The vegetation was shrub and herb dominated with few trees evident. The soil observed was very high in sand content, and could be characterized as sandy loam. Photo documentation of this site was not completed in 1996.

Results and Discussion

Site 3 exceeded three PWQO parameters on July 14, 2010. Relative to other 2010 sampling locations, Site 3 had the highest concentrations of both iron and total coliforms. Iron concentrations exceeded PWQO criterion (0.3 mg/L), with a concentration of 2.13 mg/L. Although there are several industries, including concrete and culvert manufacturers, located in close proximity to the creek, higher than average iron concentrations were likely of geologic origin. This was indicated by orange/red soil observed adjacent to the pond (Plate F Appendix H). This reddish orange tinge may be indicative of iron rich soils.

Site 3 had the second lowest DO values of the watershed exceeding PWQO with a concentration of 1.60 mg/L which is well below PWQO criterion (minimum of 5 mg/L). This low DO concentration may have been caused by the stagnation of the water due to the damming of upstream culverts. Total coliforms exceeded pre-1994 PWQO (1,000 MPN/100 mL) with a concentration greater than 2,420 MPN/100 mL. Although the Site 3 sampling location was stagnant with a low DO concentration, the abundant flora and fauna observed at the sampling site suggests a relatively healthy location for wildlife.

Iron concentrations increased significantly between the 1996 and 2010 studies. Iron exceeded PWQO criterion (0.3 mg/L) in the 1996 report with a concentration of 0.425 mg/L on August 9, 1996 and a concentration of 0.308 mg/L on August 20, 1996. The 1996 iron concentrations are considerably lower than those observed in 2010. This may be due to the lack of flow and subsequent decrease in the flushing of sediments and nutrients from the sampling site.

The damming of the stream appears to have greatly affected depth as well. The greatest depth reported from 1996 was 0.17 metres; where the depth observed on July 14, 2010 was 0.48 metres. This increased depth may have drastically affected many parameters, including aquatic vegetation and DO levels. DO concentrations in 1996 were on average 4.57 mg/L, exceeding required PWQO criterion (minimum of 5 mg/L). The 2010 measurements from Site 3 significantly decreased from 1996, with a DO concentration of 1.60 mg/L.

The terrestrial vegetation observed for the 2010 and 1996 reports was very similar. Jack pine, willow, speckled alder, saskatoon as well as several other species were inventoried for both reports. The FEC V-17 Jack Pine mixedwood/ Shrub Rich were applied to both the 1996 and 2010 reports. The complete list of species identified for Site 3 in 1996 is located within Appendix E.

Concerns of high turbidity and poor water quality were reported from Site 3 by a public source in October 2009. LRCA and Department of Fisheries and Oceans (DFO) after visiting the site concluded that the high turbidity was likely of natural origin.

4.4 Site 4: Downstream from Municipal Golf Course

Site 4 was sampled July 17, August 2 and August 15, 1996 for the 1996 Pennock Creek Watershed Assessment Report. Site 4 was not included in the 2010 update assessment. All 1996 results for this site are located in Appendix E.

4.5 Site 5: Upstream from Irrigation Pond

Site 5 was sampled July 17, August 2 and August 15, 1996 for the 1996 Pennock Creek Watershed Assessment Report. Site 5 was not included in the 2010 update assessment. All 1996 results for this site are located in Appendix E.

4.6 Site 6: Irrigation Pond, 25th Side Road

Site 6 was sampled July 17, August 2 and August 15, 1996 for the Pennock Creek Watershed Assessment Report. Site 6 was not included in the 2010 update assessment. All 1996 results for this site are located in Appendix E.

4.7 Site 7: 25th Side Road, Downstream from Irrigation Pond

Location Reference for Site 7	
Location Description	Located off of 25th Side Road, no shoulder on the bridge is available and considerable walk is required.
UTM Coordinates	Northing 5360351/ Easting 323160
Altitude/Elevation	204.734 metres above sea level

Field Measurements for Site 7						
		Date: July17, 1996	Date: August 2, 1996	Date: August 15, 1996	Average of 1996 Data	Date: July 14, 2010
Parameter	Unit	Time: 11:45 am	Time: 2:30 pm	Time: 10:30 am		Time: 11:20 am
Water Temperature	ºC	18.0	19.2	16.0	17.7	20.19
Conductivity	µS/cm	355	435	NA	395.0	530
Dissolved Oxygen	mg/L	9.0	9.0	5.9	7.97	8.04
Dissolved Oxygen	%	NA	NA	NA	NA	89.1
pH		7.55	7.45	8.10	7.70	7.75
Air Temperature	ºC	29.0	27.0	16.0	24.0	21
Channel Width	m	NA	NA	NA	NA	2.8
Channel Depth	m	0.51	0.36	0.25	0.37	0.35
Velocity	m/s	NA	NA	NA	NA	0.151

Laboratory Water Quality Results for Site 7				
Parameter	Unit	Date: August 9, 1996	Date: August 20, 1996	Date: July 14, 2010 Time: 11:20 am
Bacteriological				
Escherichia Coli	MPN/100mL	NA	NA	10
Total Coliforms	MPN/100mL	NA	NA	> **2420**
Physical				
Conductivity (EC)	µS/cm	NA	NA	494
Total Dissolved Solids	mg/L	NA	NA	380
Turbidity	NTU	8.3	8.7	11.0
Nutrients and Anions				
Ammonia-N, Total	mg/L	NA	NA	<0.020
Chloride (Cl)	mg/L	NA	NA	76.1
Nitrate-N (NO3-N)	mg/L	NA	NA	0.049
Nitrite-N (NO2-N)	mg/L	NA	NA	<0.020
Phosphorus (P)-Total	mg/L	0.04	0.14	0.0128
Sulphate (SO4)	mg/L	NA	NA	7.74
Metals				
Aluminum (Al)	mg/L	NA	NA	0.010
Cadmium (Cd)	mg/L	<0.001	<0.001	<0.000090
Copper (Cu)	mg/L	NA	NA	<0.0010
Iron (Fe)	mg/L	**2.710**	**1.83**	**1.20**
Lead (Pb)	mg/L	<0.005	<0.005	<0.0010

* Bold #'s indicate exceedance of PWQO guidelines

Flora Observed at Site 7	
FEC V-Type: V-14 Balsam Fir Mixedwood	
Dominant Species *	
Species	
Trees	Jack Pine White Spruce Balsam Fir
Shrubs	Willow Alder*
Ground Cover	Cow Vetch Ox-eye Daisy Wild Mint Inland Sedge Fireweed Timothy Grass Drooping Woodreep Canada Anemone Bulrush Swamp Milkweed
Aquatic Macrophytes and Algae	-

Fauna Observed at Site 7		
Species		**# Observed**
Birds	-	-
Mammals	-	-
Amphibians	-	-
Fish	Minnows	>50
Mollusca	-	-
Crustaceans	-	-
Insects	Water striders	>100
Other	-	-

Substrate Observations for Site 7		**Soil Pit Observations**	
Percentage Shaded	50%	Soil Characteristics	~80% sand with fine gravel on the surface. -Silty sand
Substrate Classification	Cobble		
Abundance of aquatic vegetation	None		

General Observations

Site 7, located off of 25th Side Road, north of Rosslyn Road was previously sampled in 1996. During the 2010 sampling this site was characterized by a large pool upstream flowing into the narrow channel of the sampling site. There was a buildup of woody debris downstream of the sampling site causing a small stick jam. There was an eroding bank upstream of the site, with large slumps and sediment composed of sandy clay which had fallen from the bank into the water. Floating orange mats which were likely iron bacteria was observed adjacent to the eroding bank. The soil observed at Site 7 was very sandy with fine gravel and some silt content; characterized as sandy loam.

The weather observed during sampling was overcast with thunder. Vegetation on the south bank consisted of a gravel beach, thick grasses and shrubs, while the vegetation of the north bank was composed of conifers on the upstream bank and shrubs on downstream bank. The substrate was mostly cobble with a layer of muck and easily disturbed sediment. Visibility at this location was low and the water was too murky to take an underwater picture of the substrate. In regard to aquatic fauna, Site 7 was in good condition, with abundant minnows and water striders present during sampling.

When comparing the 1996 and 2010 photos this site appeared to have some observable changes. The vegetation from the 1996 photo adjacent to the culvert appeared to be composed of dense shrub growth where the vegetation adjacent to the culvert in 2010 was shrub which was significantly less dense, with spruce trees which had become newly established. Erosion observed in 2010 appears to have already been present in 1996, but worsened slightly in regard to the degree of slumping. The culvert itself appears to have undergone little change.

Results and Discussion

Site 7 was in good condition exceeding only two PWQO parameters on July 14, 2010. Total coliform exceeded pre-1994 PWQO criterion (1,000 MPN/100 mL) with a concentration greater than 2,420 MPN/100 mL. Total coliforms observed at this site were comparable to concentrations from Site 3 (greater than 2,420 MPN/100 mL). Iron exceeded PWQO criterion (0.3 mg/L) with a concentration of 1.20 mg/L; a reduction from Site 3. The DO concentration showed significant increase from Site 3 with a healthy concentration of 8.04 mg/L.

Although the sampling site itself showed considerable flow a large relatively calm pool was just upstream of the channel. This may have significantly affected water quality results.

The laboratory results and field measurements from the 2010 sampling reported negligible change from 1996 observations. Turbidity values show a slight increase from 8.3 NTU and 8.7 NTU observed in 1996, to 11.0 NTU in 2010. Iron concentrations observed in 2010 (1.20 mg/L) showed a decrease from 1996 observations of 2.71 mg/L, August 9, 1996 and 1.84 mg/L on August 20, 1996. Temporal variations may account for these changes.

The vegetation reported from the 2010 inventory differed substantially from the 1996 report. The 1996 inventory of Site 7 reported a deciduous dominated forest and was classified as a V-6: Trembling Aspen (White Birch) - Balsam Fir/ Mountain Maple. The 2010 inventory of Site 7 reported predominately conifer species such as balsam fir and white spruce and the site was classified as a V-14: Balsam Fir Mixedwood.

4.8 Site 8: Downstream from Hillcourt Trailer Park

Site 8 was sampled July 17, August 2 and August 15, 1996 for the 1996 Pennock Creek Watershed Assessment Report. Chemical analysis for this site was completed on August 9 and August 20, 1996. This site was not sampled in the 2010 update assessment. All 1996 results for this site are located in Appendix E.

4.9 Site 9: Neebing River Confluence

Site 9 was sampled July 17, August 2 and August 15, 1996 for the 1996 Pennock Creek Watershed Assessment Report. Chemical analysis was not completed at this site. This site was not included in the 2010 update assessment. All 1996 results for this site are located in Appendix E.

4.10 Site 10: Pole Line Road, Downstream

Location Reference for Site 10	
Location Description	Located adjacent to private property with mowed lawn. Access from Pole Line Road.
UTM Coordinates	Northing 5363660/ Easting 314400
Altitude/Elevation	261.218 metres above sea level

Field Measurements for Site 10		
		Date: July 13, 2010
Parameter	Unit	Time: 12:30 pm to 1:15 pm
Water Temperature	ºC	17.16
Conductivity	µS/cm	597
Dissolved Oxygen	mg/L	5.08
Dissolved Oxygen	%	53.1
pH		7.18
Air Temperature	ºC	25
Channel Width	m	2.4
Channel Depth	m	0.26
Velocity	m/s	0.0156

Laboratory Water Quality Results for Site 10		
		Date: July 13, 2010
Parameter	Unit	Time: 12:30 pm
Bacteriological		
Escherichia Coli	MPN/100mL	14
Total Coliforms	MPN/100mL	**> 2420**
Physical		
Conductivity (EC)	µS/cm	550
Total Dissolved Solids	mg/L	424
Turbidity	NTU	6.33
Nutrients		
Ammonia-N, Total	mg/L	0.063
Chloride (Cl)	mg/L	59.6
Nitrate-N (NO3-N)	mg/L	<0.030
Nitrite-N (NO2-N)	mg/L	<0.020
Phosphorus (P)-Total	mg/L	**0.0385**
Sulphate (SO4)	mg/L	1.15
Metals		
Aluminum (Al)	mg/L	<0.010
Cadmium (Cd)	mg/L	<0.000090
Copper (Cu)	mg/L	<0.0010
Iron (Fe)	mg/L	**2.06**
Lead (Pb)	mg/L	<0.0010

* Bold #'s indicate exceedance of PWQO guidelines

Flora Observed at Site 10	
FEC V-Type: V-2 Black Ash Hardwood and Mixedwood **Dominant Species ***	
Species	
Trees	Black Ash Saskatoon
Shrubs	Mountain Maple Speckled Alder * Balsam Willow*
Ground Cover	Purple Stemmed Aster Northern Sweet Coltsfoot Wild Mint Sensitive Fern Ox-eye Daisy Dandelion Marsh Timothy Yellow Hawkweed Wild Raspberry Marsh Marigold Pickerel Weed Fireweed Horsetail* Goldenrod Cow Vetch Early Meadow-Rue
Aquatic Macrophytes and Algae	Submerged Water Starwort

Fauna Observed at Site 10		
Species		**# Observed**
Birds	Warblers	3
	Crows	Unknown, identified through call
Mammals	Chipmunk	1
Amphibians	-	-
Fish	Stickleback	
	Minnows	>10
Mollusca	-	-
Crustaceans	-	-
Insects	Water striders	>100
Other	-	-

Substrate Observations for Site 10		Soil Pit Observations	
Percentage Shaded	75-100%	Soil Characteristics	-Some gravel, predominately Silt, with Sand and clay in relatively even distribution. -Silty Loam
Substrate Classification	Cobble; silt covered.		
Abundance of aquatic vegetation	Submergent Starwort spp. was abundant.		

General Observations

Site 10, located off of Pole Line Road, due west of Wing Road was not previously sampled in 1996. This site was chosen for the 2010 study based upon accessibility and its location within a highly rural and agricultural area. The site was easily accessed from the road, via a culvert upstream. Private property was directly adjacent to the sampling site with a manicured lawn up to the water's edge and no buffer zone present. This may affect stability of the stream edge and should be a point of interest for future sampling. Just upstream of the sampling location, Pole Line Road runs perpendicular to the flow of water. The road showed considerable traffic during the time of sampling.

Weather observed at the time of sampling was sunny with scattered clouds. Site 10 had abundant woody debris upstream and downstream with some construction waste directly adjacent to the sampling site. The channel was relatively wide and shallow with a slow velocity and murky water. The sampling area was highly shaded by thick shrub growth largely composed of willow, alder and black ash as the overstory and ferns abundant in the understory. The substrate was predominately cobble with a thin layer of muck, silt and clay on the surface of the cobble. The soil observed at this site had high silt content with a relatively uniform distribution of sand and clay and could be generally characterized as silty loam. The soil pit was dug just adjacent to a manicured lawn and so it is possible that the shallow soil profile does not represent natural conditions.

The 1996 photos show that some observable changes directly downstream of the Pole Line Road culvert have occurred (Appendix H). Vegetation from 1996 to 2010 appears to have changed very little regarding composition with shrubs still the dominant land cover. Significant growth is apparent with the thicker vegetation completely shading the creek just downstream of the culvert. The soil around the culvert appears to have eroded from 1996 to 2010, with the culvert significantly more exposed in the 2010 photo.

Results and Discussion

Results indicated that Site 10 was in relatively good condition at the time of sampling, exceeding three PWQO parameters on July 13, 2010. Total coliforms exceeded pre-1994 PWQO (1,000 MPN/100 mL) with a concentration greater than 2,420 MPN/100 mL. Similarly, iron exceeded PWQO criterion (0.3 mg/L) with a concentration of 2.06 mg/L; an increase from Site 1. Phosphorus levels were above the PWQO (0.03 mg/L), with a concentration of 0.0385 mg/L. Although only slightly above PWQO guidelines the increase in phosphorus is such that a local source is likely. The area surrounding the site was predominately rural and agriculture with fertilizers and organic matter runoff potentially leading to increases of phosphorus and total coliforms.

