Water Quality and Management Of Lake Trout Lakes

County of Renfrew 2011

Protecting our environment. Ontario

August 2016

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Notice to Reader

This information is being provided to you as a reference for water quality in lake trout lakes in the County of Renfrew and to assist with future planning decisions on lake trout lakes in the County Of Renfrew.

The findings, conclusions and recommendations of the Ministry of the Environment and Climate Change (the Ministry) set out in this report are based in part, on information provided by others. The information that has been provided by others and which is relied upon by the Ministry is understood to be factual and correct; however the Ministry cannot guarantee that the information that has been provided by others is accurate or complete.

The findings, conclusions and recommendations of the Ministry of the Environment and Climate Change (the Ministry) set out in this report are based, at least in part, on information collected from recent sampling conducted by Ministry staff. The sampling was conducted in accordance with approved Ministry guidelines and methods for field operations. Water quality samples were analyzed by the Ministry of the Environment's Laboratory Services Branch in Toronto according to accredited methodologies. Temperature and dissolved oxygen profiles were recorded after calibration of the instruments according to the manufacturer's manual.

Ongoing sampling surveys will be conducted in the future by Ministry staff to evaluate changes in water quality of lake trout lakes in the County of Renfrew.

Although the Ministry endeavours to ensure that the information contained in the summary of the data is as accurate as possible, errors may occasionally occur.

A more detailed description of lakes and management of lake trout lakes in Renfrew County can be found in a previous report titled Water Quality and Management of Coldwater Lakes; County of Renfrew: 2003 This report can be obtained by calling the Kingston Regional Office at 1-800-267-0974 or 613-549-4000.

Other reports describing water quality in other Counties in Eastern Ontario can be found on the internet at https://archive.org/details/omote?&and[]=lake%20trout.

Avertissement: Cette publication hautement spécialisée, « Water Quality and Management of Lake Trout Lakes; County of Renfrew 2011 », n'est disponible qu'en anglais, conformément au Règlement de l'Ontario 671/92, selon lequel il n'est pas obligatoire de la traduire en vertu de la *Loi sur les Services en Français*. Pour obtenir des renseignements en français, veuillez communiquer avec le Bureau de le Région de l'Est du Ministère de l'Environnement et de l'Action en Matière de Changement Climatique par téléphone au (613)-549-4000.

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Introduction

Inland lakes constitute a major environmental, recreational and economic resource for the province of Ontario. In 1990, anglers spent an estimated 2.5 billion dollars in purchases and activities related to fishing in Ontario's inland lakes.[1] Increased demand for waterfront property and the proximity of lakes in southern Ontario to major urban centers has resulted in considerable residential and commercial development on many of our lakes.

Lakes have a finite capacity to accommodate most types of development. One of the primary concerns of shoreline development is its impact to water quality. Land use changes around a lake can have a detrimental effect on water quality. Continuing pressure to develop shorelines requires that periodic water quality assessments be undertaken to assist in planning decisions regarding lake development.

The primary linkage between water quality and shoreline development is nutrient input to the lake. Development can increase the supply and availability of "fertilizing" plant nutrients such as phosphorus and nitrogen. These nutrients promote the growth of algae and other aquatic plants. As the proliferating algae die off they settle to the lake bottom and decompose. The decomposition process consumes oxygen, which reduces the amount of dissolved oxygen (DO) in the bottom waters of the lake. This bottom layer is often referred to as the hypolimnion. Development can be especially detrimental to lake trout lakes. Habitat requirements for lake trout are more demanding than those of other fish species. Lake trout require clean, clear, deep lakes with well-oxygenated bottom waters. Although lake trout are present in only 1% of Ontario's lakes, these lakes make up 25% of the world's lake trout resource.[2] Lake trout lakes, more than any others, epitomize the ideal of pristine, clear, quintessential wilderness waters.

Lake trout lakes are an important part of our natural heritage and provide high quality angling and recreational experiences. In a significant number of Ontario lakes, lake trout populations have been lost or are severely impaired. Unless properly managed, these fisheries and their benefits will be lost forever.

The County of Renfrew (Fig. 1) is an upper tier municipality and is responsible for the preparation of an Official Plan (OP). The *Planning Act* requires a municipality to have regard to the Provincial Policy Statement (PPS).

[1] MOE, 1997. Economic analysis of the proposed Lakeshore Development policy: Social-economic value of water in Ontario. Economic Services Branch, Ministry of the Environment.

[2] MOE, MNR & MMAH. 2003. Lakeshore Capacity Assessment Handbook: Protecting Water Quality in Inland Lakes on Ontario's Precambrian Shield. Draft Report. February, 2003.

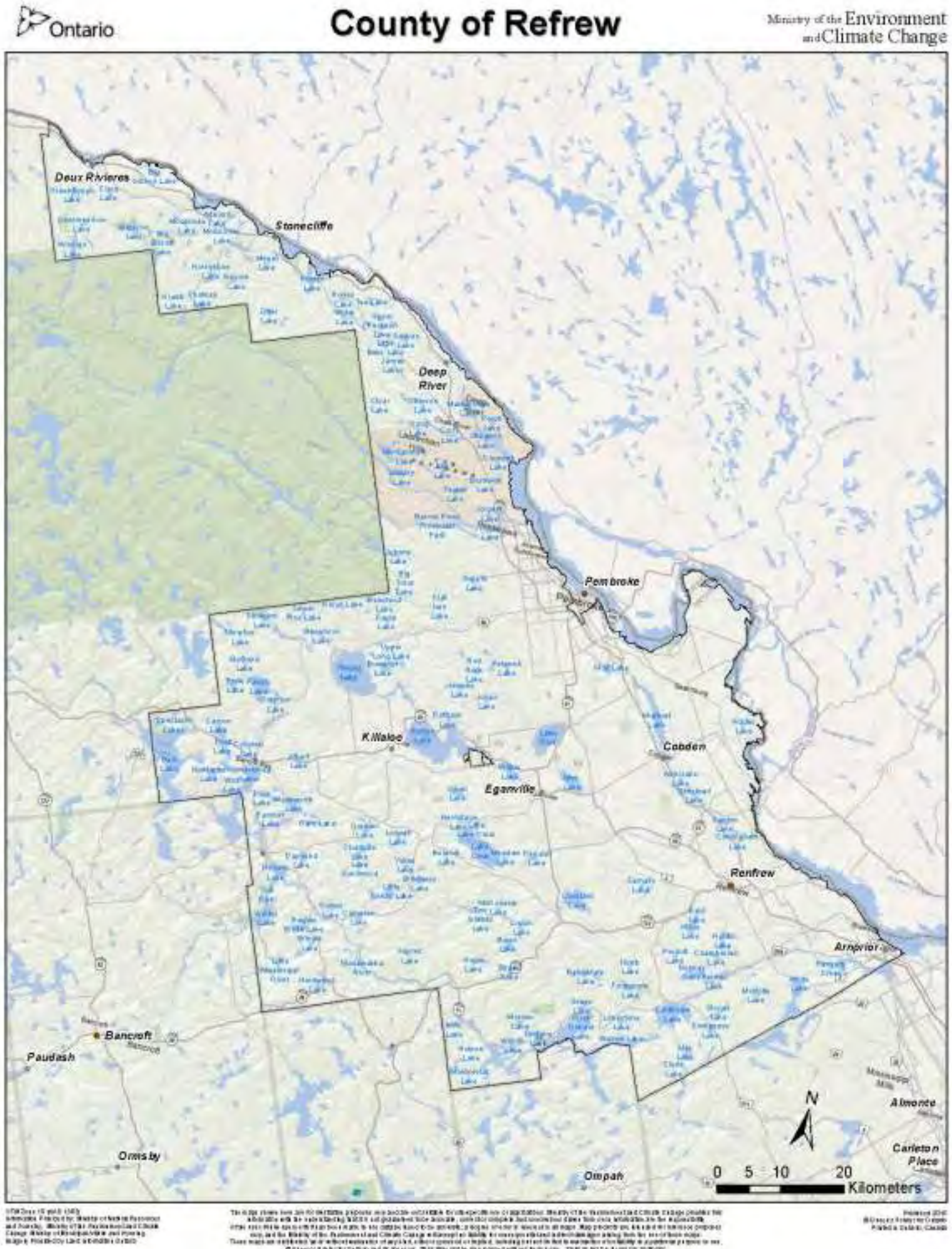


Figure 1. Map of the County of Renfrew.