DO concentrations were just above PWQO criterion (minimum of 5 mg/L) with a concentration of 5.08 mg/L. The DO concentration was low considering the shallow depth of the stream.

4.11 Site 11: 20th Side Road, Downstream

Location Reference for Site 11	
Location Description	Located off of 20th Side Road with a relatively short walk required to reach site.
UTM Coordinates	Northing 5359983/ Easting 325190
Altitude/Elevation	197.508 metres above sea level

Field Measurements for Site 11		
		Date: July 19, 2010
Parameter	Unit	Time: 11:15 am to 12:15 pm
Water Temperature	ºC	20.39
Conductivity	µS/cm	552
Dissolved Oxygen	mg/L	7.83
Dissolved Oxygen	%	86.8
pH		7.64
Air Temperature	ºC	24
Channel Width	m	1.6
Channel Depth	m	0.12
Velocity	m/s	0.06

Laboratory Water Quality Results for Site 11		
		Date: July 19, 2010
Parameter	Unit	Time: 11:15 am
Bacteriological		
Escherichia Coli	MPN/100mL	63
Total Coliforms	MPN/100mL	**1600**
Physical		
Conductivity (EC)	µS/cm	549
Total Dissolved Solids	mg/L	425
Turbidity	NTU	16.3
Nutrients		
Ammonia-N, Total	mg/L	<0.020
Chloride (Cl)	mg/L	77.3
Nitrate-N (NO3-N)	mg/L	0.124
Nitrite-N (NO2-N)	mg/L	<0.020
Phosphorus (P)-Total	mg/L	0.0169
Sulphate (SO4)	mg/L	8.25
Metals		
Aluminum (Al)	mg/L	**0.175**
Cadmium (Cd)	mg/L	<0.000090
Copper (Cu)	mg/L	0.0022
Iron (Fe)	mg/L	**1.52**
Lead (Pb)	mg/L	<0.0010

* Bold #'s indicate exceedance of PWQO guidelines

Flora Observed at Site 11	
FEC V-Type: V-14 Balsam Fir Mixedwood	
Dominant Species *	
Species	
Trees	White Birch Balsam Poplar White Spruce Balsam Fir
Shrubs	Red Osier Dogwood Speckled Alder* Willow spp. Mountain Ash Wild Red Raspberry Pin Cherry
Ground Cover	Cow Vetch Canada Goldenrod Red Clover Dark Green Bulrush Blue Joint Grass Inland Sedge Wire Grass Redtop Grass* ~50% Swamp Milkweed Yellow Sweet Clover
Aquatic Macrophytes and Algae	Algae Broad-leaved Arrowhead Wild Calla Floating Leaved Burreed Horsetail*

Fauna Observed at Site 11		
Species		**# Observed**
Birds	Chickadee	Call identified
Mammals	Deer	Tracks
Amphibians	Spring Peeper	Call identified
Fish	Minnows	>20
Mollusca	-	-
Crustaceans	-	-
Insects	Damselflies	>20
	Water striders	>50
	Moth	2

Substrate Observations for Site 11		Soil Pit Observations Site 11	
Percentage Shaded	0-10%	Soil Characteristics	The soil profile was defined with a distinct organic layer on the surface and sandy clay layer above an almost pure layer of silt. The silt was dominant after only 6 centimetres.
Substrate Classification	Varied with muck and sandy clay upstream and cobble and gravel downstream.		
Abundance of aquatic vegetation	Abundant submergent and emergent plants. Much of the substrate was completely covered in sampling location.		

General Observations

Site 11, located off of 20th Side Road was not previously sampled in 1996 and this site was chosen for the 2010 study based upon accessibility and proximity to the Pennock Creek Neebing River confluence.

This site was characterized by a large culvert and highly eroded bank, upstream of the sampling site. This eroding bank on the north side of the channel had potentially caused the formation of a vegetated sediment bar directly adjacent. Sampling was completed directly downstream of the erosion and may have affected physical parameters (i.e. conductivity and turbidity). There was abundant woody debris both up and downstream of the site, with abundant concrete and asphalt throughout the substrate. The substrate was predominately cobble with large pockets of muck and clay upstream. Soil was observed to be comprised of a thin organic layer on the surface followed by a slightly thicker clay layer and then a silt layer. The silt content was very high only a few centimetres down.

Results and Discussion

Results indicated that Site 11 was in good condition, exceeding three PWQO parameters on July 19, 2010. Total coliforms exceeded pre-1994 PWQO (1,000 MPN/100 mL) with a concentration of 1,600 MPN/100 mL, which was the lowest total coliform concentration observed from the 2010 sampling period. Iron exceeded PWQO criterion (0.3 mg/L) with a concentration of 1.52 mg/L. This was consistent with the trend of high iron throughout the watershed. Aluminum also exceeded PWQO criterion (0.075 mg/L) with a concentration of 0.175 mg/L.

The turbidity of Site 11 was the highest of any site sampled in 2010, coinciding with the trend of consecutively higher values of turbidity moving downstream. There was also a bank eroding into the channel directly upstream of the site. The erosion of the north bank may have had a considerable effect upon sediment loading and in turn the subsequent turbidity of the site.

When compared to the culvert photo taken in 1996 there appears to be no significant changes with the exception of channel debris (Appendix H). Some buildup of woody

debris was evident in 1996 on the upstream side of the culvert (Appendix H, Plate F). The 2010 upstream photo (Appendix H, Plate F) showed that debris was considerable and well established with plants beginning to grow upon the mounds of woody debris. The culvert itself appears to be relatively unchanged when compared to 1996.

4.12 Overall Site Summary

Table 4.0: Summary of 2010 Field Measurements

Parameter	Unit	Site 1	Site 10	Site 2	Site 3	Site 7	Site 11
		Date Collected					
		July 13, 2010	July 13, 2010	July 13, 2010	July 14, 2010	July 14, 2010	July 19, 2010
		Time					
		10:20 am	12:30 pm	2:00 pm	9:45 am	11:20 am	11:15 am
Water Temperature	ºC	16.32	17.16	19.2	17.5	20.19	20.39
Conductivity	µS/cm	316	597	548	541	530	552
Dissolved Oxygen	mg/L	**0.68**	5.08	6.64	**1.60**	8.04	7.83
Dissolved Oxygen	%	7.1	53.1	74	17.4	89.1	86.8
pH		6.98	7.18	7.57	7.31	7.75	7.64
Air Temperature	ºC	24	25	27	23	21	24
Channel Width	m	0.7	2.4	2.6	5.5	2.8	1.6
Channel Depth	m	0.6	0.26	0.52	0.48	0.35	0.12
Flow Rate	m^3/s	N/A	0.0973	N/A	N/A	0.200	0.012
Velocity	m/s	No flow	0.0156	No flow	No flow	0.151	0.06

* Bold #'s indicate exceedance of PWQO guidelines

Table 5.0: Summary of Averages for 1996 and 2010 Field Measurements

Parameter	Unit	Averages from all **1996** Laboratory Results	Averages from all **2010** Laboratory Results
Bacteriological			
Escherichia Coli	MPN/100mL	NA	29
Total Coliforms	MPN/100mL	NA	**2093**
Physical			
Conductivity (EC)	µS/cm	NA	487
Total Dissolved Solids	mg/L	NA	381
Turbidity	NTU	6.66	8.29

Nutrients			
Ammonia-N, Total	mg/L	NA	0.038
Chloride (Cl)	mg/L	NA	56.6
Nitrate-N (NO3-N)	mg/L	NA	0.049
Nitrite-N (NO2-N)	mg/L	NA	<0.020
Phosphorus (P)-Total	mg/L	0.137	0.0251
Sulphate (SO4)	mg/L	NA	3.04
Metals			
Aluminum (Al)	mg/L	NA	0.041
Cadmium (Cd)	mg/L	<0.001	<0.000090
Copper (Cu)	mg/L	NA	0.0013
Iron (Fe)	mg/L	**2.1396**	**1.60**
Lead (Pb)	mg/L	0.0058	<0.0010

* Bold #'s indicate exceedance of PWQO guidelines

Table 6.0: Summary of 2010 Laboratory Results

Parameter	Unit	Site 1	Site 10	Site 2	Site 3	Site 7	Site 11
		Date Collected					
		July 13, 2010	July 13, 2010	July 13, 2010	July 14, 2010	July 14, 2010	July 19, 2010
		Time					
		10:20 am	12:30 pm	2:00 pm	9:45 am	11:20 am	11:15 am
Bacteriological							
Escherichia Coli	MPN/100 mL	5	14	59	25	10	63
Total Coliforms	MPN/100 mL	**2000**	**> 2420**	**1700**	**>2420**	**> 2420**	**1600**
Physical							
Conductivity (EC)	µS/cm	303	550	511	513	494	549
Total Dissolved Solids	mg/L	261	424	400	395	380	425
Turbidity	NTU	1.92	6.33	5.24	8.93	11.0	16.3
Nutrients and Anions							
Ammonia-N, Total	mg/L	<0.020	0.063	<0.020	0.085	<0.020	<0.020
Chloride (Cl)	mg/L	18.9	59.6	52.1	55.5	76.1	77.3
Nitrate-N (NO3-N)	mg/L	<0.030	<0.030	<0.030	<0.030	0.049	0.124
Nitrite-N (NO2-N)	mg/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Phosphorus (P)-Total	mg/L	0.0245	**0.0385**	**0.0320**	0.0261	0.0128	0.0169

Sulphate (SO4)	mg/L	<0.30	1.15	0.49	0.31	7.74	8.25
Metals							
Aluminum (Al)	mg/L	0.011	<0.010	0.030	<0.010	0.010	**0.175**
Cadmium (Cd)	mg/L	<0.00009	<0.00009	<0.00009	<0.00009	<0.00009	<0.00009
Copper (Cu)	mg/L	<0.0010	<0.0010	0.0013	<0.0010	<0.0010	0.0022
Iron (Fe)	mg/L	**1.45**	**2.06**	**1.26**	**2.13**	**1.20**	**1.52**
Lead (Pb)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010

* Bold #'s indicate exceedance of PWQO guidelines

Table 7.0: Summary of Averages of 1997 and 2010 Laboratory Results

Parameter	Unit	Averages for all 1996 Data Sampled July 17, August 2 and August 15, 1996	Averages for all 2010 Data Sampled once: Between July 13 and July 19, 2010
Water Temperature	ºC	17.24	19.8
Conductivity	µS/cm	386	550
Dissolved Oxygen	mg/L	6.97	7.24
Dissolved Oxygen	%	NA	80.4
pH		7.28	7.61
Air Temperature	ºC	23.63	25
Channel Width	m	NA	2.1
Channel Depth	m	0.38	0.32
Velocity	m/s	NA	0.015

5 Overall Discussion

Results from the 2010 Pennock Creek Watershed sampling indicated that all sampling locations were in good condition at the time of sampling. The 2010 laboratory results reported three parameters, aluminum, iron and phosphorus, which exceeded PWQO criteria. Observable changes in water quality from 1996 to 2010 were reported only in regard to point sources and site specific locations. Change not associated with temporal variation was likely caused by an obstruction of flow and the subsequent formation of a stagnant water body.

5.1 Climate

Meteorological data located in Table 1.0, Table 2.0 and Table 3.0 indicates that the 2010 sampling period had higher than average air temperatures and lower than average total precipitation. The LRCA Area of Jurisdiction and Thunder Bay District were in a declared Level I Low Water Condition (i.e. received precipitation less than 80% of average) for the months of April, July, August, September, October and November and were in a declared Level II Low Water Condition (i.e. received precipitation between 40-60% of average) for the months of May and June. Precipitation is an important consideration for many reasons including its effect upon mixing. Lower levels of precipitation can affect water quality results by reducing the mixing of layers within the water column.

5.2 Hydrology

Elevation plays an important role in direction of water drainage and stream velocity. Site 1 was the highest point in elevation sampled for the 2010 sampling period at 288.02 metres above sea level. The lowest point in elevation sampled for the 2010 sampling period was Site 11, at 197.51 metres above sea level. Between Sites 1 and 11 the elevation changed by 90.5 metres, with a slope of 0.78 percent for the watershed.

Flow velocity was highly variable within the watershed ranging from 0.151 cubic metres per second at Site 7, to no flow at Sites 1, 3 and 11. The average flow velocity of all sites in 2010 was 0.015 cubic metres per second. The channel depth observed in 2010 ranged from 0.12 metres to 0.6 metres with an average of 0.32 metres. 1996 depth observations were similar ranging from 0.13 metres to 0.68 metres with average depth 0.38 metres. Depth measurements are highly subjective, depending upon the exact location of the reading and the condition of the substrate. The channel width of the sampling sites was highly variable ranging from 0.7 metres to 5.5 metres, for an average width of 2.6 metres. Width and velocity were not recorded during 1996 sampling.

5.3 Dissolved Oxygen

DO concentrations reported from the 2010 sampling period were highly variable throughout the watershed. There appeared to be a strong relationship between stagnation and low DO concentrations. Both Sites 1 and 3 were the only sites with DO concentrations which did not meet PWQO. The flow reported from Sites 1 and 3 was stagnant. Lotic (moving water) systems typically have higher DO concentrations then lentic (still/stagnant water) systems (Wetzel, 2001) and low flow may have caused the low DO concentrations. Both Sites 1 and 3 were also observed to have muck substrate with an organic layer thicker relative to other sampling sites. A thick organic layer and

the subsequent increase in decomposition would naturally have an inverse relationship with DO concentrations.

As shown in the overall averages of the 2010 and 1996 field measurements, DO concentrations were relatively similar. In 1996 average DO was 6.97 mg/L for all sites and sampling periods, while 2010 reported an average DO of 7.24 mg/L for all sites. Sites 1 and 3 did not meet PWQO criterion (must be greater than 5 mg/L) for both 2010 and 1996. The DO concentrations observed for the 2010 and 1996 sampling periods was considered healthy overall with only site specific exceedances and slight variation apparent through time.

5.4 pH

The pH values observed for both the 1996 and 2010 studies were within a similar range. In 1996, pH ranged from 6.97 to 7.63, while the 2010 data showed a range in pH from 6.98 to 7.75. All sites for both the 1996 and 2010 sampling periods were within the PWQO criterion for pH (6.5-8.5). The consistency of acceptable values shown both temporally and spatially is a good indicator of buffering capacity and the watersheds quality regarding pH levels.

Laboratory results indicated relatively low concentrations of most metals (below PWQO) for all sampling locations. Iron and aluminum were the only metals to exceed PWQO criteria at the time of sampling and both elements commonly occur in nature and are unlikely to pose a threat to water quality or aquatic life.

5.5 Bacteriological

Laboratory results reported low *E. coli* concentrations, below PWQO (100 MPN/100 mL) at all sampling locations. Total coliforms exceeded pre-1994 PWQO criterion (1,000 MPN/100 mL) at all sites with an average of 2,093 MPN/100 mL for the watershed.

High total coliform concentrations can be from a variety of sources both natural and anthropogenic in origin. The natural niches for members of coliform bacteria range from being fecal specific, such as *E. coli*, to being widely distributed in the water, soil, and vegetation (Leclerc *et al.*, 2001; Rompré *et al.*, 2002). If densities of warm blooded wildlife are high, natural sources of fecal coliforms can often be concentrated in wetlands and along the shorelines of lakes and rivers. Other sources such as human or livestock waste are also common and can cause concentrated amounts to occur through runoff or poor waste water management techniques.

5.6 Metals

Results indicated high iron concentrations at all sampling locations, and every site exceeded PWQO criterion (0.3 mg/L) in both 1996 and 2010 assessments. There

appeared to be an overall decrease from the 1996 values, with some site specific increases in 2010. The range of concentrations reported throughout the watershed from 1996 and 2010 were comparable. Results from 1996 reported iron concentrations which ranged from 0.308 mg/L to 4.94 mg/L with an overall average of 2.14 mg/L. In 2010, iron concentrations ranged from 1.45 mg/L to 2.13 mg/L with an average of 1.60 mg/L. The highest iron concentration reported during 2010 sampling was from Site 3 on July 14, 2010 with a concentration of 2.13 mg/L. Although iron concentrations from Site 3 were higher than the PWQO guidelines, wildlife did not appear to be affected and this location was reported to have more signs of wildlife than any other sampling location. In the 1996 assessment the highest iron concentration was observed at Site 5 on August 20, 1996 exceeding PWQO criterion (0.3 mg/L) with a concentration of 4.94 mg/L.

High iron levels in water may lead to the production of iron bacteria which are un-aesthetically appealing and may cause build up in water lines and pipes. Iron deposits in a creek may be the result of industrial waste or local geology. Although there are industrial and agricultural activities in the area, consistently high iron concentrations and iron rich soils found at every site suggest the iron concentrations are of geologic origin. Furthermore, iron formation is present with the sedimentary rock of the region.

The only other metal to exceed PWQO was aluminum. Site 11 exceeded PWQO (0.075 mg/L) with a concentration of 0.175 mg/L reported on July 19, 2010. The singular occurrence of the aluminum exceedance is likely in response to a point source at or just upstream of the sampling site. Aluminum is the most abundant metal found in nature and its presence may be natural or caused by local land use. Aluminum was not tested for in 1996; therefore no comparison can be made.

Laboratory results from 1996 and 2010 sampling indicated low concentrations of lead and cadmium from both sampling periods. Lead was below PWQO criterion (0.01 mg/L) with concentrations less than 0.001 mg/L reported from all 2010 sampling locations. The 1996 study reported only one exceedance of PWQO criterion for lead, with a concentration of 0.013 mg/L reported from Site 3. Cadmium did not exceed the PWQO criterion (0.001 mg/L) from any of the 1996 or 2010 sampling locations.

5.7 Nutrients

Laboratory results from 2010 indicated that nutrients did not consistently exceed PWQO criteria. Phosphorus was the only nutrient to exceed PWQO criterion (0.03 mg/L) at both Site 10 (0.0385 mg/L) and Site 2 (0.032 mg/L) which were sampled on July 13, 2010. Site 10 was located in a rural area and the phosphorus concentrations which were reported may be in response to any number of agricultural practices such as fertilizer application, cattle farming and pesticides. Higher than average phosphorus concentrations may also be caused by large quantities of decaying material. Increased algal growth indicative of nutrient loading was not present, suggesting that sites with higher than average phosphorus were unlikely affected. The Site 2 exceedance may have been in

response to the upstream influence of Site 10, but may also have been from decaying material upstream. Phosphorus concentrations observed in 1996 indicated exceedance of PWQO criterion (0.03 mg/L) at all sites, with an average concentration of 0.056 mg/L on August 9, 1996, and an average of 0.218 mg/L on August 20, 1996. Phosphorus levels observed in 2010 have decreased since sampling that was conducted in 1996.

Ammonia was below PWQO at all sampling locations, with two higher than average values at Site 3 with an ammonia concentration of 0.085 mg/L and at Site 10 with a concentration 0.063 mg/L. These reported concentrations were likely in response to point sources, as no other site went above an ammonia concentration of <0.02 mg/L.

5.8 Conductivity and Turbidity

Several parameters which currently lack PWQO criteria (i.e. turbidity and conductivity) reported trends throughout the watershed. Turbidity was observed increasing from the headwaters to the confluence. This relationship can be generally characterized with the turbidity of 1.92 NTU reported from Site 1 (headwaters) on July 13 2010, and the turbidity of 16.3 NTU reported from Site 11(confluence) on July 19, 2010. The average turbidity for all samples was 8.29 NTU for the 2010 sampling period. Site 11 was undergoing erosion and this may be a leading cause to the higher level of turbidity; however sampling was not completed all on the same day and this relationship may be in response to temporal and not spatial variation. Turbidity levels found during the 1996 Pennock Creek study ranged between 1.2 NTU and 9.7 NTU, with a general trend similar to the 2010 report; increasing from headwaters to confluence. The increase in turbidity from 1996 observations to the 2010 observations may be in response to an increase in suspended sediment within the water column; however it is noted that in general turbidity levels were considered low.

Laboratory results of total dissolved solids from 2010 ranged from 261 mg/L to 425 mg/L. Laboratory results of conductivity ranged from 303 microsiemens/centimetre (μS/cm) to 550 μS/cm. Conductivity levels recorded in the field ranged from 316 μS/cm and 596 μS/cm. For all measurements of conductivity and total dissolved solids, Sites 10 and 11 reported the highest conductivity, where Site 1 reported the lowest conductivity.

6 Conclusion

To conclude, water quality analysis completed for the 2010 Pennock Creek Watershed Assessment indicated that the Pennock Creek Watershed was in good condition, with minimal exceedances of PWQO at the time of sampling. The 2010 laboratory results reported three parameters, aluminum, iron and phosphorus, which exceeded PWQO criteria. It was likely that the exceedingly high aluminum, phosphorus, iron and total coliform concentrations were the result of natural occurring processes within the watershed.

Furthermore, comparison of 1996 and 2010 water quality results from Pennock Creek indicated that that there had been negligible change between the two study periods. Average values showed close correlation and only some site specific changes were observed. Any changes to physical parameters reported for most sites from 1996 to 2010 (i.e. conductivity, water temperature and depth) were likely caused by natural variation.

The 1996 and 2010 sampling periods reported DO concentrations from Sites 1 and 3 which were below PWQO (minimum of 5 mg/L). Flow was not recorded in 1996, but observation in 2010 showed that both of these locations were stagnant with highly organic substrates. Site 1 did not appear to be disturbed in anyway suggesting that this location may naturally have low DO concentrations. Site 3 was reported to have blocked culverts which had caused the stagnant conditions. Removal of the blockage at Site 3 may improve the water quality (DO) of this location.

7 Recommendations

Upon completion of the 2010 Pennock Creek Watershed Assessment, the following recommendations are made for consideration:

- Observations from Site 3 indicated that water quality (dissolved oxygen) may be affected by the blockage of two culverts directly upstream. It is recommended that the potential removal of this blockage be investigated.
- Staff and funding permitting it is recommended that an update to the 2010 Pennock Watershed Assessment be completed in the next five to ten years to ensure that the health of the watershed is maintained.
- Future sampling should consider the reanalysis of Site 3.
- To minimize variability in the occurrence of point source contamination, future sampling should consider two sampling periods, in which both physical and chemical analysis is completed.
- Benthic analysis indicates water quality over an extended period of time and it should be considered for future watershed assessments.
- Future documentation of biological attributes should consider the use of transects to quantify site vegetation.

8 References

CEQE. Canadian Environmental Quality Guidelines. 1999. Canadian Water Quality Guidelines for the Protection of Aquatics Life: Dissolved Oxygen (Fresh Water). Canadian Council of Ministers of the Environment.

Dillon Consulting Engineers and Planners.1975. Rosslyn Village Drainage Study, Prepared for the Lakehead Region Conservation Authority. M. M. Dillon Limited

Dillon Consulting Engineers and Planners. 1982. Pennock Creek Floodplain and Fill Line Mapping Study, Prepared for the Lakehead Region Conservation Authority. M. M. Dillon Limited

Hartviksen. C., W. Momot. 1987. Fishes of the Thunder Bay Area of Ontario. A Guide for Identifying and Locating the Local Fish Fauna. Wildwood Publications, R.R. 13, Box 65, Thunder Bay Ontario. P7B 5E4.

LRCA. 1985. Cedar Falls Conservation Area Master Plan. Lakehead Region Conservation Authority, Thunder Bay Ontario, Canada

LRCA. 1996. Pennock Creek Watershed Study. Lakehead Region Conservation Authority, Thunder Bay Ontario, Canada

LRCA. 2008. Watershed Characterization Report. Lakehead Region Conservation Authority, Thunder Bay Ontario, Canada

MNR. 2010. Ontario's Forest Regions. Retrieved September 2, 2010 from http://www.mnr.gov.on.ca/en/Business/Forests/2ColumnSubPage/STEL02_163390.html. Ministry of Natural Resources.

TBFN. 2010. Thunder Bay Field Naturalists Birding Page. Retrieved September 2, 2010 from http://www.tbfn.net/birding.htm

MAPS

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

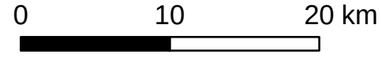
Pennock Creek Watershed

M-1: Key Plan

TOWNSHIP OF DORION
MUNICIPALITY OF SHUNIAH
TOWNSHIP OF CONMEE
CITY OF THUNDER BAY
MUNICIPALITY OF OLIVER PAIPOONGE
TOWNSHIP OF O'CONNOR
TOWNSHIP OF GILLIES
MUNICIPALITY OF NEEBING
Caribou Is.
Brodeur Is.
Grey Is.
Shaganash Is.
Edward Is.
Porphyry Is.
Pie Is.
Flatland Is.
Thompson Is.
Spar Is.
Victoria Is.
Isle Royale
Lake Superior
Minnesota

Legend

- Pennock Creek Watershed
- Municipal Boundary
- LRCA Jurisdiction Boundary
- Water Body



This publication was produced by:
Lakehead Region Conservation Authority
130 Conservation Rd.
Thunder Bay, ON
P7B 6T8

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

Datum: NAD 83
Projection: UTM Zone 16N
Date: August, 2010

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

Pennock Creek Watershed

M-2: Site Plan

N

Legend

- Sampling Site 1996
- Sampling Site 1996 & 2010
- New Sampling Site 2010
- Pennock Creek Watershed
- Railway

Roads

- Highway
- Road

Permanent Watercourse

- River
- Creek
- Stream

Drainage

- Waterbody
- Wetland
- Provincially Significant Wetland

0 1 2 km

This publication was produced by:
Lakehead Region Conservation Authority
130 Conservation Rd.
Thunder Bay, ON
P7B 6T8

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

Datum: NAD 83
Projection: UTM Zone 16N
Date: August, 2010

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

Pennock Creek Watershed

M-3: Topography

N

Legend

- Pennock Creek Watershed
- Township Boundary

Roads

- Highway
- Road

Contour Lines

- 50m Contour Intervals
- 10m Contour Intervals

Permanent Watercourse

- River
- Creek
- Stream

Drainage

- Waterbody
- Wetland

0 1 2 km

This publication was produced by:
Lakehead Region Conservation Authority
130 Conservation Rd.
Thunder Bay, ON
P7B 6T8

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

Datum: NAD 83
Projection: UTM Zone 16N
Date: August, 2010

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

Pennock Creek Watershed

M-4: Bedrock Geology

N

Legend

- Pennock Creek Watershed

Surficial Points Features

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

Roads

- Highway
- Road

Permanent Watercourse

- River
- Creek
- Stream

Drainage

- Waterbody
- Wetland

Bedrock Formation

PALEOPROTEROZOIC

- 22a, Sedimentary rocks

MESOPROTEROZOIC

- 5, Mafic to intermediate metavolcanic rocks

NEO-TO MESOARCHEAN Intrusive Rocks

- 15, Massive granodiorite to granite

0 1 2 km

This publication was produced by:
Lakehead Region Conservation Authority
130 Conservation Rd.
Thunder Bay, ON
P7B 6T8

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

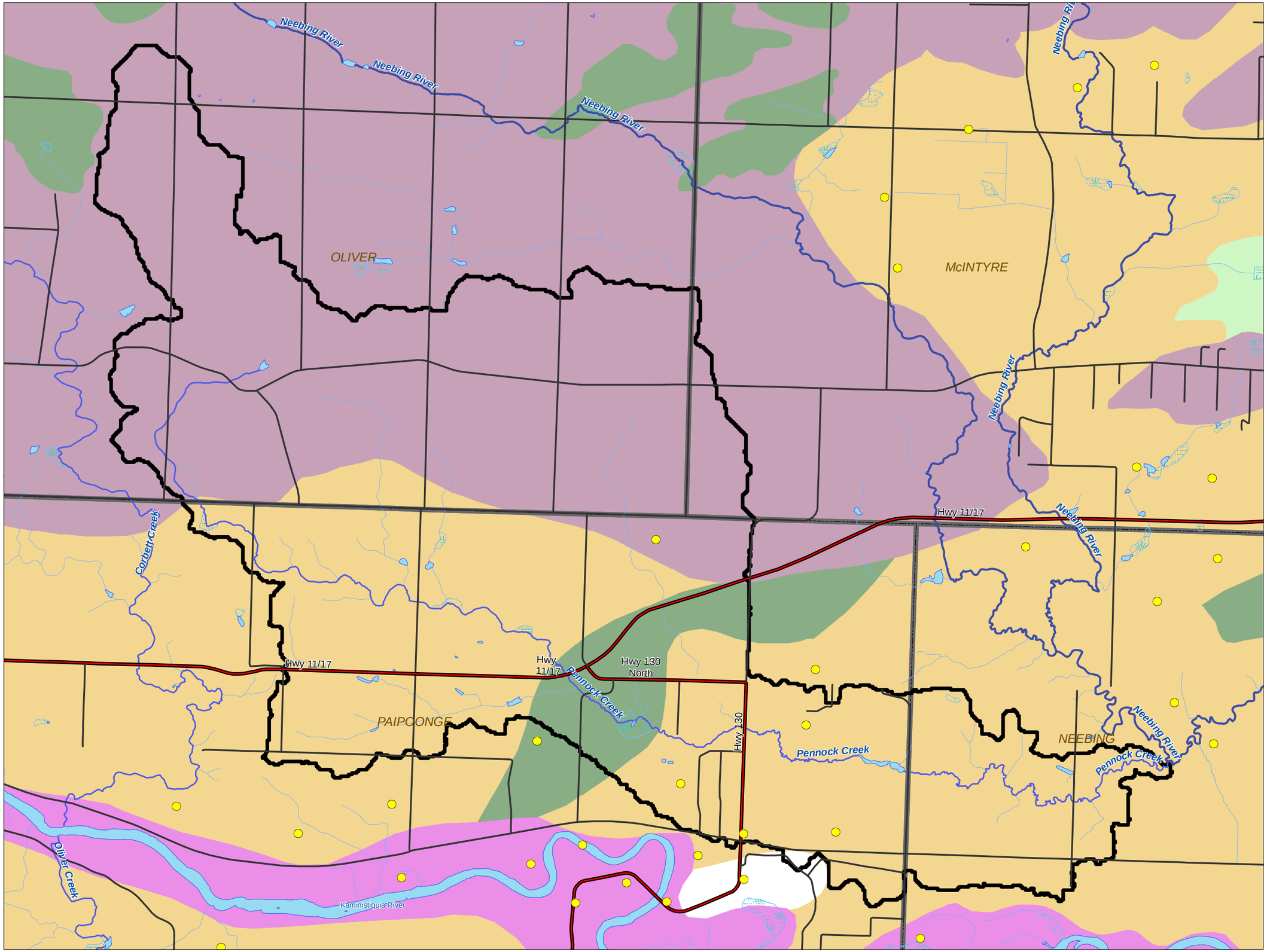
Datum: NAD 83
Projection: UTM Zone 16N
Date: August, 2010