The Provincial Policy Statement outlines matters of provincial interest in land use planning. The PPS requires that development be permitted only if there will be no negative impact on natural heritage features such as fish habitat and water quality.

In order to assist the County in developing land use policies pertaining to shoreline development, the Eastern Region of the Ministry of the Environment and Climate Change undertook a water quality assessment of 38 cold water lakes in Renfrew County. Of the 38 lakes sampled in 2003, nineteen lakes were lake trout lakes and nineteen were cold water lakes that support populations of brook and rainbow trout, lake whitefish or lake herring. The data from the 2003 survey can be found in a previous report titled Water Quality and Management of Lake Trout Lakes; County of Renfrew 2003.

This report documents the water quality of 22 lake trout lakes sampled in 2010 and 2011 with detailed lake data sheets (Appendix 3) added for 7 new lakes included in this study. Some lakes were also sampled in other years between 2003 and 2011.

Sources of Phosphorus

In lakes on the Canadian Shield, phosphorus is the most limiting nutrient for the growth of algae and aquatic plants. It is found naturally in all aquatic ecosystems. Lakes receive phosphorus from surface runoff from their surrounding land area; from tributary inflows from upstream lakes and wetlands; from atmospheric deposition directly on the lake surface and from the bottom sediments of a lake which can re-solubilize phosphorus under anoxic (no oxygen) conditions.

Surface runoff from across the watershed can pick up particles of soil and vegetation containing phosphorus. This surface runoff drains into lakes and their tributary streams.
The phosphorus in atmospheric deposition includes dust, pollen and other wind borne particulates from bare agricultural fields and unpaved roads. Human activities in the vicinity of a lake introduce a supply of phosphorus, sometimes referred to as the artificial or anthropogenic load. Domestic sewage contains high levels of phosphorus and nitrogen. The most common form of sewage disposal servicing shoreline development is the septic tank leaching bed system. A leaching bed provides for an underground release of sewage effluent into the soil. Phosphorus and nitrogen from the effluent can migrate through the ground and impact water resources. Although some of the phosphorus and nitrogen from the sewage effluent is adsorbed by the soil or taken up by vegetation, over the long-term these nutrients may be released to the lake.

Sewage is not the only source of phosphorus arising from shoreline development activities. Land use changes in the immediate vicinity of a lake can result in additional phosphorus inputs. Disturbance of the natural shoreline through the clearing of trees and undergrowth and the addition of lawns, driveways and other landscape features decrease the permeability of the ground.

This “ground hardening” reduces infiltration of water resulting in increased surface runoff to the lake. The application of fertilizers to lawns and gardens and increased soil erosion caused by the disturbance of the natural shoreline introduce additional sources of phosphorus to the lake.

Effects of Phosphorus

Unlike other aquatic pollutants, phosphorus is not directly toxic to aquatic life. High levels of phosphorus, however, can set off a sequence of events that can have serious impacts on the quality of recreational waters and their fisheries.

Phosphorus, more than any other nutrient, promotes the growth of algae and larger aquatic plants (macrophytes). Because phosphorus in freshwater ecosystems is the nutrient in shortest supply, small additions of phosphorus can result in accelerated growth and increased abundance of algae and macrophytes.

Algae are single-celled, mostly microscopic, green plants. A certain amount of algae and aquatic plants are essential for the proper functioning of a healthy lake ecosystem. They provide food and shelter to fish and, through the process of photosynthesis, release oxygen to the water column. Generally, an increase in the production of algae gives rise to an increase in growth at all levels of the food chain up to and including fish. This causes changes in species composition and reduces levels of oxygen in the bottom waters of deeper lakes. The increase in biological productivity of a lake in response to nutrient enrichment is referred to as eutrophication.

While a certain amount of nutrient enrichment is beneficial, run-away eutrophication can bring about a loss in the recreational value of a body of water and degrade the structure of the biological community. Excessive growth of rooted aquatic plants can blanket the shallow regions and interfere with swimming and boating, while increased concentrations of algae in the water can result in decreased water clarity. Algae and other organic matter eventually settle to the bottom of the lake where they decompose through bacterial action. This decomposition process consumes oxygen.

Cold water salmonid species of fish, such as lake trout, require cold, well-oxygenated water found at the bottom of deep lakes and are sensitive to oxygen depletion which occurs in the deeper bottom waters. Reduced levels of oxygen in deeper waters force these species to migrate into shallower, warmer, well oxygenated water. These conditions increase the stress levels on lake trout and expose juvenile lake trout to predation.

Lake Trophic Classification

One common method of classifying lakes is on a continuously rising trophic (nutrient enrichment) scale according to their biological productivity. This classification system is normally related to the nutrient concentration levels in a lake system, its water clarity and its algal biomass.

Lakes with relatively little nutrient input and low productivity are referred to as oligotrophic. Oligotrophic lakes are characterized by low levels of algae, exceptionally clear water, low species diversity and a well-oxygenated hypolimnion (deep bottom waters that remain cold throughout the summer). These types of lakes provide conditions that are suitable for salmonid species such as lake trout.

At the other end of the spectrum are the eutrophic (enriched) lakes. These lakes are rich in nutrients and highly productive. Eutrophic lakes are generally characterized by dense populations of aquatic plants and algae, reduced water clarity, and if thermally stratified, depletion or low levels of dissolved oxygen in the hypolimnion. These types of lakes are usually not suitable for cold-water species such as lake trout.

Mesotrophic lakes occupy an intermediate position on the spectrum between eutrophy and oligotrophy and are considered moderately enriched.

While changes to trophic state do not occur at sharply defined stages, numeric criteria are still useful at defining different levels of enrichment (Table 1).

Table 1. Lake Trophic Classification Scheme.

Trophic State	Total Phosphorus (□g /L)	Secchi Disc (m)	Algal Density
Oligotrophic	< 10	> 5	low
Mesotrophic	10 - 20	3 - 5	moderate
Eutrophic	> 20	< 3	high

Lake Processes

In order to understand factors influencing the water quality of a lake, it is necessary to consider several natural lake processes. Lakes in southern Ontario, typical of other northern temperate lakes, undergo an annual cycle of physical, chemical and biological changes that affect temperature and oxygen concentrations and significantly influence lake trout habitat.

Physical Changes

During the winter when lakes are ice-covered, water temperatures range from 0°C at the surface to 4°C at the bottom. In the spring, after ice-out, the entire lake volume is at or slightly warmer than 4°C, the temperature of maximum water density. At this time, wind action is capable of mixing the entire lake volume. The net result is relatively uniform well mixed water mass from the surface to the bottom.

Following this brief period of spring mixing, termed spring overturn, warmer weather brings about a gradual warming of the surface waters. The warmer surface water is less dense and therefore floats over the colder, denser bottom water. This temperature-dependent density gradient divides the lake into three distinct thermally stratified layers: the epilimnion, metalimnion and hypolimnion (Fig. 2).