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

Pennock Creek Watershed

M-5: Surficial Geology

N



Legend

- Pennock Creek Watershed
- Township Boundary

Surficial Points Features

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

Roads

- Highway
- Road

Permanent Watercourse

- River
- Creek
- Stream

Drainage

- Waterbody
- Wetland

Surficial Geology

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

0 1 2 km

This publication was produced by:
Lakehead Region Conservation Authority
130 Conservation Rd.
Thunder Bay, ON
P7B 6T8

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

Datum: NAD 83
Projection: UTM Zone 16N
Date: August, 2010

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

Pennock Creek Watershed

M-6: Soils

N

Legend

- Pennock Creek Watershed
- Township Boundary

Roads

- Highway
- Road

Permanent Watercourse

- River
- Creek
- Stream

Drainage

- Waterbody
- Wetland

Thunder Bay Soils

- CURRENT RIVER (C)
- DORION (D)
- FORT WILLIAM (FW)
- JARVIS RIVER (J)
- LAPPE (L)
- MUCK (M)
- NEEBING (Ne)
- NOLALU (N)
- ORGANICS - JUMBON (Jo)
- ORGANICS - MURILLO (Mo)
- ORGANICS - PASSER (Ps)
- ORGANICS - PENASSEN (Pn)
- ORGANICS - WOLF RIVER (Wf)
- OSKONDOGA (O)
- PAIPOONGE (Pa)
- SLATE RIVER (SR)
- WOLFPUP (W)

0 1 2 km

This publication was produced by:
Lakehead Region Conservation Authority
130 Conservation Rd.
Thunder Bay, ON
P7B 6T8

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

Datum: NAD 83
Projection: UTM Zone 16N
Date: August, 2010

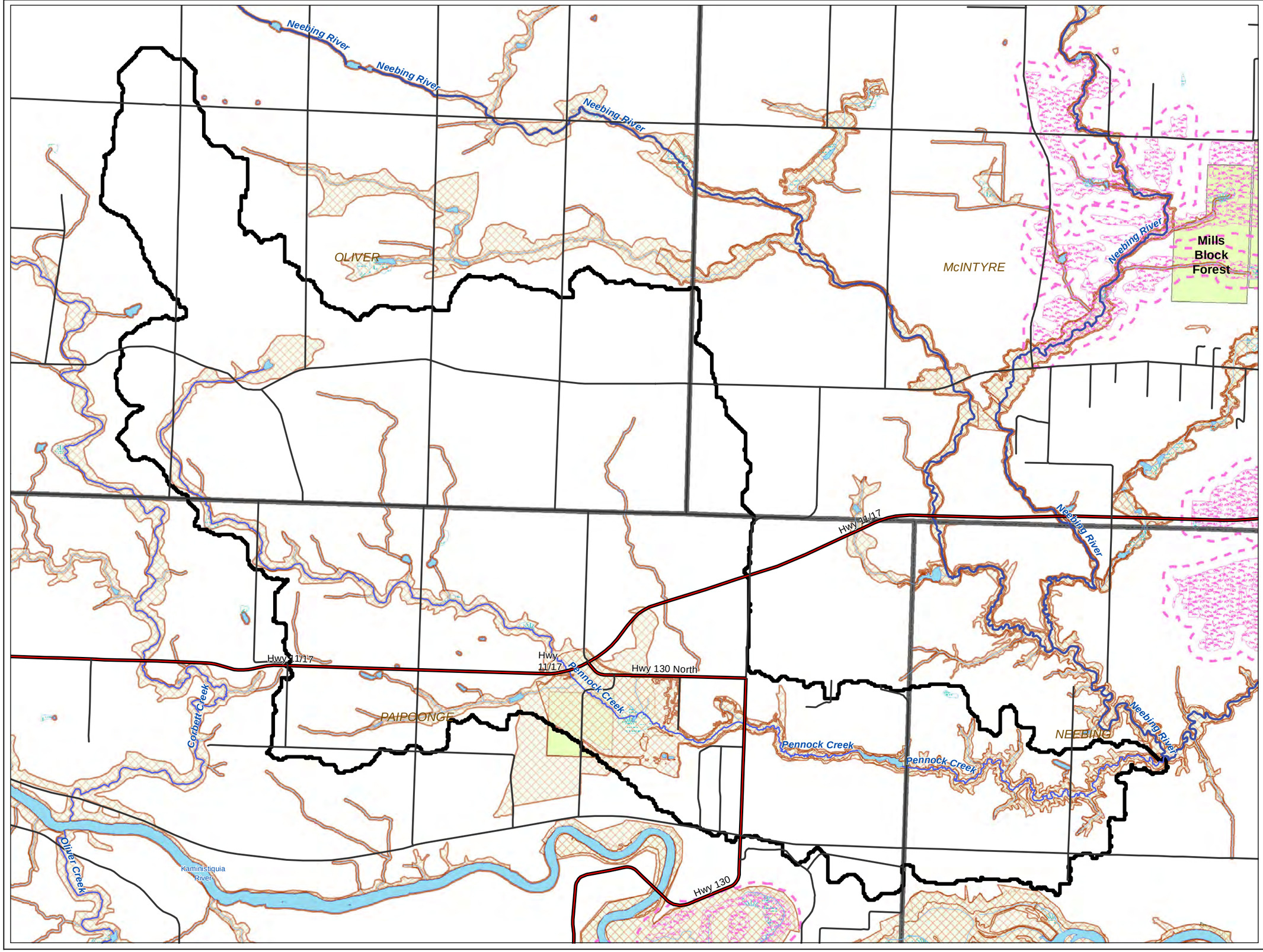
Neebing River
Corbett Creek
Oliver Creek
Kaministiquia River
Pennock Creek
Hwy 11/17
Hwy 130 North
Hwy 130
OLIVER
PAIPOONGE
McINTYRE
NEEBING

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

Pennock Creek Watershed

M-7: Approximate Regulated Areas

N



Legend

- Pennock Creek Watershed
- Township Boundary

Roads

- Highway
- Road

Permanent Watercourse

- River
- Creek
- Stream

Drainage

- Waterbody
- Wetland
- Approximate Regulated Area
- Provincially Significant Wetland (PSW) (Regulated)
- PSW 120 Metre Regulated Area
- LRCA Owned Property

0 1 2 km

This publication was produced by:
Lakehead Region Conservation Authority
130 Conservation Rd.
Thunder Bay, ON
P7B 6T8

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

Datum: NAD 83
Projection: UTM Zone 16N
Date: August, 2010

APPENDIX A:

TECHNIQUES FOR DATA COLLECTION

Appendix A: Techniques for Data Collection

Location
The sample sites were chosen using a 1:50,000 scale topographic map. The sample sites were also described in terms of road access and road crossings.

Latitude, Longitude, and Elevation
The Universal Transverse Mercator (UTM) coordinates for each site were measured with a Trimble Geo XH 2005 hand held GPS unit.

Photographs
Photographs were taken at each site using both the Stylus 1030SW shock and water proof camera and the Capilo 500SE GPS Camera. Upstream and downstream photographs as well as culvert, bridge and outstanding litter or erosion photographs were all taken at each site. Substrate photographs were attempted at each with the waterproof camera.

Channel width & depth
The width of the Stream was done using a 100 m fibreglass measuring tape. Channel depth was measured by using a stainless steel meter stick.

Flow
The velocity of river flow at sites was measured using a bobber and 100 m fibreglass measuring tape. Distances measured varied depending upon stream obstructions and variable depth. The flow was then calculated using the equation **Q=V*A**, where **Q** is flow/ discharge, **V** is velocity (distance divided by time), and **A** is the cross sectional area of the stream.

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

Water Temperature
Water temperature was measured with the YSI 600 QS. The readings were taken after the probe was submerged and all variables on the meter were stabilized.

Conductivity
Conductivity was measured with the YSI 600 QS. The accuracy of the reading was ±0.001 mS/cm or ±1.0%; whichever was greater. The readings were recorded once the probe was completely submerged and all readings stabilized. In addition to conductivity readings taken in the field, laboratory analysis of the samples provided a second reading of conductivity which is included within the results.

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

Dissolved Oxygen
The YSI 600 QS measured dissolved oxygen for the samples. The readings were recorded once the probe was submerged in the water and all variables were stabilized.

Tree, Shrub & Herb Species
Identification was made in the vicinity of the sample sites, no transects were made. Observations made approximately 50 metres from either stream edge were taken.

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

OBBN In-Stream Materials Key

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

Grain Size	Description
Boulder	> 25.6 cm in diameter
Cobbles	6.4 - 25.6 cm in diameter
Gravel	0.2 – 6.4 cm in diameter
Sand	< 0.2 cm in diameter
Silt	Finer inorganic material than sand
Muck	Mainly organic combination of silt and clay
Clay	Inorganic origin with no apparent structure

.

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

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

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

APPENDIX B:

WATER QUALITY PARAMETERS

Appendix B: 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. Temperature is important, as warmer water holds less dissolved oxygen and warmer water will allow bacteria to reproduce and grow more quickly. Temperature can vary depending on the source of the water, depth and velocity of the stream, sunlight intensity and the amount of shade by the shoreline vegetation.

Dissolved Oxygen

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

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, as well the material can settle on top of fish spawning grounds (and their eggs). Highly turbid water will appear murky or dirty. Turbidity will be higher after heavy rainfall, but high levels may also indicate soil erosion.

Nutrients
Like terrestrial plants, aquatic plants and algae require nutrients for growth and productivity. The main nutrients of concern are 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 (*E. coli*) are naturally found in the intestines of humans and warm-blooded animals. Unlike other bacteria in this family, *E. coli* does not usually occur naturally on plants or in soil and water. The inability of *E. coli* to grow in water combined with its short survival time in water environments means that the detection of *E. coli* in a

water system is a good indicator of recent fecal contamination. Potential sources of *E. coli* include: leaking septic systems, runoff from manure storage facilities or wild animal waste (i.e. beavers and Canadian Geese). These bacteria can cause irritation of the skin and eyes when contact is made and can cause gastro-intestinal disorders.

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

Aluminum (Al)
Antimony (Sb)
Arsenic (As)
Barium (Ba)
Beryllium (Be)
Bismuth (Bi)
Boron (B)
Cadmium* (Cd)
Chromium (Cr)
Cobalt (Co)
Copper (Cu)
Iron (Fe)
Lead (Pb)
Manganese (Mn)
Molybdenum (Mo)
Nickel (Ni)
Selenium (Se)
Silicon (Si)
Silver (Ag)
Strontium (Sr)
Thallium (TI)
Tin (Sn)
Titanium (Ti)
Tungsten (W)
Uranium (U)
Vanadium (V)
Zinc (Zn)
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 being 75 μg/L.

Antimony
Antimony is a metallic element that is a blue-white colour in its stable form. Acute intoxication is characterized by abdominal pain, vomiting, diarrhea, dehydration, muscular pain, shock, haemoglobinuria, anuria and uraemia. In addition, severe myocardial symptoms and convulsions have been observed with acute doses of

antimonials, as well some deaths were attributed to liver necrosis. The maximum concentration of antimony under PWQO guidelines is 20 μg/L.

Arsenic

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

Barium

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

Beryllium

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

Bismuth

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

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

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

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

Chromium
Chromium is a lustrous, hard metal. Chromium (III) is an essential nutrient, but higher intake may cause skin rashes. Chromium (VI) is 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 many minerals. It is a dietary requirement, but too much can lead to muscle weakness, lethargy and confusion. There are no current PWQO guidelines for magnesium.

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

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

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

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

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

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

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

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

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

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

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

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

APPENDIX C:

WATER QUALITY GUIDELINES

Appendix C: 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 10°C (18°F). However, in special circumstances, local conditions may require a significantly lower temperature difference than 10°C (18°F). Potential dischargers are to apply to the MOEE for guidance as to the allowable temperature rise for each thermal discharge. This ministry will also specify the nature of the mixing zone and the procedure for the establishment of a representative control location for temperature recording on a case-by-case basis.

2. Discharge Temperature Permitted

   The maximum temperature of the receiving body of water, at any point in the thermal plume outside a mixing zone, shall not exceed 30°C (86°F) or the temperature of a representative control location plus 10°C (18°F) or the allowed temperature difference, 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 20 µg/L.

The percentages of un-ionized ammonia (NH3) in aqueous ammonia solution for different temperature and pH conditions are listed in the table below. For example, at 20°C and pH of 8.0, a total ammonia concentration of 500 µg/L would give an un-ionized ammonia concentration of 500 x 3.8/100 = 19 µg/L which is less than the un-ionized ammonia Objective of 20 µg/L.

The table below is taken from 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 NH3

pKa = 0.09018 + 2729.92/T, where T = ambient water temperature in Kelvin (K = °C + 273.16)

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

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

Percent NH3 in aqueous ammonia solutions for 0-30 °C and pH 6-10

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

Temp.	pH								
°C	**6.0**	**6.5**	**7.0**	**7.5**	**8.0**	**8.5**	**9.0**	**9.5**	**10.0**
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.
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 20 µg/L;

A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration for the ice-free period of 10 µg/L or less. This should apply to all lakes naturally below this value.

Excessive plant growth in rivers and streams should be eliminated at a total phosphorus concentration below 30 µg/L.

Bacteriological

Escherichia coli:

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

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

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

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

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

Metals

Aluminum:

Aluminum amounts should not exceed the following:

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

Antimony:

The amount of Antimony should not exceed 20 µg/L.

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

Barium:
There are currently no PWQO guidelines for Barium.

Beryllium:
Beryllium amounts should not exceed the following:

Hardness as CaCO3 (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 for Bismuth.

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

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

Calcium:
There are currently no PWQO guidelines for Calcium.

Chromium:
Chromium amounts should not exceed the following:

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

Cobalt:
The amount of Cobalt should not exceed 0.9 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 for Manganese.

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

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

Potassium:
There are currently no PWQO guidelines for Potassium.

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

Silicon:
There are currently no PWQO guidelines for Silicon.

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

Strontium:
There are currently no PWQO guidelines for Strontium.

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

Tin:
There are currently no PWQO guidelines for Tin.

Titanium:
There are currently no PWQO guidelines for Titanium.