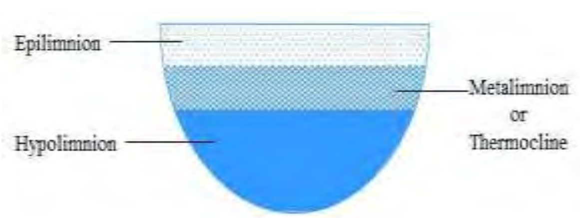


Figure 2. Thermal Stratification of Lake.

The epilimnion is the zone of warm lighter surface water and includes the near shore area called the littoral zone where most of the rooted aquatic plants are found. The hypolimnion is the zone of deep, cold and relatively undisturbed bottom water. During the summer, once this separation of surface and bottom water strata is established, the lake is said to be thermally stratified.

Between the epilimnion and the hypolimnion, there is a zone of rapid decrease in water temperature called the metalimnion. Within this zone, the depth where the maximum decrease in temperature occurs is defined as the thermocline.

During summer stratification, wind-induced physical mixing will circulate warm water throughout the epilimnion. The depth of the epilimnion is determined to some extent by lake area, fetch and local topography, water clarity as well as other features. In general, lakes with a long fetch, flat local topography and large surface area mix more deeply than other lakes. Summer mixing in the epilimnion does not play a role in the temperature regime below the thermocline. The warming of the surface water confines lake trout, which require cold water temperatures, to deeper waters.

During late August or early September, a brief period exists with little net gain or loss of heat, after which the surface of the lake begins to cool. Temperatures in the epilimnion gradually decline and stratification eventually breaks down as the temperature of the surface layer approaches that of the hypolimnion. De-stratification is complete when epilimnetic temperatures equal hypolimnetic temperatures and wind-induced mixing of the water column results in fall overturn. A relatively long period of autumnal circulation distributes oxygen and nutrients throughout the lake until ice cover is established.

Biological Changes

Algal production occurs in the epilimnion where sunlight is available for photosynthesis. Dead algae and other organic matter eventually sink to the hypolimnion and consume dissolved oxygen through decomposition processes. This process can severely deplete the dissolved oxygen levels in the hypolimnion.

The amount of plant biomass or organic matter produced depends upon the availability of nutrients. In freshwater lakes, phosphorus is the nutrient which is normally least available relative to plant requirements and therefore the nutrient which determines the amount of organic matter produced.

Chemical Changes

For lake trout, one of the most important chemical changes in a lake is those which affect the amount of oxygen in the water. During the spring mixing period, oxygen from the atmosphere and photosynthetic activity of algae and macrophytes is uniformly distributed throughout all lake depths. If mixing is complete and of sufficient duration, the oxygen concentration will approach saturation at all depths of the lake. Although most lakes mix completely, some lakes that are very deep and have a small surface area or are sheltered from the wind may undergo only partial mixing in the hypolimnion. These lakes enter the summer stratification period with a dissolved oxygen deficit in the hypolimnion.

Once stratification is established, the surface waters continue to be supplied with oxygen through exchange with the atmosphere and by photosynthesis. Both algae and rooted plants produce oxygen in the presence of nutrients and light. Although there is a demand for oxygen in the epilimnion by respiration and decomposition, the supply of oxygen usually greatly exceeds the demand. Wind-induced mixing near the surface ensures the distribution of oxygen throughout the epilimnion.

Aquatic life in the hypolimnion depends upon the amount of oxygen acquired during spring overturn.

Since photosynthetic oxygen production is light-dependent and adequate light seldom reaches the hypolimnion, only the surface water is available for photosynthetic oxygen production. In the hypolimnion, the oxygen incorporated during mixing, is gradually consumed over the summer and early fall by biochemical processes. These include respiration by living organisms, reduction by oxygen-consuming chemical reactions, and most importantly through bacterial decomposition of organic matter (e.g. algae) supplied to the hypolimnion.

Fall overturn results, once again, in the uniform distribution of oxygen to all depths of the lake. Wintertime temperature conditions beneath the ice do not restrict lake trout to the deeper waters.

These lake processes when combined play an important role in determining the quality of lake trout habitat available at the end of the stratified season. In highly sensitive lakes small increases in phosphorus supply can significantly affect lake trout habitat.

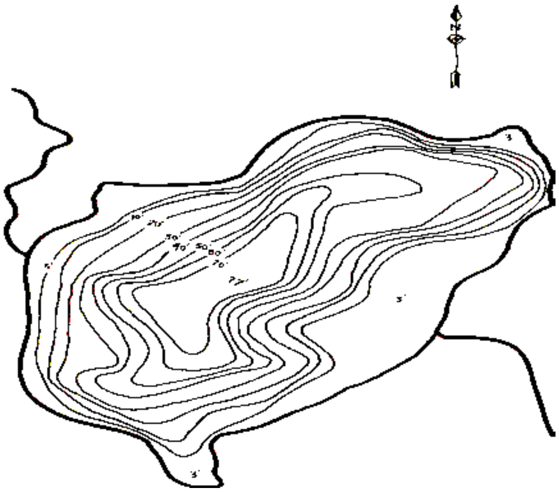
Description of Study Lakes

Lake morphometry refers to measures of the physical dimensions of a lake. This includes its shape, depth and area. The lake morphometry determines the lakes flushing rate which is the time required for a lake to replenish its volume through inputs like precipitation and stream inflows. The morphometric features for lake trout lakes in the County of Renfrew are summarized in Table 2. The individual lake data sheets provided in the Appendix include a map of depth contours (bathymetric chart) for each lake.

Lakes vary greatly in their response to nutrient inputs. The response depends both on the rate of supply of nutrients and the morphometry. The morphometric features act together with water quality to determine the amount of dissolved oxygen habitat available.

Table 2. Morphometric Features of the County of Renfrew Study Lakes.

Lake	Surface Area (ha)	Total Lake Volume ($x10^6$ m^3)	Mean Depth (m)	Maximum Depth (m)	Shoreline Length (km)	Watershed Area (ha)
Astrolabe	14.2	1.67	11.8	29		
Bark	3799	923.3	24.27	87.5	90	272200
Big Gibson	7.82	4.75	7.22	38.1	7.74	749
Big Limestone	31.7	4.19	13.2	30	3.68	
Britchless	114	1.32	1.2	4.9	8.53	
Burns	143	16.13	11.34	36.58	8.7	712
Carson	273	33.5	12.3	44.5	9.7	257900
Charlotte	115.7	12.13	7.44	23.77		
Diamond	80.9	11.27	13.84	39.62	4.51	
Green-Brougham	75	12.63	16.8	43	6.4	413
Green-Radcliffe	29.1	2.12	7.3	22.5	2.9	
Kamaniskeg	2914	377	9.3	40.5	46.7	
Lake Clear	1730.5	173	11.2	42.7	31.5	7705
McSourley	32.9	5.5	19.4	36	6.13	391
Morrow	41.9	2.77	7.5	22.9	6.53	
Muskrat	120.5	215.5	17.8	64.1	34	
Paugh	713	100	14.1	51.8	18	7500
Raglan (White)	137	12.6	9.2	20.1	15.3	944
Round	3074	404.6	13.2	54.9	31	
Trout	137	21.17	15.4	42.7	7.4	4106
Valiant	37.92	1.82	6	20	3.67	37.92
Wabun	44.9	5.4	13.3	28	5.08	44.9
Wadsworth	199	14.31	7.2	26.2	12.6	4709
Waterloo	184	13.8	7.6	23	14.5	2347
Wendigo	160.7	16.1	10	21.9	12.9	



The mean depth of a lake can be mathematically expressed as the volume of a lake divided by the surface area. In general, lakes with greater mean depths have higher oxygen concentrations in the hypolimnion. Exceptions include lakes with many bays, islands, multiple basins or small surface areas relative to their maximum depth.