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

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

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

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

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

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 D:

LABORATORY WATER QUALITY RESULTS

Appendix D: Laboratory Water Quality Results

Laboratory Water Quality Results for Site 1: Headwaters, Murillo			
Parameter	**Units**	**PWQO**	13-Jul- 10
Physical Tests			10:30 am
Conductivity (EC)	uS/cm	n/a	303
Total Dissolved Solids	mg/L	n/a	261
Turbidity	NTU	<10% of natural	1.92
Anions and Nutrients			
Ammonia-N, Total	mg/L	n/a	<0.020
Chloride (Cl)	mg/L	n/a	18.9
Nitrate-N (NO3-N)	mg/L	n/a	<0.030
Nitrite-N (NO2-N)	mg/L	n/a	<0.020
Phosphorus (P)-Total	mg/L	0.03	0.0245
Sulphate (SO4)	mg/L	n/a	<0.30
Bacteriological Tests			
Escherichia Coli	MPN/100mL	100	5
Total Coliforms	MPN/100mL	1000 (prior to 1994)	**2000**
Total Metals			
Aluminum (Al)	mg/L	0.075	0.011
Antimony (Sb)	mg/L	0.02	<0.0050
Arsenic (As)	mg/L	0.005 (interim)	0.0011
Barium (Ba)	mg/L	n/a	0.019
Beryllium (Be)	mg/L	0.011	<0.0010
Bismuth (Bi)	mg/L	n/a	<0.0010
Boron (B)	mg/L	0.2	<0.050
Cadmium (Cd)	mg/L	0.0001 (interim)	<0.000090
Calcium (Ca)	mg/L	n/a	38.0
Chromium (Cr)	mg/L	0.001 for Cr(VI)	<0.0010
Cobalt (Co)	mg/L	0.0009	<0.00050
Copper (Cu)	mg/L	0.005 (interim)	<0.0010
Iron (Fe)	mg/L	0.3	**1.45**
Lead (Pb)	mg/L	0.001 (interim)	<0.0010
Magnesium (Mg)	mg/L	n/a	13.1
Manganese (Mn)	mg/L	n/a	1.22
Molybdenum (Mo)	mg/L	0.04	<0.0010
Nickel (Ni)	mg/L	0.025	<0.0020
Potassium (K)	mg/L	n/a	<1.0
Selenium (Se)	mg/L	0.1	<0.00040
Silicon (Si)	mg/L	n/a	9.8
Silver (Ag)	mg/L	0.0001	<0.00010
Strontium (Sr)	mg/L	n/a	0.0587
Thallium (Tl)	mg/L	0.0003	<0.00030
Tin (Sn)	mg/L	n/a	<0.0010
Titanium (Ti)	mg/L	n/a	<0.0020
Tungsten (W)	mg/L	0.03	<0.010
Uranium (U)	mg/L	0.005	<0.0050
Vanadium (V)	mg/L	0.006	<0.0010
Zinc (Zn)	mg/L	0.02 (interim)	<0.0030
Zirconium (Zr)	mg/L	0.004	<0.0040

*Bold #'s indicate exceedance of PWQO guidelines

Laboratory Water Quality Results for Site 2: Vibert Road			
Parameter	**Units**	**PWQO**	13-Jul-10
Physical Tests			12:30 pm
Conductivity (EC)	uS/cm	n/a	511
Total Dissolved Solids	mg/L	n/a	400
Turbidity	NTU	<10% of natural	5.24
Anions and Nutrients			
Ammonia-N, Total	mg/L	n/a	<0.020
Chloride (Cl)	mg/L	n/a	52.1
Nitrate-N (NO3-N)	mg/L	n/a	<0.030
Nitrite-N (NO2-N)	mg/L	n/a	<0.020
Phosphorus (P)-Total	mg/L	0.03	**0.0320**
Sulphate (SO4)	mg/L	n/a	0.49
Bacteriological Tests			
Escherichia Coli	MPN/100mL	100	59
Total Coliforms	MPN/100mL	1000 (prior to 1994)	**1700**
Total Metals			
Aluminum (Al)	mg/L	0.075	0.030
Antimony (Sb)	mg/L	0.02	<0.0050
Arsenic (As)	mg/L	0.005 (interim)	0.0016
Barium (Ba)	mg/L	n/a	0.026
Beryllium (Be)	mg/L	0.011	<0.0010
Bismuth (Bi)	mg/L	n/a	<0.0010
Boron (B)	mg/L	0.2	<0.050
Cadmium (Cd)	mg/L	0.0001 (interim)	<0.000090
Calcium (Ca)	mg/L	n/a	66.0
Chromium (Cr)	mg/L	0.001 for Cr(VI)	<0.0010
Cobalt (Co)	mg/L	0.0009	<0.00050
Copper (Cu)	mg/L	0.005 (interim)	0.0013
Iron (Fe)	mg/L	0.3	**1.26**
Lead (Pb)	mg/L	0.001 (interim)	<0.0010
Magnesium (Mg)	mg/L	n/a	21.6
Manganese (Mn)	mg/L	n/a	0.480
Molybdenum (Mo)	mg/L	0.04	<0.0010
Nickel (Ni)	mg/L	0.025	<0.0020
Potassium (K)	mg/L	n/a	1.5
Selenium (Se)	mg/L	0.1	0.00048
Silicon (Si)	mg/L	n/a	7.0
Silver (Ag)	mg/L	0.0001	<0.00010
Strontium (Sr)	mg/L	n/a	0.0979
Thallium (Tl)	mg/L	0.0003	<0.00030
Tin (Sn)	mg/L	n/a	<0.0010
Titanium (Ti)	mg/L	n/a	<0.0020
Tungsten (W)	mg/L	0.03	<0.010
Uranium (U)	mg/L	0.005	<0.0050
Vanadium (V)	mg/L	0.006	<0.0010
Zinc (Zn)	mg/L	0.02 (interim)	0.0111
Zirconium (Zr)	mg/L	0.004	<0.0040

*Bold #'s indicate exceedance of PWQO guidelines

Laboratory Water Quality Results for Site 3: Cooper Road			
Parameter	**Units**	**PWQO**	14-Jul-10
Physical Tests			10:00 am
Conductivity (EC)	uS/cm	n/a	513
Total Dissolved Solids	mg/L	n/a	395
Turbidity	NTU	<10% of natural	8.93
Anions and Nutrients			
Ammonia-N, Total	mg/L	n/a	0.085
Chloride (Cl)	mg/L	n/a	55.5
Nitrate-N (NO3-N)	mg/L	n/a	<0.030
Nitrite-N (NO2-N)	mg/L	n/a	<0.020
Phosphorus (P)-Total	mg/L	0.03	0.0261
Sulphate (SO4)	mg/L	n/a	0.31
Bacteriological Tests			
Escherichia Coli	MPN/100mL	100	25
Total Coliforms	MPN/100mL	1000 (prior to 1994)	**> 2420**
Total Metals			
Aluminum (Al)	mg/L	0.075	<0.010
Antimony (Sb)	mg/L	0.02	<0.0050
Arsenic (As)	mg/L	0.005 (interim)	0.0012
Barium (Ba)	mg/L	n/a	0.030
Beryllium (Be)	mg/L	0.011	<0.0010
Bismuth (Bi)	mg/L	n/a	<0.0010
Boron (B)	mg/L	0.2	<0.050
Cadmium (Cd)	mg/L	0.0001 (interim)	<0.000090
Calcium (Ca)	mg/L	n/a	60.3
Chromium (Cr)	mg/L	0.001 for Cr(VI)	<0.0010
Cobalt (Co)	mg/L	0.0009	<0.00050
Copper (Cu)	mg/L	0.005 (interim)	<0.0010
Iron (Fe)	mg/L	0.3	**2.13**
Lead (Pb)	mg/L	0.001 (interim)	<0.0010
Magnesium (Mg)	mg/L	n/a	19.7
Manganese (Mn)	mg/L	n/a	1.83
Molybdenum (Mo)	mg/L	0.04	<0.0010
Nickel (Ni)	mg/L	0.025	<0.0020
Potassium (K)	mg/L	n/a	1.9
Selenium (Se)	mg/L	0.1	0.00042
Silicon (Si)	mg/L	n/a	8.5
Silver (Ag)	mg/L	0.0001	<0.00010
Strontium (Sr)	mg/L	n/a	0.0873
Thallium (Tl)	mg/L	0.0003	<0.00030
Tin (Sn)	mg/L	n/a	<0.0010
Titanium (Ti)	mg/L	n/a	<0.0020
Tungsten (W)	mg/L	0.03	<0.010
Uranium (U)	mg/L	0.005	<0.0050
Vanadium (V)	mg/L	0.006	<0.0010
Zinc (Zn)	mg/L	0.02 (interim)	0.0067
Zirconium (Zr)	mg/L	0.004	<0.0040

*Bold #'s indicate exceedance of PWQO guidelines

Laboratory Water Quality Results for Site 7: 25th Side Road			
Parameter	**Units**	**PWQO**	14-Jul-10
Physical Tests			11:30 am
Conductivity (EC)	uS/cm	n/a	494
Total Dissolved Solids	mg/L	n/a	380
Turbidity	NTU	<10% of natural	11.0
Anions and Nutrients			
Ammonia-N, Total	mg/L	n/a	<0.020
Chloride (Cl)	mg/L	n/a	76.1
Nitrate-N (NO3-N)	mg/L	n/a	0.049
Nitrite-N (NO2-N)	mg/L	n/a	<0.020
Phosphorus (P)-Total	mg/L	0.03	0.0128
Sulphate (SO4)	mg/L	n/a	7.74
Bacteriological Tests			
Escherichia Coli	MPN/100mL	100	10
Total Coliforms	MPN/100mL	1000 (prior to 1994)	> **2420**
Total Metals			
Aluminum (Al)	mg/L	0.075	0.010
Antimony (Sb)	mg/L	0.02	<0.0050
Arsenic (As)	mg/L	0.005 (interim)	<0.0010
Barium (Ba)	mg/L	n/a	0.055
Beryllium (Be)	mg/L	0.011	<0.0010
Bismuth (Bi)	mg/L	n/a	<0.0010
Boron (B)	mg/L	0.2	<0.050
Cadmium (Cd)	mg/L	0.0001 (interim)	<0.000090
Calcium (Ca)	mg/L	n/a	52.3
Chromium (Cr)	mg/L	0.001 for Cr(VI)	<0.0010
Cobalt (Co)	mg/L	0.0009	<0.00050
Copper (Cu)	mg/L	0.005 (interim)	<0.0010
Iron (Fe)	mg/L	0.3	**1.20**
Lead (Pb)	mg/L	0.001 (interim)	<0.0010
Magnesium (Mg)	mg/L	n/a	15.9
Manganese (Mn)	mg/L	n/a	0.299
Molybdenum (Mo)	mg/L	0.04	<0.0010
Nickel (Ni)	mg/L	0.025	<0.0020
Potassium (K)	mg/L	n/a	1.5
Selenium (Se)	mg/L	0.1	<0.00040
Silicon (Si)	mg/L	n/a	8.1
Silver (Ag)	mg/L	0.0001	<0.00010
Strontium (Sr)	mg/L	n/a	0.0774
Thallium (Tl)	mg/L	0.0003	<0.00030
Tin (Sn)	mg/L	n/a	<0.0010
Titanium (Ti)	mg/L	n/a	<0.0020
Tungsten (W)	mg/L	0.03	<0.010
Uranium (U)	mg/L	0.005	<0.0050
Vanadium (V)	mg/L	0.006	<0.0010
Zinc (Zn)	mg/L	0.02 (interim)	<0.0030
Zirconium (Zr)	mg/L	0.004	<0.0040

*Bold #'s indicate exceedance of PWQO guidelines

Laboratory Water Quality Results for Site 10: Pole Line Road			
Parameter	**Units**	**PWQO**	13-Jul-10
Physical Tests			12:30 pm
Conductivity (EC)	uS/cm	n/a	550
Total Dissolved Solids	mg/L	n/a	424
Turbidity	NTU	<10% of natural	6.33
Anions and Nutrients			
Ammonia-N, Total	mg/L	n/a	0.063
Chloride (Cl)	mg/L	n/a	59.6
Nitrate-N (NO3-N)	mg/L	n/a	<0.030
Nitrite-N (NO2-N)	mg/L	n/a	<0.020
Phosphorus (P)-Total	mg/L	0.03	**0.0385**
Sulphate (SO4)	mg/L	n/a	1.15
Bacteriological Tests			
Escherichia Coli	MPN/100mL	100	14
Total Coliforms	MPN/100mL	1000 (prior to 1994)	> **2420**
Total Metals			
Aluminum (Al)	mg/L	0.075	<0.010
Antimony (Sb)	mg/L	0.02	<0.0050
Arsenic (As)	mg/L	0.005 (interim)	0.0014
Barium (Ba)	mg/L	n/a	0.024
Beryllium (Be)	mg/L	0.011	<0.0010
Bismuth (Bi)	mg/L	n/a	<0.0010
Boron (B)	mg/L	0.2	<0.050
Cadmium (Cd)	mg/L	0.0001 (interim)	<0.000090
Calcium (Ca)	mg/L	n/a	65.7
Chromium (Cr)	mg/L	0.001 for Cr(VI)	<0.0010
Cobalt (Co)	mg/L	0.0009	<0.00050
Copper (Cu)	mg/L	0.005 (interim)	<0.0010
Iron (Fe)	mg/L	0.3	**2.06**
Lead (Pb)	mg/L	0.001 (interim)	<0.0010
Magnesium (Mg)	mg/L	n/a	21.5
Manganese (Mn)	mg/L	n/a	0.624
Molybdenum (Mo)	mg/L	0.04	<0.0010
Nickel (Ni)	mg/L	0.025	<0.0020
Potassium (K)	mg/L	n/a	1.5
Selenium (Se)	mg/L	0.1	<0.00040
Silicon (Si)	mg/L	n/a	7.7
Silver (Ag)	mg/L	0.0001	<0.00010
Strontium (Sr)	mg/L	n/a	0.0934
Thallium (Tl)	mg/L	0.0003	<0.00030
Tin (Sn)	mg/L	n/a	<0.0010
Titanium (Ti)	mg/L	n/a	<0.0020
Tungsten (W)	mg/L	0.03	<0.010
Uranium (U)	mg/L	0.005	<0.0050
Vanadium (V)	mg/L	0.006	<0.0010
Zinc (Zn)	mg/L	0.02 (interim)	<0.0030
Zirconium (Zr)	mg/L	0.004	<0.0040

*Bold #'s indicate exceedance of PWQO guidelines

Laboratory Water Quality Results for Site 11: 20th Side Road			
Parameter	**Units**	**PWQO**	19-Jul-10
Physical Tests			11:15 am
Conductivity (EC)	uS/cm	n/a	549
Total Dissolved Solids	mg/L	n/a	425
Turbidity	NTU	<10% of natural	16.3
Anions and Nutrients			
Ammonia-N, Total	mg/L	n/a	<0.020
Chloride (Cl)	mg/L	n/a	77.3
Nitrate-N (NO3-N)	mg/L	n/a	0.124
Nitrite-N (NO2-N)	mg/L	n/a	<0.020
Phosphorus (P)-Total	mg/L	0.03	0.0169
Sulphate (SO4)	mg/L	n/a	8.25
Bacteriological Tests			
Escherichia Coli	MPN/100mL	100	63
Total Coliforms	MPN/100mL	1000 (prior to 1994)	**1600**
Total Metals			
Aluminum (Al)	mg/L	0.075	**0.175**
Antimony (Sb)	mg/L	0.02	<0.0050
Arsenic (As)	mg/L	0.005 (interim)	0.0017
Barium (Ba)	mg/L	n/a	0.056
Beryllium (Be)	mg/L	0.011	<0.0010
Bismuth (Bi)	mg/L	n/a	<0.0010
Boron (B)	mg/L	0.2	<0.050
Cadmium (Cd)	mg/L	0.0001 (interim)	<0.000090
Calcium (Ca)	mg/L	n/a	66.8
Chromium (Cr)	mg/L	0.001 for Cr(VI)	<0.0010
Cobalt (Co)	mg/L	0.0009	<0.00050
Copper (Cu)	mg/L	0.005 (interim)	0.0022
Iron (Fe)	mg/L	0.3	**1.52**
Lead (Pb)	mg/L	0.001 (interim)	<0.0010
Magnesium (Mg)	mg/L	n/a	18.3
Manganese (Mn)	mg/L	n/a	0.232
Molybdenum (Mo)	mg/L	0.04	0.0010
Nickel (Ni)	mg/L	0.025	<0.0020
Potassium (K)	mg/L	n/a	2.0
Selenium (Se)	mg/L	0.1	0.00041
Silicon (Si)	mg/L	n/a	8.4
Silver (Ag)	mg/L	0.0001	<0.00010
Strontium (Sr)	mg/L	n/a	0.0978
Thallium (Tl)	mg/L	0.0003	<0.00030
Tin (Sn)	mg/L	n/a	<0.0010
Titanium (Ti)	mg/L	n/a	0.0074
Tungsten (W)	mg/L	0.03	<0.010
Uranium (U)	mg/L	0.005	<0.0050
Vanadium (V)	mg/L	0.006	0.0017
Zinc (Zn)	mg/L	0.02 (interim)	<0.0030
Zirconium (Zr)	mg/L	0.004	<0.0040

*Bold #'s indicate exceedance of PWQO guidelines

APPENDIX E:

1996 RESULTS

Appendix E: 1996 Water Quality Results/Field Observations

Field Measurements recorded July 17, 1996							
Site	**Depth (m)**	**Air Temp. (°C)**	**Water Temp. (°C)**	**pH**	**D.O. (mg/L)**	**Conductivity (μmhos/cm)**	**Comments**
Site 1	0.42	31.0	20.5	7.25	3.8	200	- sampled at 3:15pm
Site 2	0.62	30.0	21.5	6.45	9.9	348	- sampled at 2:45pm
Site 3	0.17	30.0	19.5	7.5	6.8	375	- sampled at 2:30pm - site below ponding area
Site 4	0.68	24.5	17.0	6.15	6.8	370	- sampled at 10:00am
Site 5	0.53	26.0	17.2	7.10	8.3	360	- sampled at 11:00am
Site 6	0.25	28.0	19.5	7.15	10.2	352	- sampled at 11:20am - steady breeze
Site 7	0.51	29.0	18.0	7.55	9.0	355	- sampled at 11:45am - ponding area
Site 8	0.59	29.0	19.0	7.35	9.5	385	- trailer court ditch drains into creek - sampled at 3:35pm
Site 9	0.58	30.5	19.0	6.15	8.9	395	- sampled at 3:50pm - beach area

Field Measurements recorded August 2, 1996							
Site	**Depth (m)**	**Air Temp. (°C)**	**Water Temp. (°C)**	**pH**	**D.O. (mg/L)**	**Conductivity (μmhos/cm)**	**Comments**
Site 1	0.38	21.5	16.6	7.30	3.9	355	- sampled at 9:15am
Site 2	0.51	21.5	15.0	7.40	7.5	448	- sampled at 9:45am
Site 3	0.13	22.0	15.5	7.55	3.2	428	- sampled at 10:00am
Site 4	0.32	22.0	12.5	7.50	7.2	425	- sampled at 10:30am - lots of sewage fungus
Site 5	0.42	26.0	15.0	8.05	9.2	450	- sampled at 1:40pm - murky water
Site 6	0.23	26.0	25.0	7.60	9.4	370	- sampled at 2:00pm
Site 7	0.36	27.0	19.2	7.45	9.0	435	- sampled at 2:30pm - murky
Site 8	0.48	28.0	20.0	7.65	9.8	445	- trailer court ditch drains into creek - sampled at 2:55pm
Site 9	0.41	28.0	20.1	7.45	9.4	460	- sampled at 3:10pm - beach area

Field Measurements recorded August 15, 1996							
Site	**Depth (m)**	**Air Temp. (°C)**	**Water Temp. (°C)**	**pH**	**D.O. (mg/L)**	**Conductivity (µmhos/cm)**	**Comments**
Site 1	0.38	15.0	15.4	7.05	3.2	N/A	- sampled at 9:05am
Site 2	0.25	15.0	14.5	7.15	5.1	N/A	- sampled at 9:30am
Site 3	0.14	15.0	15.0	7.25	3.7	N/A	- sampled at 9:45am
Site 4	0.54	15.0	11.0	7.65	4.5	N/A	- sampled at 10:00am
Site 5	0.30	16.0	13.2	7.75	7.2	N/A	- sampled at 10:10am
Site 6	0.31	16.0	16.0	7.75	5.0	N/A	- sampled at 10:20am
Site 7	0.25	16.0	16.0	8.10	5.9	N/A	- sampled at 10:30am
Site 8	0.23	24.0	17.5	6.65	6.0	N/A	- sampled at 1:45pm
Site 9	0.27	24.0	17.0	7.30	5.9	N/A	- sampled at 2:24pm

Total Averages for all 1996 Field Measurements						
Site	**Depth (m)**	**Air Temp. (°C)**	**Water Temp. (°C)**	**pH**	**D.O. (mg/L)**	**Conductivity (µmhos/cm)**
Site 1	0.39	22.5	17.5	7.20	3.63	277.5
Site 2	0.46	22.2	17.0	7.00	7.50	398.0
Site 3	0.15	22.3	16.7	7.43	4.57	401.5
Site 4	0.52	20.5	13.5	7.10	6.17	397.5
Site 5	0.42	22.7	15.1	7.63	8.23	405.0
Site 6	0.26	23.3	20.2	7.50	8.20	361.0
Site 7	0.37	24.0	17.7	7.70	7.97	395.0
Site 8	0.43	27.0	18.8	7.00	8.43	415.0
Site 9	0.42	28.2	18.7	6.97	8.07	427.5

Chemical Analysis August 9, 1996								
Analytical Paramater	**Units**	**Site 1**	**Site 3**	**Site 5**	**Site 7**	**Site 8**	**Range**	**Average**
Cadmium (Cd)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0	<0.001
Iron (Fe)	mg/L	0.843	0.425	3.410	2.710	1.890	2.985	1.856
Lead (Pb)	mg/L	<0.005	0.013	<0.005	<0.005	<0.005	0.0008	0.0066
Total Alkalinity	mg/L	84.8	170.5	154.1	137.4	140.2	85.7	137.76
Total Phosphorous	mg/L	0.07	0.09	0.04	0.04	0.04	0.05	0.056
Total Suspended Solids	mg/L	6.00	7.60	8.00	9.60	10.67	4.67	8.374
Turbitity	NTU	1.5	1.2	7.0	8.3	9.7	8.5	5.54

Chemical Analysis August 20, 1996								
Analytical Paramater	**Units**	**Site 1**	**Site 3**	**Site 5**	**Site 7**	**Site 8**	**Range**	**Average**
Cadmium (Cd)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0	<0.001
Iron (Fe)	mg/L	1.06	0.308	4.94	1.83	3.98	3.88	2.42
Lead (Pb)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	0	<0.005
Total Alkalinity	mg/L	91.0	195.0	132.0	137.0	139.0	104	138.8
Total Phosphorous	mg/L	0.26	0.26	0.24	0.14	0.19	0.12	0.218
Total Suspended Solids	mg/L	24.0	2.0	13.0	3.0	42.0	40.0	16.8
Turbitity	NTU	3.5	N/A	7.0	8.7	13	9.5	10.39

Observations of Terrestrial and Aquatic Life- 1996					
Site	**Riparian**	**Forest**	**Field**	**Birds & Mammals**	**Aquatic Life**
1	cattail grasses dragonflies frogs moths blue flag	speckled alder tamarack wild red raspberry goldenrod flat topped aster black spruce upland willow prickly wild rose	daisy horestail thistle fireweed red clover goldenrod yellow goatsbeard	ducklings crow sparrow black birds	water mite water boatman snails minnows
2	ladyfern red osier dogwood grasses frogs	black ash wild red raspberry showy mountain ash balsam poplar eastern white cedar white birch squashberry	fireweed yellow goatsbeard dandilion		black-nosed dace orb snail crane fly larva leech sewage fungus
3	grasses dragonfly arrowhead	jack pine speckled alder willow prickly wild rose wild red raspberry choke cherry saskatoon showy mountain ash	fireweed daisy goldenrod horsetail thistle jewelweed white clover dandelion jewel weed creamy peavine	fox	leech minnows water boatman orb snail dragonfly nymph water flea mayfly
4	grasses dragonfly red osier dogwood	speckled alder willow	jewelweed fireweed thistle	crow sparrow	minnows orb snail leech water strider
5	moth highbush cranberry red osier dogwood grasses	red pine jack pine willow speckled alder	fireweed		minnows water strider water flea
6	red osier dogwood frogs grasses	tamarack eastern white cedar white birch balsam fir willow speckled alder saskatoon wild red raspberry	daisy	loon chipmunk	orb snail water flea water spider
7	moth dragonfly	speckled alder white birch	daisy goldenrod		crayfish orb snail

	grasses cattails re-osier dogwood horsetails	balsam fir wild red raspberry balsam poplar trembling aspen willow tamarack saskatoon wild mint choke cherry cedar	fireweed flat-topped aster thistle brown eyed susan		water measurer water strider clam water snake black-nosed dace water spider damesfly giant water bug waterflea sewage fungus
8	grasses red osier dodwood dragonfly bumblebee horsetails	black ash white birch white pine wild red raspberry willow speckled alder	goldenrod flat topped aster fireweed thistle 3-tooth cinquefoil		minnows suckers water bug sewage fungus
9	ladyfern dragonfly	speckled alder willow balsam poplar white birch white pine black ash	fireweed goldenrod		crayfish minnows suckers sewage fungus

Forest Ecosytem Classification for all 1996 Sampling Locations	
Site	**Vegetation Type**
1	V-23: conifer
2	V-2: mainly hardwood
3	V-17: conifer mixed wood
4	V-18: conifer mixed wood
5	V-13: conifer mixed hardwood
6	V-22: conifer
7	V-6: mainly hardwood
8	V-2: mainly hardwood
9	V-2: mainly hardwood

APPENDIX F:

FOREST ECOSYSTEM CLASSIFICATION

Appendix F: Forest Ecosystem Classification

Site 1: V-23 Tamarack (Black Spruce)
Site 2: V-2 Black Ash Hardwood and Mixedwood
Site 3: V-17 Jack Pine Mixedwood/ Shrub Rich
Site 7: V-14 Balsam Fir Mixedwood
Site 10:V-2 Black Ash Hardwood and Mixedwood
Site 11: V-14 Balsam Fir Mixedwood

V-2 Black Ash Hardwood and Mixedwood
Description: Hardwood and mixedwood stands containing black ash in the overstory. The understory is typically dense and floristically diverse. Of limited areal extent; occurring in low-lying locations on deep, moist to wet, usually no-calcareous substrates.

V-14 Balsam Fir Mixedwood
Description: An extremely variable mixedwood type. The canopy, comprising mainly of balsam fir, may contain a mixture of several species. The understory varies from shrub rich to moderately herb and shrub poor. Usually occurs on deep, fresh to moist, mineral soils but encompassing a wide range of soil and site conditions.

V-17 Jack Pine Mixedwood/ Shrub Rich
Description: Jack pine mixedwoods with spruce and fir occasional in the canopy. The understory is typically rich in herb and low shrub species. Occurring on upland, fresh to dry, course textures soils.

V-23 Tamarack (Black Spruce)/Speckled Alder/Labrador Tea
Description: Wet tamarack stands, often with black spruce in the overstory. The shrub layer is typically dominated by low, ericaceous species although thickets of balsam fir or black spruce may occur.

APPENDIX G:

PLANT SPECIES COMMON AND LATIN NAMES

Appendix G: Common and Latin Names of Identified Species

Common and Latin Names of Identified Plants

Trees	
Common Names	**Latin Names**
Balsam Fir	*Abies balsamea*
Balsam Poplar	*Populus balsamifera*
Black Ash	*Fraxinus nigra*
Black Spruce	*Picea mariana*
Eastern White Cedar	*Thuja occidentalis*
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*
Tamarack/Eastern Larch	*Larix laricina*
Trembling Aspen	*Populus tremuloides*
White Birch	*Betula papyrifera*
White Pine	*Pinus strobus*
White Spruce	*Picea glauca*

Shrubs	
Common Names	Latin Names
Balsam Poplar	*Populus balsamifera*
Beaked Hazel	*Corylus cornuta*
Bear Berry	*Arctostaphylos uva-ursi*
Buffalo Berry	*Shepherdia canadensis*
Bush Honeysuckle	*Diervilla lonicera*
Canada Elderberry	*Sambucus canadensis*
Chokecherry	*Prunus virginiana*
Currant Spp.	*Ribes spp.*
Gooseberry	*Ribes spp.*
Hairy Honeysuckle	*Lonicera hispidula*
High-bush Cranberry	*Viburnum trilobum*
Honeysuckle Spp.	*Lonicera spp.*

Ninebark	*Physocarpus Spp.*
Pincherry	*Prunus pensylvanica*
Prickly Wild rose	*Rosa acicularis*
Pussy Willow	*Salix discolor*
Red Berried Elder	*Sambucus racemosa*
Red-osier Dogwood	*Cornus stolonifera*
Saskatoon (serviceberry)	*Amelanchier alnifolia*
Slender Willow	*Salix petiolaris*
Swamp Red Currant	*Ribes triste*
Sweet Gale	*Myrica gale*
Wild Red Raspberry	*Rubus idaeus var. strigosus*
Willow	*Salix spp.*
Leather Leaf	*Chamaedaphne calyculata*

Herbs	
Common Names	**Latin Names**
Aster	*Symphyotrichum spp.*
Birdsfoot Trefoil	*Lotus cornicutatus*
Meadowsweet	*Latifolia*
Bunch Berry	*Cornus canadensis*
Buttercup	*Ranunculus repens*
Canada Anemone	*Anemone Canadensis*
Canada Goldenrod	*Solidago Canadensis*
Canada Mayflower	*Maianthemum*
Canada Thistle	*Cirsium arvense*
Common Evening Primose	*Oenothera biennis*
Common Plantain	*Plantago major*
Common Strawberry	*Fragaria virginiana*
Common Yarrow	*Achillea millefolium*
Corn Sow Thistle	*Sonchus arvensis*
Cow Parsnip	*Heracleum lanatum*
Cow Vetch	*Vivia cracca*
Cream Colored Vetchling	*Lathyrus ochroleucus*
Creeping Bellflower	*Campanula rapunculoides*
Crown Vetch	*Coronilla varia*
Dandelion	*Taraxacum officinale*
Dwarf Raspberry	*Rubus pubesiens*
Early Meadow-Rue	*Thalictrum dioicum*

Heal-All	*Prunella vulgaris*
Hop Clover	*Trifolium aureum*
Kidney-leaved Violet	*Viola renifolia*
Jewelweed	*Impatiens capensis*
Large Leaf Aster	*Aster macrophyllus*
Fragrant Bedstraw	*Galium triflorum*
Golden Rod	*Solidago spp.*
Grasses	*Poaceae spp.*
Lily	*Liliaceace spp.*
Lupine	*Lupinus polyphyllus*
Meadow-rue	*Thalictrum*
Mountain Blueeyed Grass	*Sisyrinchium montanum*
Naked Mitrewort	*Mitella nuda*
Narrowleaf Spirea	*Spiraea alba*
Northern Bluebell	*Mertensia paniculata*
Northern Blueflag	*Iris versicolor*
Northern Blue Violet	*Viola septentrionalis*
Northern Marsh Violet	*Viola epipsila*
Northern Sweet Coltsfoot	*Petasites frigidus*
Nodding Trillum	*Trillium cernum*
Orange Hawkweed	*Hieracium aurantiacum*
Ox-eye Daisy	*Leucanthemum vulgare*
Pearly Everlasting	*Anaphalis margaritacea*
Pineapple Weed	*Matricaria discoidea*
Pink Pyrola	*Pyrola asarifolia*
Red Clover	*Trifolium pratense*
Rose-Twisted Stalk	*Streptopus amplexifolius*
Wild Sasparilla	*Aralia nudicaulis*
Sedges	*Cyperaceae spp.*
Silverwort	*Hepatica triloba*
Stone Crop	*Sedum spp.*
Sweet Coltsfoot	*Petasites frigidus*
Tall White Bog Orchid	*Platanthera dilotata*
Twin Flower	*Linnaea borealis*
Thyme Leaved Sandwort	*Arenaria serphyllifolia*
Violet	*Viola spp.*
Water Horsetail	*Equisetum fluviatile*
Wild Columbine	*Aquilegia canadensis*

Wild Lily-of-the-valley	*Maianthemum canadense*
Wood Lily	*Lilium philadelphicum*
White Baneberry	*Actaea pachypoda*
White Pea Spp.	*Lathyrus sativa*
White Sweet-Clover	*Melilotus alba*
Wild Chamomile	*Matricaria chamomilla*
Wild Chives	*Allium schoenoprasum*
Wood Aneome	*Anemone quinquefolia*
Woodland Strawberry	*Fragaria Vesca*