Lakes with multiple basins may have only one basin that is deep enough for lake trout to inhabit. However mean depth includes the surface area and volume of the entire lake even though only one basin may have lake trout habitat. The morphometry of these lakes distorts the relative mean depth in comparison with single basin lakes.

Sampling Methods

A water quality survey of lake trout lakes in the County of Renfrew was conducted in 2011. Each lake was first sampled in May for general chemistry. The fall sampling period (conducted during the first two weeks of September) included general chemistry, temperature and dissolved oxygen profiles.

Lake trout lakes located within Provincial Parks or surrounded by Crown Land were not sampled.

Sampling stations were located in the deepest hole(s) of each lake in order to obtain a full depth profile. The deep holes were located using historic bathymetric maps and were field verified using electronic depth sounders.

In multi-basin lakes, where significant differences in limnological features may exist, an additional station was sampled at the deepest part of the secondary basin.

During each fall sampling visit, water clarity was measured using a Secchi disc, surface and bottom water samples were collected for chemical analyses, and vertical profiles of temperature and oxygen were taken using a Y.S.I. dissolved oxygen and temperature meter.

The oxygen meter was air calibrated prior to each profile according to the manufacturer's instructions. Surface water samples were collected as composite (i.e. all depths represented) samples through the euphotic zone. The euphotic zone is the zone in which there is sufficient light to sustain photosynthesis. For this survey the euphotic zone was defined as twice the Secchi visibility depth.

Samples were also collected from one meter above the bottom using a Kemmerer bottle sampler. Water samples were submitted for analysis to the Ministry of the Environment and Climate Change laboratory and analyzed according to standard methods of the Laboratory Services Branch.

Data collected during the survey are presented in the appendix to this report.

Water Quality and Lake Trout Habitat

Lake trout, *Salvelinus namaycush*, are found in recently glaciated lakes on or near the Precambrian Shield. These lakes are noted for their pristine water quality which includes high clarity, low levels of dissolved solids, organic carbon and phosphorus, high concentrations of dissolved oxygen, cool year-round bottom water temperatures and relatively stable water levels.

Self-sustaining populations of lake trout are found in these lakes because they provide the specific environmental conditions required by the species.

Lake trout are long lived and late maturing with the first spawning of females occurring at 6 to 10 years of age. This late maturation combined with modest egg production and low recruitment makes lake trout extremely vulnerable to over-fishing, and degradation or loss of spawning or summer habitat.

Loss of summer habitat is greatly influenced by shoreline development and phosphorus loading. During summer months, lake trout live in the hypolimnion. The hypolimnion is isolated from the upper waters during this period of stratification and is not replenished with new supplies of oxygen from the atmosphere or through photosynthesis.

To sustain lake trout in the summer months the hypolimnion must retain an adequate amount of dissolved oxygen. As previously described, nutrient enrichment through shoreline development can deplete dissolved oxygen levels in the hypolimnetic waters.

Dissolved Oxygen

Low dissolved oxygen in bottom waters reduces the ability of lake trout to obtain oxygen from the water, which in turn affects their cellular metabolic activity and compromises their ability to swim, feed, grow and avoid predators.

The Ministry of Natural Resources and Forests (MNRF) has determined that a volume-weighted mean hypolimnetic dissolved oxygen concentration of 7 mg/L is required to meet the needs of juvenile lake trout and to ensure that natural recruitment in a lake continues.[3]

[3] Evans, D.O. 1999. Metabolic scope-for-activity of juvenile lake trout and the limiting effect of reduced dissolve oxygen: defining a new dissolved oxygen criterion for the protection of lake trout habitat. Lakeshore Capacity Assessment Handbook, 2001.

In this study, the volume-weighted mean hypolimnetic dissolved oxygen . concentrations (MVWHDO) during the critical period were calculated for each lake. Values are presented in Table 3.

This level (7 mg/L) of dissolved oxygen in the hypolimnion has been adopted as the criterion used for protection of lake trout habitat and is determined during the period of late August or early September prior to the beginning of fall overturn. This coincides with the critical period of lowest dissolved oxygen concentrations in the hypolimnion.

The hypolimnion is determined from the temperature profile and is defined as the area of water below the thermocline where temperature change is less than 1 °C per metre of depth.

Volume-weighted mean hypolimnetic dissolved oxygen is calculated in the following way. The hypolimnion is considered in terms of a series of depth strata (usually one metre thick).

Morphometric data obtained from bathymetric maps are required to calculate the volume of each depth stratum. The volume of each stratum is calculated from the individual contour areas of the lake using the following formula:

$$\frac{V = m\,(A_t + A_b) + \sqrt{(A_t * A_b)}}{3}$$

where,

V is volume in cubic metres (m^3)
A_t is the area (m^2) of the top of the stratum
A_b is the area (m^2) of the bottom of stratum
m is the depth of stratum in metres

The volume of each hypolimnion stratum is multiplied by the oxygen concentration observed for that stratum. These individual concentrations are then summed. The total dissolved oxygen concentration in the hypolimnion is divided by the total volume of water in the hypolimnion to yield a volume-weighted mean hypolimnetic dissolved oxygen concentration.

Other water chemistry parameters were analyzed to measure water quality conditions of the study lakes. These include; total phosphorus, nitrogen ammonia, nitrates, nitrites, total Kjeldahl nitrogen (TKN), dissolved inorganic carbon (DIC), dissolved organic carbon (DOC), pH and total alkalinity.

A summary of the euphotic zone (EUP) chemistry data is presented in Table 4 and meter over bottom (MOB) in Table 5.

Phosphorus

The importance of phosphorus as the limiting nutrient in controlling productivity and dissolved oxygen content has been extensively discussed throughout the document. Total Phosphorus concentrations in the euphotic zone of Renfrew County lake trout lakes ranged from 0.002 to 0.32 mg/L. The average was 0.014 mg/L. This average is high and is driven by the high total phosphorus concentrations in Muskrat Lake.

Nitrogen

Nitrogen like phosphorus is an essential plant nutrient. Nitrogen occurs naturally in all lakes but can also be introduced through human activities. Nitrogen exists in lakes as molecular nitrogen

(N_2), ammonia (NH_3), nitrate (NO_3^-), nitrite (NO_2) and organic nitrogen (TKN).

Ammonia is the end product of decomposition and cellular metabolism. In an aqueous solution, the form un-ionized ammonia (NH_3) can be highly toxic to many organisms. The amount of un-ionized ammonia is dependent on pH and water temperature; generally, the higher the pH and temperature, the higher the concentration of un-ionized ammonia. Bacteria can convert ammonia to nitrite and then to nitrate in a process called nitrification. This process consumes oxygen.

Total ammonia nitrogen (TAN) levels in the County of Renfrew study lakes ranged from 0.001 to 0.306 mg/L with an average of 0.0159 mg/L. The Provincial Water Quality Objective (PWQO) for ammonia is based on its toxic form which is called un-ionized ammonia. The PWQO for un-ionized ammonia is 0.02 mg/L.

Nitrite is rapidly oxidized to nitrate in surface waters and is therefore seldom present in any significant concentrations. Higher levels of nitrites could indicate a source of organic pollution.

Nitrite concentrations ranged from 0.001 to 0.045 mg/L and averaged 0.0032 mg/L. There is no PWQO for nitrite. The Canadian Environmental Quality Guidelines (CCME) for the protection of aquatic life is 0.06 mg/L.