Ferns/Mosses	
Common Names	**Latin Names**
Spike Moss	*Selaginella spp.*
Central Peat Moss	*Sphagnum centrale*
Cinnamon Fern	*Osmunda cinnamomea*
Common Fern Moss	*Thuidium delicatulum*
Horsetail	*Equisetum spp.*
Lady Fern	*Athyrium filix-femina*
Meadow Horsetail	*Equisetum pratense*
Plume Moss	*Ptilium crista-castrensis*
Sensitive Fern	*Onoclea sensibilis*
Stair Step Moss	*Hylocomium splendens*
Wavy Moss	*Dicranum polysetum*
Field Horsetail	*Equisetum arvense*

Aquatic Plants	
Common Names	**Latin Names**
Broad-leaved Arrowhead	*Sagittaria latifolia*
Common Cattail	*Typha latifolia*
Green Algae	*Chlorophyta*
Pondweed	*Potamogeton spp.*
Water Smartweed	*Polygonum amphibium*
Yellow Pond Lily	*Nuphar lutea*
Common Bladderwort	*Utricularia vulgaris*
Water Plantain	*Alisma plantago-aquatica*
Floating Arrowhead	*Saggitaria cuneata*
Broad Leaved Arrowhead	*Saggitaria latifolia*
Water Arum, Wild Calla	*Calla palustis*

Pickerelweed	*Pontederia cordata*
Floating Leaved Burreed	*Sparganium fluctuans*
Duckweed	*Lemna spp*
Large Leaved Pondweed	*Potamogeton amplifolius*
Floating Leaved Pondweed	*Potamogeton natans*
Submerged Water Starwort	*Callitriche hermaphroditica*
Coontail	*Ceratophyllum demersum*
Small Yellow Water Crowfoot	*Ranunculus gmelinii*

APPENDIX H

SITE PHOTOGRAPHY AND DESCRIPTIONS

Appendix H: Site Photography of Upstream, Downstream and Substrate Conditions

Site 1 – Headwaters-Murillo

A: 2010 Upstream Photo

B: 2010 Downstream Photo

C: 2010 Substrate Photo

D: 2010 Outstanding Feature Photo

E: 1996 Photo of Culvert, Facing Downstream

Comments

Site 1, located in the Village of Murillo was adjacent to the CN railway. The upstream water channel was characterized by a marsh habitat with muck substrate in the channel center and gravel substrate closer to the stream edge. Vegetation on the edges of the stream was a dense mixture of wetland shrubs, reeds and cattails. No tall vegetation (over two metres) was in close proximity to the stream; leaving the water completely un-shaded. The adjacent area to the northeast was predominately conifer dominated. As displayed on Plate C the water was considerably turbid, with an obvious orange tinge. An old beaver dam may have been recently cleared, with beaver chewed woody debris along the edges of the stream culvert (Plate D). Metal bars had been installed on the outside of culvert underlying the train tracks; perhaps to prevent beaver access through the culvert. Depths at this site were considerable (greater than one metre), with a muck bottom. When compared to the culvert photo taken in 1996 some change to the culvert and surrounding area is apparent. The culvert in 1996 did not have a metal grating to prevent beaver activity and similarly no beaver activity adjacent to the culvert is evident from the 1996 photo. The predominately herb vegetation observed in 2010 appears to be consistent with the vegetation documented in Plate E.

Site 2- Vibert Road

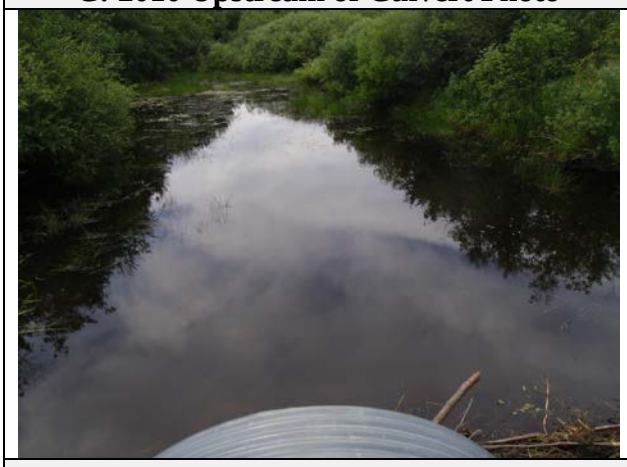
A: 2010 Upstream Photo	B: 2010 Downstream Photo
	

C: 2010 Substrate Photo

Comments

Site 2 was located off of Vibert Road, downstream of Highway 11/17. The bridge for Vibert Road just upstream of the sampling was new from the realignment of Highway 11/17 in recent years. The flow of the creek was perpendicular to the road. This narrow sampling site was abundant in both riparian vegetation such as reeds and canary grass; as well as aquatic plants such as wild calla and starwort. The substrate of this site was characterized by a cobble and organic mix, with a highly murky water column evident. The channel was relatively narrow and shallow with what appeared to be slow subsurface flow. The channel was partially shaded, with no vegetation tall enough to provide shade throughout the day.

Site 3 – Cooper Road, Downstream	
A: 2010 Upstream Photo	**B: 2010 Downstream Photo**
	

C: 2010 Upstream of Culvert Photo	D: 2010 Beaver Dam Upstream Photo
	
E: 2010 Culvert, Upstream Direction Photo	**F: 2010 Iron rich Soil, floating orange mats**
	

G: 2010 Culvert Photo	H: October 16, 2009 Culvert Photo
	

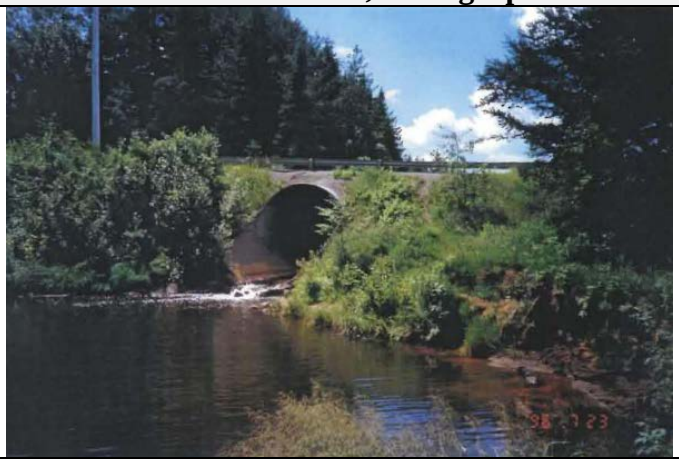
Comments

Site 3 was located at the end of Cooper Road; adjacent to an industrial sector. This site appeared to be considerably disturbed relative to all site locations. Both culverts were dammed on the upstream side, by what was observed to be beaver activity, and both culverts were perched on the downstream side. Low water levels in the culvert can be observed by looking at the waterline of the culvert on Plate E. This beaver dam had created a small stagnant pond downstream of the culverts. Upstream of the dam, all qualitative parameters including colour, depth, width, flow and vegetation the creek appeared remarkably different. Plate A shows considerable vegetation established on the downstream side of the culverts, suggesting the dams presence through an extended period of time. The water was highly turbid, with a cobble and muck substrate. Abundant aquatic vegetation had established, with abundant emergent plants along the edges of the pond and submergents in the middle of the small water body. What appeared to be floating mats of iron bacteria and iron rich soil were observed as well (Plate F). The culverts themselves did not appear to be compromised by the blockage and the road was still sufficiently wide for vehicle transport. Site 3 should be investigated in the summer of 2011 to ensure that water quality and the roadway have not further degraded.

2010 photo documentation of Site 3 displayed no significant changes from the photos taken by the LRCA during a site visit in October 2009. The 2009 and 2010 photos show that both culverts have low flow with considerable vegetation growth just downstream of the culverts. Erosion surrounding the culverts does not appear to have increased from 2009 to 2010.

Site 7 - 25th Side Road, Downstream from Irrigation Pond	
A: 2010 Upstream Photo	**B: 2010 Downstream Photo**
	

C: 2010 Culvert Opening to Large Pool Photo	D: 2010 Eroding Bank Photo
	

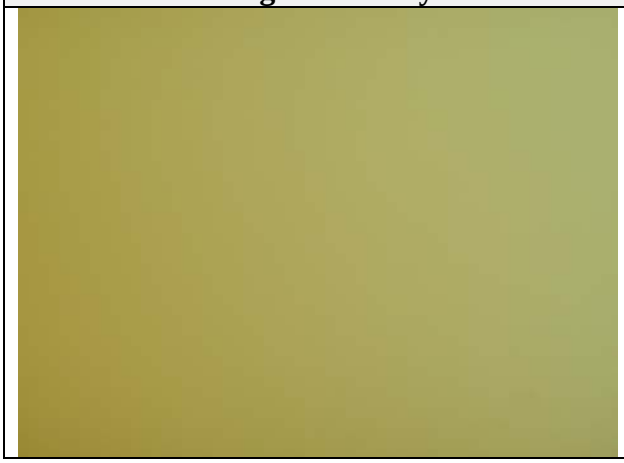
E: 1996 Culvert Photo, Facing Upstream


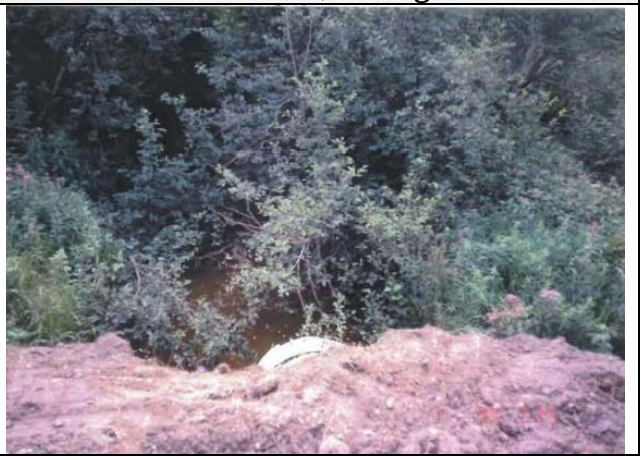
Comments

Site 7 was located off of 25th Side Road . This site was characterized by a large widening of the channel into a pool downstream of the 25th Side Road culvert. The pool narrowed again into the channel where sampling was conducted. There was considerable woody debris downstream from the sampling site creating a small stick jam which seemed to have little effect upon flow. As displayed on Plate D, there was an eroding bank upstream of the site, with erosion slumps composed of sandy clay just in front of the bank. There was also floating orange debris (likely iron bacteria) in the water comparable to that found at Site 3. The vegetation of the site was varied on each side of the stream, with the south side gravel beach and the north side largely thick grasses and shrubs. The substrate was composed mostly of cobble with a layer of muck and easily disturbed sediment. The water was turbid, making an underwater picture of the substrate not possible.

When compared to the 1996 culvert photo, this site appears to have undergone some significant changes. The vegetation adjacent to the culvert appeared to be composed of dense shrub growth in 1996. The vegetation adjacent to the culvert in 2010 was mostly shrub growth but appeared to be significantly less dense with a spruce tree present. The erosion observed in 2010 appears to have already been present in 1996, with the forward slump of the bank increasing over time.

Site 10 – Pole Line Road	
A: 2010 Upstream Photo	**B: 2010 Downstream Photo**
	

C: 2010 High Turbidity Photo	**D: 2010 Manicured Lawn Photo**
	

E: 2010 Culvert Downstream Photo	**F: 1996 Culvert Photo, Facing Downstream**
	

Comments

Site 10 located off of Pole Line Road was directly adjacent to private land. The general area was characterized by agricultural lands. This site had abundant woody debris upstream with some concrete debris as well as some woody debris downstream. The vegetation was composed largely of shrubs such as willow, alder and black ash with ferns abundant in the understory. The stream was very shallow with a relatively low flow rate, and highly turbid water. The substrate was largely cobble with a thin layer of muck, silt and clay overlying the cobble. The lawn adjacent to the stream was manicured up to the waters edge. This may yet affect stability of the stream edge as well as run off from the adjacent property. The 1996 culvert photos show that some observable changes directly downstream of the culvert have occurred. Shrub growth has remained the dominant the vegetation type with an increase in growth which provides complete shade to the sampling location. The soil around the culvert appears to have eroded; causing the culvert to be significantly more exposed in 2010 than in 1996.

Site 11– 20th Side Road, Closest Site to Confluence	
A: 2010 Upstream Photo	**B: 2010 Downstream Photo**
	

C: 2010 Eroded Bank Photo	D: 2010 Narrowing of Channel (facing downstream, upstream of site) Photo
	

E: 1996 Culvert Photo, Facing Upstream	F: 1996 Culvert Photo, Facing Downstream
	

Comments

Site 11 located on 20th Side Road was the site closest to the Pennock Creek and Neebing River confluence. This site is characterized by a very large culvert upstream followed by a narrowing of the channel around a vegetated sediment bar within the channel (Plate D). This bar of sediment appeared to be formed by an eroding bank on the left side of the stream. Sampling was done directly downstream of the eroded bank. There was abundant woody debris both up and downstream of the site, with abundant concrete and asphalt throughout the stream and substrate. The culvert particularly had abundant build up of woody debris, with some vegetation beginning to take root. There was a highly eroded bank, perhaps responsible for the vegetated island, upstream of the sampling site. The substrate was characterized largely by cobble with large pockets of muck and clay upstream. Vegetation of the site was highly variable, dominated by shrubs and herbs upstream and a conifer stand downstream. Grasses were the dominant vegetation covering the encroaching sediment bars. When compared to the culvert photo taken in 1996 there appears to be no significant changes with the exception of channel debris. Plate E shows that no debris had built up at the downstream end of the culvert. Some build up was evident on the upstream side of the culvert displayed on Plate F. Plate A, the 2010 upstream photo, shows that debris was considerable, with plants beginning to grow upon the mounds of woody debris. The culvert itself appears to be in relatively good condition.

APPENDIX I

LABORATORY CERTIFICATES OF ANALYSIS AND ANALYTICAL REPORTS

Due to a technical error in the field, samples collected in 2010 at sampling Site 11 were mislabelled as Site 9, which was only sampled during the 1996 Watershed Assessment. Laboratory analytical results reported as Site 9 in 2010 have been referred to within the text of the report as Site 11.

Certificate of Analysis

LAKEHEAD REGION CONSERVATION AUTHORITY

ATTN: TAMMY COOK

130 CONSERVATION ROAD
P.O. BOX 10427
THUNDER BAY ON P7B 6T8

Report Date: 23-JUL-10 13:41 (MT)
Version: FINAL

Lab Work Order #: **L908385** **Date Received:** **14-JUL-10**

Project P.O. #: NOT SUBMITTED
Job Reference:
Legal Site Desc:
CofC Numbers: L908385

Other Information:

Comments:

Richard Clara
General Manager, Thunder Bay

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L908385-1	L908385-2	L908385-3	L908385-4	L908385-5
	Description	GRAB	GRAB	GRAB	GRAB	GRAB
	Sampled Date	13-JUL-10	13-JUL-10	13-JUL-10	14-JUL-10	14-JUL-10
	Sampled Time	10:30	12:30	14:00	10:00	11:30
	Client ID	PC1 PENNOCK CREEK - SITE #1	PC2 PENNOCK CREEK - SITE #10	PC3 PENNOCK CREEK - SITE #2	PC4 PENNOCK CREEK - SITE #3	PC5 PENNOCK CREEK - SITE #7
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (EC) (uS/cm)	303	550	511	513	494
	Total Dissolved Solids (mg/L)	261	424	400	395	380
	Turbidity (NTU)	1.92	6.33	5.24	8.93	11.0
Anions and Nutrients	Ammonia-N, Total (mg/L)	<0.020	0.063	<0.020	0.085	<0.020
	Chloride (Cl) (mg/L)	18.9	59.6	52.1	55.5	76.1
	Nitrate-N (NO3-N) (mg/L)	<0.030	<0.030	<0.030	<0.030	0.049
	Nitrite-N (NO2-N) (mg/L)	<0.020	<0.020	<0.020	<0.020	<0.020
	Phosphorus (P)-Total (mg/L)	0.0245	0.0385	0.0320	0.0261	0.0128
	Sulphate (SO4) (mg/L)	<0.30	1.15	0.49	0.31	7.74
Bacteriological Tests	Escherichia Coli (MPN/100mL)	5	14	59	25	10
	Total Coliforms (MPN/100mL)	2000	> 2420	1700	> 2420	> 2420
Total Metals	Aluminum (Al) (mg/L)	0.011	<0.010	0.030	<0.010	0.010
	Antimony (Sb) (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Arsenic (As) (mg/L)	0.0011	0.0014	0.0016	0.0012	<0.0010
	Barium (Ba) (mg/L)	0.019	0.024	0.026	0.030	0.055
	Beryllium (Be) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Bismuth (Bi) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Boron (B) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Cadmium (Cd) (mg/L)	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090
	Calcium (Ca) (mg/L)	38.0	65.7	66.0	60.3	52.3
	Chromium (Cr) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Cobalt (Co) (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Copper (Cu) (mg/L)	<0.0010	<0.0010	0.0013	<0.0010	<0.0010
	Iron (Fe) (mg/L)	1.45	2.06	1.26	2.13	1.20
	Lead (Pb) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Magnesium (Mg) (mg/L)	13.1	21.5	21.6	19.7	15.9
	Manganese (Mn) (mg/L)	1.22	0.624	0.480	1.83	0.299
	Molybdenum (Mo) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Nickel (Ni) (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
	Potassium (K) (mg/L)	<1.0	1.5	1.5	1.9	1.5
	Selenium (Se) (mg/L)	<0.00040	<0.00040	0.00048	0.00042	<0.00040
	Silicon (Si) (mg/L)	9.8	7.7	7.0	8.5	8.1
	Silver (Ag) (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Strontium (Sr) (mg/L)	0.0587	0.0934	0.0979	0.0873	0.0774
	Thallium (Tl) (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
	Tin (Sn) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L908385-1	L908385-2	L908385-3	L908385-4	L908385-5
	Description	GRAB	GRAB	GRAB	GRAB	GRAB
	Sampled Date	13-JUL-10	13-JUL-10	13-JUL-10	14-JUL-10	14-JUL-10
	Sampled Time	10:30	12:30	14:00	10:00	11:30
	Client ID	PC1 PENNOCK CREEK - SITE #1	PC2 PENNOCK CREEK - SITE #10	PC3 PENNOCK CREEK - SITE #2	PC4 PENNOCK CREEK - SITE #3	PC5 PENNOCK CREEK - SITE #7
Grouping	**Analyte**					
WATER						
Total Metals	Titanium (Ti) (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
	Tungsten (W) (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U) (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Vanadium (V) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Zinc (Zn) (mg/L)	<0.0030	<0.0030	0.0111	0.0067	<0.0030
	Zirconium (Zr) (mg/L)	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
CL-TB	Water	Chloride (Cl)	APHA 4110 B-Ion Chromatography
EC-CAP-TB	Water	Conductivity (EC)	APHA 2510 B-electrode
MET-ONT-PWQO-WT	Water	Metals, Total PWQO	EPA 200.8 (ICP/MS)
NH4-TB	Water	Ammonia-N, Total	APHA 4500-NH3 G - Colourimetry
NO2-TB	Water	Nitrite-N	APHA 4110 B-Ion Chromatography
NO3-TB	Water	Nitrate-N	APHA 4110 B-Ion Chromatography
P-TOT-TB	Water	Phosphorus (P)-Total	APHA 4500-P B,F Colourimetry
SO4-TB	Water	Sulphate (SO4)	APHA 4110 B-Ion Chromatography
SOLIDS-TDS-TB	Water	Total Dissolved Solids	APHA 2540 C
TC,EC-18QT97-TB	Water	Total Coliform and E.coli	APHA SM 9223B C-18
TURBIDITY-TB	Water	Turbidity	APHA 2130 B-Nephelometer

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

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

Laboratory Definition Code	Laboratory Location
WT	ALS LABORATORY GROUP - WATERLOO, ONTARIO, CANADA
TB	ALS LABORATORY GROUP - THUNDER BAY, ONTARIO, CANADA

Chain of Custody Numbers:

L908385

GLOSSARY OF REPORT TERMS

Surrogate A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg milligrams per kilogram based on dry weight of sample.
mg/kg wwt milligrams per kilogram based on wet weight of sample.
mg/kg lwt milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L milligrams per litre.
< - Less than.
D.L. The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as receieved by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC # L908385 Page 1 of 1

Report To Tammy Cook	**Report Format / Distribution**
Company: Lakehead Region Conservation Authority	Standard ✓ Other (specify):
Contact: Scott Drebit	PDF ✓ Excel ✓ Digital Fax
Address: 130 Conservation Rd Box 10427 Thunder Bay, ON P7B 6T8	Email 1: info@lakeheadca.com
Phone: 344-5857 Fax: 345-9156	Email 2: Scott@lakeheadca.com
Invoice To Same as Report ? (Yes) No	**Client / Project Information**
THE QUESTIONS BELOW MUST BE ANSWERED FOR WATER SAMPLES (circle Yes or No)	Job #:
Are any samples taken from a regulated DW System? Yes (No)	PO / AFE:
If yes, an authorized Drinking Water COC MUST be used for this submission.	LSD:
Is the water sampled intended to be potable for human consumption? Yes (No)	Quote #: Q23374
Lab Work Order # (lab use only)	**ALS Contact:** **Sampler:** S. Drebit D. Brazeau

Service Requested (Rush for routine analysis subject to availability)
✓ Regular (Default)
Priority (Specify Date Required → →) Surcharges apply
Emergency (1 Business Day) - 100% Surcharge
For Emergency < 1 Day, ASAP or Weekend - Contact ALS

Analysis Request
Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Routine	Total Metals (P)	Nutrients (P)	Total Coliform E. coli (P) (TC/EC)	Number of Containers
PC1	Pemark Creek - Site # 1	13-JUL-10	10:30	Grab	✓	✓	✓	✓	4
PC2	Pemark Creek - Site # 10	13-JUL-10	12:30	Grab	✓	✓	✓	✓	4
PC3	Pemark Creek - Site # 7	13-JUL-10	14:00	Grab	✓	✓	✓	✓	4
PC4	Pemark Creek - Site # 3	14-JUL-10	10:00	Grab	✓	✓	✓	✓	4
PC5	Pemark Creek - Site # 7	14-JUL-10	11:30	Grab	✓	✓	✓	✓	4

NOT CONSUMED

Special Instructions / Regulations / Hazardous Details

Reg 153 Table 1 2 3 TCLP MISA (PWQO) OTHER (please specify):
Circle one - Note drinking water samples MUST USE DW Chain of Custody

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

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)			SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / (No ?) If Yes add SIF
	14 Jul/10	2:55 pm	ATC	14-JULY	2:55	15.5°C	KM	July 14/10	3:35	

14.7/16.3

TYFM014 26-Mar-10

Certificate of Analysis

LAKEHEAD REGION CONSERVATION AUTHORITY

ATTN: TAMMY COOK

130 CONSERVATION ROAD
P.O. BOX 10427
THUNDER BAY ON P7B 6T8

Report Date: 30-JUL-10 14:26 (MT)
Version: FINAL

Lab Work Order #: **L910511** **Date Received:** **20-JUL-10**

Project P.O. #: NOT SUBMITTED
Job Reference:
Legal Site Desc:
CofC Numbers: L910511

Other Information:

Comments:

Richard Clara
General Manager, Thunder Bay

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L910511-1	L910511-2	L910511-3	L910511-4	
	Description	WATER	WATER	WATER	WATER	
	Sampled Date	19-JUL-10	19-JUL-10	19-JUL-10	19-JUL-10	
	Sampled Time	11:15	13:00	14:10	14:55	
	Client ID	PC9 PENNOCK CREEK - SITE #9	CC12 CORBETT CREEK - SITE #12	CC9 CORBETT CREEK - SITE #9	CC7 CORBETT CREEK - SITE #7	
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (EC) (uS/cm)	549	374	549	300	
	Total Dissolved Solids (mg/L)	425	283	424	240	
	Turbidity (NTU)	16.3	2.40	3.92	4.23	
Anions and Nutrients	Ammonia-N, Total (mg/L)	<0.020	<0.020	<0.020	<0.020	
	Chloride (Cl) (mg/L)	77.3	35.8	30.5	5.89	
	Nitrate-N (NO3-N) (mg/L)	0.124	0.856	<0.030	<0.030	
	Nitrite-N (NO2-N) (mg/L)	<0.020	<0.020	<0.020	<0.020	
	Phosphorus (P)-Total (mg/L)	0.0169	<0.0050	0.0298	0.0159	
	Sulphate (SO4) (mg/L)	8.25	7.78	<0.30	1.49	
Bacteriological Tests	Escherichia Coli (MPN/100mL)	63	35	210	110	
	Total Coliforms (MPN/100mL)	1600	2000	2000	> 2420	
Total Metals	Aluminum (Al) (mg/L)	0.175	0.042	0.030	0.027	
	Antimony (Sb) (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	
	Arsenic (As) (mg/L)	0.0017	<0.0010	0.0013	<0.0010	
	Barium (Ba) (mg/L)	0.056	0.016	0.018	0.013	
	Beryllium (Be) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Bismuth (Bi) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Boron (B) (mg/L)	<0.050	<0.050	<0.050	<0.050	
	Cadmium (Cd) (mg/L)	<0.000090	<0.000090	<0.000090	<0.000090	
	Calcium (Ca) (mg/L)	66.8	41.6	83.6	45.7	
	Chromium (Cr) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Cobalt (Co) (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
	Copper (Cu) (mg/L)	0.0022	0.0017	<0.0010	<0.0010	
	Iron (Fe) (mg/L)	1.52	0.436	0.596	0.832	
	Lead (Pb) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Magnesium (Mg) (mg/L)	18.3	14.9	25.8	15.0	
	Manganese (Mn) (mg/L)	0.232	0.0179	1.27	0.0963	
	Molybdenum (Mo) (mg/L)	0.0010	<0.0010	<0.0010	0.0012	
	Nickel (Ni) (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	
	Potassium (K) (mg/L)	2.0	2.1	1.1	1.1	
	Selenium (Se) (mg/L)	0.00041	<0.00040	0.00044	<0.00040	
	Silicon (Si) (mg/L)	8.4	8.7	8.6	7.0	
	Silver (Ag) (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Strontium (Sr) (mg/L)	0.0978	0.0572	0.109	0.0640	
	Thallium (Tl) (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	
	Tin (Sn) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L910511-1	L910511-2	L910511-3	L910511-4	
	Description	WATER	WATER	WATER	WATER	
	Sampled Date	19-JUL-10	19-JUL-10	19-JUL-10	19-JUL-10	
	Sampled Time	11:15	13:00	14:10	14:55	
	Client ID	PC9 PENNOCK CREEK - SITE #9	CC12 CORBETT CREEK - SITE #12	CC9 CORBETT CREEK - SITE #9	CC7 CORBETT CREEK - SITE #7	
Grouping	**Analyte**					
WATER						
Total Metals	Titanium (Ti) (mg/L)	0.0074	0.0022	<0.0020	<0.0020	
	Tungsten (W) (mg/L)	<0.010	<0.010	<0.010	<0.010	
	Uranium (U) (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	
	Vanadium (V) (mg/L)	0.0017	<0.0010	<0.0010	<0.0010	
	Zinc (Zn) (mg/L)	<0.0030	<0.0030	0.0098	<0.0030	
	Zirconium (Zr) (mg/L)	<0.0040	<0.0040	<0.0040	<0.0040	

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
CL-TB	Water	Chloride (Cl)	APHA 4110 B-Ion Chromatography
EC-CAP-TB	Water	Conductivity (EC)	APHA 2510 B-electrode
MET-ONT-PWQO-WT	Water	Metals, Total PWQO	EPA 200.8 (ICP/MS)
NH4-TB	Water	Ammonia-N, Total	APHA 4500-NH3 G - Colourimetry
NO2-TB	Water	Nitrite-N	APHA 4110 B-Ion Chromatography
NO3-TB	Water	Nitrate-N	APHA 4110 B-Ion Chromatography
P-TOT-TB	Water	Phosphorus (P)-Total	APHA 4500-P B,F Colourimetry
SO4-TB	Water	Sulphate (SO4)	APHA 4110 B-Ion Chromatography
SOLIDS-TDS-TB	Water	Total Dissolved Solids	APHA 2540 C
TC,EC-18QT97-TB	Water	Total Coliform and E.coli	APHA SM 9223B C-18
TURBIDITY-TB	Water	Turbidity	APHA 2130 B-Nephelometer

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

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

Laboratory Definition Code	Laboratory Location
WT	ALS LABORATORY GROUP - WATERLOO, ONTARIO, CANADA
TB	ALS LABORATORY GROUP - THUNDER BAY, ONTARIO, CANADA

Chain of Custody Numbers:

L910511

GLOSSARY OF REPORT TERMS

Surrogate A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg milligrams per kilogram based on dry weight of sample.
mg/kg wwt milligrams per kilogram based on wet weight of sample.
mg/kg lwt milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L milligrams per litre.
< - Less than.
D.L. The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as receieved by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Report To	Tammy Cook
Company:	Lakehead Region Conservation Authority
Contact:	Scott Drebit
Address:	130 Conservation Rd P.O. Box 10427
	Thunder Bay, ON P7B 6T8
Phone:	344-5857 Fax: 345-9156
Invoice To	Same as Report ? (Yes) No

THE QUESTIONS BELOW MUST BE ANSWERED FOR WATER SAMPLES (circle Yes or No)

Are any samples taken from a regulated DW System? Yes (No)

If yes, an authorized Drinking Water COC MUST be used for this submission.

Is the water sampled intended to be potable for human consumption? Yes (No)

Report Format / Distribution

Standard ✓ Other (specify):

PDF ✓ Excel ✓ Digital Fax

Email 1: info@lakeheadca.com

Email 2: Scott@lakeheadca.com

Client / Project Information

Job #:

PO / AFE:

LSD:

Quote #: Q23274

Service Requested (Rush for routine analysis subject to availability)

✓ Regular (Default)

Priority (Specify Date Required → →) Surcharges apply

Emergency (1 Business Day) - 100% Surcharge

For Emergency < 1 Day, ASAP or Weekend - Contact ALS

Lab Work Order # (lab use only):

ALS Contact:

Sampler: S. Drebit, D. Brazeau

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Routine	Total Metals (P)	Nutrients (P)	Total Coliform/E.Coli (P)	Number of Containers
1 PC9	Pemock Creek - Site #9	19-JUL-10	11:15	Grab	✓	✓	✓	✓	4
2 CC17	Corbett Creek - Site #17	19-JUL-10	13:00	Grab	✓	✓	✓	✓	4
3 CC9	Corbett Creek - Site #9	19-JUL-10	14:10	Grab	✓	✓	✓	✓	4
4 CC7	Corbett Creek - Site #7	19-JUL-10	14:55	Grab	✓	✓	✓	✓	4

Special Instructions / Regulations / Hazardous Details

Reg 153 Table 1 2 3 TCLP MISA (PWQO) OTHER (please specify):

Circle one - Note drinking water samples MUST USE DW Chain of Custody

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
	Jul 20/10	3:08 pm	VB	20-Jul-10	3:08 pm	9.6 °C		July 20/10	3:10	

8:04 9.0 °C

TYFM014 26-Mar-10