Nitrate is readily available to algae and may stimulate the growth of algae and larger plants. Nitrate concentrations ranged from 0.005 to 0.38 mg/L and averaged 0.05 mg/L. There is no current PWQO for nitrate but the current CCME guideline is 13.0 mg/L NO_3-N.

Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen and is important in assessing the availability of nitrogen and its potential contribution to eutrophication. Nitrogen is seldom limiting in freshwater ecosystems. The TKN concentrations in the study lakes ranged from 0.16 to 4.45 mg/L and averaged 0.37 mg/L. There is no PWQO for TKN.

Carbon

Carbon is a nutrient required for biological processes. It is usually readily available in inorganic or organic forms.

Dissolved organic carbon (DOC) is the largest source of organic carbon in most lakes. DOC is released when living organisms decompose in the lake. The bulk of organic carbon in water consists of humic substances and partly degraded plant and animal matter. Waters with high DOC values are usually highly colored (orange-red) due to high amounts of humic material that reduces water clarity. Reduction in water clarity can affect the success of predation by some predators. High concentrations of organic carbon may also indicate that decomposition processes are very active and may result in lower dissolved oxygen levels in the hypolimnion.

The DOC in the study lakes ranged from 3.0 to 23.5mg/L and averaged 5.08 mg/L. There is no Provincial Water Quality Objective (PWQO) for DOC.

Dissolved inorganic carbon (DIC) is a major nutrient used in photosynthesis by algae and submergent aquatic plants. The total inorganic carbon concentration in freshwater depends on pH.

The DIC levels in the study lakes ranged from 0.2 to 39.6 mg/L and averaged 9.75 mg/L. There is no PWQO for DIC.

Acidity and Alkalinity

The acidity of a solution is measured on a pH scale. The pH scale is logarithmic. This means that a change in one unit of pH represents a ten-fold increase or decrease in acidity. For example, a pH of 5 is ten times more acidic then a pH of 6 and 100 times more acidic than a pH of 7. A pH of 7 represents a solution that is neither acidic nor alkaline and is referred to as being neutral. Waters below pH 7 are acidic and above 7 are alkaline. To protect aquatic life the Provincial Water Quality Objective for pH is between 6.5 and 8.5. The pH of. the study lakes ranged from 6.42 to 8.57.

Alkalinity is the measurement of water's ability to neutralize acids. It usually indicates the presence of carbonate, bicarbonates, or hydroxide ions. Alkalinity results are expressed in terms of an equivalent amount of calcium carbonate. Lakes on the Canadian Shield (granite bedrock) usually have alkalinity values between 0 and 50 mg/L while waters formed on limestone bedrock have values ranging from 100 to 250 mg/L.

Lakes with low alkalinity have little capacity to buffer acidic inputs and are susceptible to acidification (low pH). Lake trout populations are particularly sensitive to acid precipitation inputs to low alkalinity lakes. Many common lake trout food sources have high mortality rates when exposed to slightly lower pHs. The resulting lack of food inhibits growth and reproduction (egg development) of lake trout.

Alkalinity values in the study lakes ranged from 3 to 160 mg/L with an average of 41.65 mg/L.

Based on acid sensitivity studies carried out by the Ministry in 1989, the study lakes range from not sensitive to moderately sensitive to acid rain inputs.[4]

Conductivity

Conductivity measures the ability of water to conduct an electric current. Conductivity is proportional to the total dissolved mineral content and solids in natural waters. The study lakes in the County of Renfrew had conductivities ranging from 20µs/cm to 323 µs/cm and averaged 112.2 µs/cm.

[4] MOE, 1989. Acid Sensitivity of Lakes in Ontario. Public Affairs and Communication Branch. Ministry of the Environment, Toronto. 31p.

Table 3. Mean Volume-Weighted Hypolimnetic Dissolved Oxygen Concentrations (MVWHDO) for County of Renfrew Trout Lakes, 2005-2011.

Lake	MVWHDO					
	Basin	2005	2006	2007	2010	2011
Bark	1				9.58	
	2				9.79	9.10
	3				9.14	
Big Gibson	1					5.43
Big Limestone	1					2.79
Burns-Griffith	1					5.87
Carson	1					9.24
Charlotte	1					3.39
Diamond	1		5.48			7.31
Green-Brougham	1		3.32			3.52
Kamaniskeg	1				8.24	8.18
	2				5.58	5.09
Lake Clear	1				2.30	4.59
McSourley	1					4.54
Morrow	1					0.83
	2					5.90
Muskrat	1					3.05
	2	3.22		2.64		4.08
Paugh	1				7.91	8.43
Raglan White	1					3.23
Round	1				7.67	7.80
Trout (Stubbs)	1					8.94
Valiant	1					1.29
Wabun	1					2.27
Wadsworth	1					5.30
	2					5.34
Waterloo	1					4
Wendigo	1			6.97		4.78

Table 4a. Summary Chemistry Data for Euphotic Zone (Surface, EUP) for County of Renfrew Study Lakes (all units in mg/L unless otherwise noted). Chemical Abbreviations are explained in the Glossary of Terms Section.

Lake	Date	Basin	Secchi (m)	TP	NH_3-N	NO_2-N	NO_3 + NO_2-N	TKN	DOC	DIC	pH	Alk	Cond (µS/cm)	Ca	Hard	TSS	TDS
Bark	15-Sep-10	1	3.5	0.003	0.004	0.001	0.01	0.26	4.9	1.7	7.08	6.6	37	2.8	11	1.8	24
	15-Sep-10	2	3.5	0.005	0.016	0.001	0.01	0.27	5.1	1.4	7.15	6.6	37	2.65	10.6	2.1	24
	15-Sep-10	3	3	0.002	0.002	0.001	0.016	0.27	4.7	1.4	7.13	6.3	36	2.6	10.4	1.9	23
	17-May-11	1		0.002	0.027	0.002	0.099	0.25	5	1.3	7.19	5.9	34	2.84	11	0.7	22
	17-May-11	2	4.5	0.002	0.037	0.003	0.101	0.26	5.2	1.1	7.18	6.2	34	2.83	11	0.5	22
	14-Sep-11	2	4	0.005	0.038	0.003	0.04	0.24	5.1	1.5	7.26	6.7	35	2.8	12	0.9	23
Big Gibson	02-Aug-11	1	2.75	0.008	0.033	0.002	0.031	0.3	7.4	1.8	7.26	8.3	124	3.62	15	1.3	81
	12-Sep-11	1	3.9	0.006	0.015	0.001	0.011	0.27	7.2	1.5	7.27	8.5	122	3.66	16	1.1	79
Big Limestone	09-Aug-11	1	5.4	0.005	0.025	0.001	0.025	0.24	5.3	30.1	8.54	124	243	41.6	140	1	158
	20-Sep-11	1	5	0.005	0.002	0.001	0.01	0.3	5	29.2	8.46	125	238	44.7	140	1.3	155
Burns - Griffith	17-May-11	1	5.5	0.003	0.041	0.001	0.038	0.24	3.9	12.3	8.21	50.9	110	18.5	54	1.5	72
	19-Jul-11	1	6.65	0.006	0.026	0.001	0.018	0.25	4.3	12.2	8.17	49.3	111	18.4	55	0.5	72
	12-Sep-11	1	6.4	0.002	0.034	0.004	0.052	0.17	4.4	12.3	8.04	50.7	113	19.1	56	1.5	73
Carson	18-May-11	1		0.002	0.21	0.001	0.024	0.19	3.4	3.5	7.67	13.2	69	5.07	21	0.5	45
	20-Jul-11	1	5	0.006	0.023	0.002	0.028	0.19	3.7	3.3	7.67	13.4	67	4.82	21	1.6	44
	13-Sep-11	1	5.6	0.003	0.034	0.003	0.052	0.17	3.7	3.3	7.54	13.9	69	4.9	20	1.5	45
Charlotte	19-May-11	1	10.2	0.008	0.138	0.005	0.037	0.26	3.1	19.8	8.19	83.1	174	30	91	2.7	113
	13-Sep-11	1	3.5	0.007	0.032	0.001	0.037	0.36	3.4	20.1	8.29	81.3	173	30.9	94	1	113
Lake Clear	17-May-11	1	5.5	0.004	0.029	0.001	0.017	0.28	3.2	27.8	8.57	113	261	37.2	120	1.2	170
	12-Sep-11	1		0.007	0.031	0.001	0.037	0.29	3.6	26.3	8.38	105	251	35.2	120	1	163
Diamond	19-May-11	1	2.6	0.014	0.037	0.004	0.01	0.29	5.9	6.6	7.81	30	91	11.6	39	0.8	59
	18-Jul-11	1	4	0.009	0.022	0.002	0.039	0.24	5.9	7	7.94	28.7	94	10.8	37	1.3	61
	13-Sep-11	1	3.2	0.005	0.033	0.003	0.04	0.26	6	7.6	7.85	32.6	99	12.7	42	1.2	65
Green-Brougham	17-May-11	1	6.5	0.004	0.03	0.001	0.031	0.26	3.3	22.1	8.44	87.9	204	30.6	99	0.9	133
	14-Sep-11	1	6.7	0.005	0.035	0.003	0.037	0.23	3.6	21.7	8.29	87.8	204	31.7	100	0.9	133

Table 4b. Summary Chemistry Data for Euphotic Zone (Surface, EUP) for County of Renfrew Study Lakes (all units in mg/L unless otherwise noted). Chemical Abbreviations are explained in the Glossary of Terms Section.

Lake	Date	Basin	Secchi (m)	TP	NH_3-N	NO_2-N	NO_3 + NO_2-N	TKN	DOC	DIC	pH	Alk	Cond (µS/cm)	Ca	Hard	TSS	TDS
Kamaniskeg	15-Sep-10	1	4.1	0.01	0.127	0.001	0.01	0.8	4.8	2.7	7.25	10.6	58	4.05	15.8	3	38
	15-Sep-10	2	4.1	0.014	0.007	0.001	0.01	0.26	4.3	1.8	7.13	7.3	43	3.2	12.6	1.4	28
	18-May-11	1	4	0.002	0.023	0.001	0.061	0.24	4.3	2.6	7.54	10.2	61	4.46	18	0.5	40
	18-May-11	2	3.75	0.002	0.027	0.001	0.091	0.24	4.8	1.6	7.32	7	40	3.11	12	0.5	26
	18-Jul-11	1	3.5	0.014	0.041	0.003	0.071	0.59	4.8	2.4	7.49	9.4	52	3.8	17	2.5	34
	18-Jul-11	2	3.75	0.006	0.041	0.003	0.069	0.26	5	1.7	7.36	6.7	39	2.67	12	1	25
	12-Sep-11	2	4	0.004	0.035	0.003	0.046	0.24	4.8	2.3	7.51	12.1	49	49	18	0.9	32
	14-Sep-11	1	4.6	0.013	0.035	0.003	0.045	0.28	4.6	2.1	7.42	9.6	51	4.11	17	1.3	33
McSourley	11-May-11	1	3	0.003	0.037	0.002	0.01	0.25	4.3	5	7.69	21.1	157	7.9	29.2	1.6	102
	08-Aug-11	1	5.45	0.002	0.021	0.001	0.023	0.22	5.3	5.2	7.74	21.6	156	7.21	28	1.7	101
	19-Sep-11	1	4.8	0.005	0.002	0.001	0.01	0.27	5.3	5.2	7.64	23	152	8.11	31	1.1	99
Morrow	19-Jul-11	1	6.75	0.005	0.038	0.002	0.041	0.27	5.6	23.7	8.39	94.5	194	33.1	100	0.6	126
	19-Jul-11	2	5	0.003	0.032	0.002	0.041	0.25	5.6	25.8	8.36	102	209	35	110	0.5	136
	14-Sep-11	1	6	0.007	0.035	0.004	0.038	0.32	5.7	24	8.33	98.6	196	34.8	110	1.7	128
	14-Sep-11	2	6	0.011	0.032	0.002	0.026	0.35	5.6	26.7	8.33	108	214	38.1	120	2.4	139
Muskrat	19-Jul-11	1	3.3	0.023	0.041	0.004	0.051	0.48	6.7	28.8	8.47	118	303	35.3	130	2.2	197
	12-Sep-11	1	2.4	0.32	0.075	0.006	0.071	0.38	6.7	27.5	8.38	116	300	37.3	140	3.2	300
Paugh	15-Sep-10	1	4.6	0.004	0.004	0.001	0.012	0.27	5.1	3	7.3	11.3	43	4	16.2	1.2	28
	18-May-11	1	4	0.006	0.032	0.003	0.051	0.27	5.7	2	7.43	10.7	43	4.51	18	0.5	28
	20-Jul-11	1	3.25	0.003	0.032	0.003	0.037	0.27	5.5	2.6	7.57	11.3	43	4.68	20	1.1	28
	14-Sep-11	1	4.75	0.006	0.031	0.004	0.038	0.23	5.4	2.7	7.51	11.9	44	3.72	17	0.9	29
Raglan (White)	19-May-11	1	3.2	0.011	0.034	0.003	0.01	0.29	3.4	26	8.35	107	240	38	120	2.4	156
	12-Sep-11	1	4.1	0.005	0.033	0.003	0.034	0.29	3.6	24.6	8.38	103	231	34	110	1.2	150
Round	18-May-11	1	4	0.002	0.029	0.002	0.064	0.27	5.5	4.1	7.75	17.1	58	5.71	23	0.5	38
	13-Sep-11	1	3.1	0.005	0.033	0.004	0.043	0.26	5.6	4.5	7.7	20.6	63	6.18	26	0.6	41
Trout	18-May-11	1	4.5	0.002	0.021	0.001	0.024	0.21	3.4	3.4	7.66	14.4	74	5.38	22	0.5	48
	20-Jul-11	1	4.5	0.006	0.032	0.002	0.024	0.22	3.9	3.3	7.66	14.7	73	4.86	22	1.3	48
	13-Sep-11	1	6	0.006	0.037	0.003	0.048	0.2	3.6	3.7	7.55	14.1	74	5.34	23	0.5	48
Valiant	08-Aug-11	1	2.8	0.005	0.023	0.001	0.021	0.24	6.7	0.3	6.83	3	20	1.62	6.3	3.3	13
	13-Sep-11	1	3.4	0.004	0.023	0.002	0.024	0.25	6.1	0.2	6.83	3.2	21	1.81	7.1	1.2	13

Table 4c. Summary Chemistry Data for Euphotic Zone (Surface, EUP) for County of Renfrew Study Lakes (all units in mg/L unless otherwise noted). Chemical Abbreviations are explained in the Glossary of Terms Section.

Lake	Date	Basin	Secchi (m)	TP	NH_3-N	NO_2-N	NO_3 + NO_2-N	TKN	DOC	DIC	pH	Alk	Cond (µS/cm)	Ca	Hard	TSS	TDS
Wabun	19-Jul-11	1	5.5	0.022	0.041	0.003	0.053	0.36	4.4	14.8	8.25	59.7	131	21.5	69	0.8	85
	12-Sep-11	1	5.75	0.012	0.033	0.001	0.046	0.31	4.6	15.1	8.13	61.7	131	22.1	69	1.5	85
Wadsworth	18-May-11	1	2.3	0.008	0.038	0.004	0.01	0.3	5.6	7.3	7.81	29.3	79	9.75	34	1.1	51
	18-May-11	2	2.4	0.007	0.035	0.004	0.01	0.3	5.4	6.4	7.8	27.4	79	9.62	33	1	51
	20-Jul-11	1	4	0.007	0.04	0.003	0.069	0.26	5.5	7.3	7.9	29.5	83	9.51	35	0.8	54
	20-Jul-11	2	3.5	0.009	0.034	0.003	0.054	0.28	5.5	7.2	7.89	28.7	82	9.38	34	1.4	53
	13-Sep-11	1	3.4	0.02	0.034	0.001	0.041	0.34	5.8	8.2	7.88	32.3	87	11.5	41	1.6	57
	13-Sep-11	2	3.3	0.004	0.036	0.001	0.04	0.27	5.7	8.2	7.88	32.9	86	10.7	38	1	56
Waterloo	04-Aug-11	1	2.65	0.002	0.031	0.002	0.037	0.29	6.5	0.6	6.95	4.1	21	1.44	6.5	1.6	14
	13-Sep-11	1	3.3	0.004	0.017	0.001	0.015	0.25	6.2	0.5	7.03	5.3	22	1.8	8.2	1.4	14
Wendigo	11-May-11	1	4	0.004	0.034	0.003	0.031	0.21	4.5	1.4	7.23	7.1	28	2.85	11	1.2	18
	02-Aug-11	1	4.05	0.011	0.039	0.003	0.038	0.28	5.7	1.6	7.23	7.6	29	2.38	10	2.2	19
	13-Sep-11	1	4.1	0.005	0.022	0.001	0.01	0.23	5.3	1.4	7.27	7.7	29	2.4	11	1.1	19

Table 5a. Summary Chemistry Data for Metre Over Bottom (MOB) for County of Renfrew Study Lakes (all units in mg/L unless otherwise noted). Chemical Abbreviations are explained in the Glossary of Terms Section.

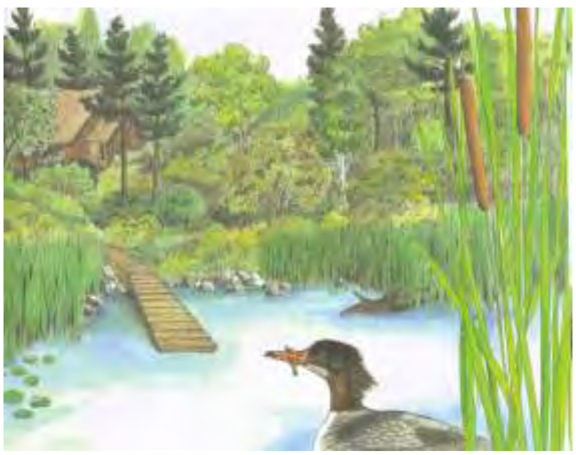
Lake	Date	Basin	TP	NH_3-N	NO_2-N	NO_3 + NO_2-N	TKN	DOC	DIC	pH	Alk	Cond (µS/cm)	Ca	Hard	TSS	TDS
Bark	15-Sep-10	1	0.002	0.002	0.001	0.157	0.23	4.3	1.1	6.88	5.8	36	2.75	10.8	0.8	24
	15-Sep-10	2	0.011	0.004	0.002	0.156	0.23	4.4	1.2	6.91	5.8	37	2.75	10.6	1	24
	15-Sep-10	3	0.002	0.002	0.001	0.157	0.23	4.3	1.1	6.88	5.8	36	2.75	10.8	0.8	24
	14-Sep-11	2	0.018	0.036	0.004	0.185	0.27	4.8	1.3	7.1	5.9	36	3.76	14	1.4	23
Big Gibson	02-Aug-11	1	0.032	2.94	0.045	0.037	4	23	8	7.25	37.8	201	8.97	31	16.5	131
	12-Sep-11	1	0.038	3.14	0.042	0.028	4.45	23.5	7.5	7.5	39.6	201	9.62	32	38.4	131
Big Limestone	09-Aug-11	1	0.099	0.436	0.003	0.031	1.06	5.5	39.6	8.29	157	303	52	170	12.1	197
	20-Sep-11	1	0.106	0.528	0.002	0.01	1.16	5.4	38.5	7.97	160	305	55.6	170	8.8	198
Burns - Griffith	19-Jul-11	1	0.026	0.025	0.002	0.19	0.29	3.8	12.4	8.01	50.2	113	18.5	55	1.9	74
	12-Sep-11	1	0.002	0.043	0.002	0.263	0.16	3.9	13.4	8	56.5	117	19.9	58	1.4	76
Burns - Sherwood	14-Sep-11	2	0.018	0.036	0.004	0.185	0.27	4.8	1.3	7.1	5.9	36	3.76	14	1.4	23
Carson	20-Jul-11	1	0.008	0.038	0.004	0.166	0.27	6.6	0.7	6.85	4	28	2.45	10	1	18
	13-Sep-11	1	0.004	0.032	0.003	0.118	0.16	3.1	3.4	7.53	14	68	4.91	20	0.9	44
Charlotte	13-Sep-11	1	0.014	0.032	0.001	0.17	0.3	3.4	21.8	8.06	85.4	183	32.7	98	1.2	119
Clear	16-Sep-10	1	0.05	0.067	0.003	0.156	0.32	3	27.6	7.99	116	267	39.1	127	2.7	174
	12-Sep-11	1	0.053	0.052	0.002	0.283	0.33	3.3	29.9	8.18	118	273	40.7	130	1.1	177
Diamond	18-Jul-11	1	0.013	0.026	0.002	0.143	0.24	5.6	7.2	7.85	30.3	94	10.7	37	0.5	61
	13-Sep-11	1	0.026	0.031	0.003	0.172	0.24	5.6	8.1	7.7	30.2	96	12	40	1.3	62
Green - Brougham	14-Sep-11	1	0.026	0.116	0.013	0.073	0.39	3.2	24.2	8.19	94.3	215	34.1	110	1.8	142
Kamaniskeg	15-Sep-10	1	0.012	0.011	0.001	0.118	0.25	3.9	2.5	6.98	9.8	59	3.85	15.4	1.2	38
	15-Sep-10	2	0.007	0.002	0.001	0.128	0.22	4.1	1.7	6.87	7	41	3.1	12	1	27
	18-Jul-11	1	0.004	0.034	0.002	0.168	0.23	4.3	2.8	7.41	10.1	60	3.94	17	1	39
	18-Jul-11	2	0.007	0.033	0.003	0.172	0.23	4.8	1.8	7.25	7	40	2.8	12	0.9	26
	12-Sep-11	2	0.01	0.037	0.003	0.047	0.27	4.8	1.5	7.32	7.6	42	42	13	2.4	27
	14-Sep-11	1	0.01	0.036	0.002	0.182	0.22	4.3	2.9	7.43	11.3	62	4.44	20	0.8	40

Table 5b. Summary Chemistry Data for Metre Over Bottom (MOB) for County of Renfrew Study Lakes (all units in mg/L unless otherwise noted). Chemical Abbreviations are explained in the Glossary of Terms Section.

Lake	Date	Basin	TP	NH_3-N	NO_2-N	NO_3 + NO_2-N	TKN	DOC	DIC	pH	Alk	Cond (µS/cm)	Ca	Hard	TSS	TDS
McSourley	08-Aug-11	1	0.003	0.027	0.001	0.133	0.21	4.2	6.3	7.65	25	181	8.71	33	1.7	118
	19-Sep-11	1	0.007	0.002	0.001	0.036	0.22	4	6.4	7.29	24	179	9.33	34	2.1	116
Morrow	19-Jul-11	2	0.014	0.028	0.002	0.186	0.26	5.7	28.6	8.23	112	229	38.6	120	1.7	149
	14-Sep-11	1	0.047	0.341	0.006	0.037	0.76	5.3	26.1	8.11	103	201	35.1	110	5.9	131
	14-Sep-11	2	0.16	0.528	0.012	0.053	0.96	7.2	32.6	8.21	137	258	43	130	6.3	168
Muskrat	19-Jul-11	1	0.104	0.034	0.003	0.25	0.18	6.3	29.3	8.38	117	308	35.9	130	34.9	200
	12-Sep-11	1	0.43	0.031	0.002	0.38	0.21	5.9	30.2	8.19	121	312	38.8	140	1.4	203
Paugh	15-Sep-10	1	0.004	0.002	0.001	0.119	0.23	5	2.9	7.11	10.5	43	4.1	16.4	1.3	28
	20-Jul-11	1	0.004	0.032	0.003	0.133	0.23	5.3	2.5	7.46	11.1	43	4	17	0.6	28
	14-Sep-11	1	0.004	0.029	0.003	0.138	0.22	5.1	2.7	7.39	11.3	44	4.06	18	0.6	28
Raglan (White)	12-Sep-11	1	0.036	0.38	0.004	0.044	0.82	3.4	29.4	8.19	116	258	42.6	130	6.2	168
Round	13-Sep-11	1	0.005	20.6	0.003	0.176	0.21	4.9	4.1	7.57	20.6	59	5.93	24	0.5	39
Trout	20-Jul-11	1	0.012	0.03	0.003	0.107	0.22	3.3	3.3	7.58	13	74	4.77	21	1.6	48
	13-Sep-11	1	0.008	0.046	0.003	0.108	0.21	3.2	3.8	7.46	13.6	75	5.39	22	1	49
Valiant	08-Aug-11	1	0.03	0.261	0.005	0.046	0.66	6.5	2.4	7.04	6.5	27	2.33	8.8	19.8	17
	13-Sep-11	1	0.03	0.481	0.006	0.027	0.93	7.2	3.4	7.1	8.5	30	2.58	10	15.4	19
Wabun	19-Jul-11	1	0.089	0.203	0.005	0.089	0.54	4.1	16.2	8.02	63.8	142	22.5	71	1.9	93
	12-Sep-11	1	0.101	0.207	0.002	0.066	0.57	4	17.2	7.94	65	142	24.3	74	2.6	93
Wadsworth	20-Jul-11	1	0.01	0.034	0.003	0.205	0.22	5.2	8.6	7.87	35.9	93	10.9	39	0.9	60
	20-Jul-11	2	0.006	0.027	0.002	0.174	0.26			7.81	29.6	83	10.6	37.2		
	13-Sep-11	1	0.005	0.037	0.001	0.041	0.28	5.8	8.3	7.91	33.3	87	11.1	39	1.4	57
	13-Sep-11	2	0.009	0.031	0.001	0.214	0.27	5.3	8.6	7.67	32.8	86	11.1	38	1.6	56
Waterloo	04-Aug-11	1	0.053	0.039	0.004	0.215	0.6	5.9	1.2	6.8	4.3	23	1.63	7.2	9.5	15
	13-Sep-11	1	0.015	0.018	0.003	0.15	0.27	5.7	1.2	6.9	4.3	24	1.99	9.1	2.2	15
Wendigo	02-Aug-11	1	0.041	0.034	0.002	0.161	0.33	4.5	1.9	7.14	6.8	30	2.81	11	3.1	19
	13-Sep-11	1	0.026	0.023	0.004	0.132	0.4	4.5	2.2	7.24	8	31	2.6	11	2.3	20

Lakeshore Capacity Assessment

Lakeshore Capacity Assessment is an analytical tool developed by the Province of Ontario to provide a consistent and uniform approach to quantifying water quality impacts resulting from shoreline development on Precambrian Shield Lakes.[5] Development in this context encompasses any activity that has the potential to have an adverse impact on water quality and aquatic habitat through the creation of additional lots or changes in land use. This includes permanent residences, cottages, resorts, trailer parks and campgrounds.



Lakeshore Capacity Assessment is based on two main objectives: maintaining water quality to protect recreational values and ensuring that there is sufficient dissolved oxygen to maintain valued fisheries. The goal of Lakeshore Capacity Assessment is to ensure sustainable development of our inland recreational lakes using a watershed based approach.

Phosphorus limits the amount of plant (algae) growth in a body of water. As previously explained, too much phosphorus can lead to excessive algal growth, depletion of dissolved oxygen in the hypolimnion and loss of cold water habitat for lake trout.

Phosphorus originates from both natural sources and from shoreline development. On the Precambrian Shield where a significant portion of the land use is still in a natural forested state, the primary controllable source of phosphorus is often shoreline development.

Lake Capacity Assessment is based upon the use of MOECC's Lakeshore Capacity Model (LCM). The LCM was first developed in the early1970's to address the relationship between shoreline development and algal production. It has been subsequently refined and updated, most notably with a component that links shoreline development and dissolved oxygen.

The LCM provides a method for estimating the supply of phosphorus to a lake from land runoff, atmospheric deposition, upstream sources and shoreline development. The model relates the supply of phosphorus from these sources with the lake's morphometry and water budget to predict phosphorus concentrations in a lake.

The predicted phosphorus concentration can, in turn, be used to derive other indices of lake trophic status such as algal densities, water clarity and dissolved oxygen.

[5] MOE, MNR, & MMAH. Lakeshore Capacity Assessment Handbook: protecting Water Quality in Inland lakes on Ontario's Precambrian Shield. Consultation Draft. May 2010.

Alternatively, for a given standard of water quality protection, be it a phosphorus or dissolved oxygen level, the model can be used to establish a permissible phosphorus supply for the lake which can in turn be translated into a permissible number of shoreline development units.

For cold-water lake trout lakes, the MNRF criterion is a volume-weighted hypolimnetic mean of 7 mg/L dissolved oxygen. Lakes are deemed to be at-capacity if:

i) Measured volume-weighted mean hypolimnetic dissolved oxygen, taken at the end of the summer, is consistently below the 7 mg/L criterion.

ii) Model predictions conclude that the loading associated with the existing vacant lots of record and/or new development proposal(s) will reduce the volume-weighted mean hypolimnetic dissolved oxygen below the 7 mg/L criterion.

Lakes are deemed to have additional development capacity if:

i) Measured volume-weighted mean hypolimnetic dissolved oxygen, taken at the end of the summer, is consistently above the 7 mg/L criterion.

Of the 22 study lakes presented in Table 3, seven basins had dissolved oxygen concentrations in the hypolimnion above 7 mg/L, eighteen basins were below the 7 mg/L criterion and two basins require additional profiles in order to classify them.

A municipality may decide on how to allocate remaining development capacity between seasonal residences, permanent residences and other shore-land uses. Municipalities must also consider that many seasonal cottages have converted to permanent residences over the last 10 to 20 years and that this trend will likely continue.

Lake Capacity Assessment addresses only one aspect of water quality, i.e., trophic status as determined by a lake's phosphorus supply. There are other pollutants e.g. (bacteria, mercury, and spillage of marine fuel) besides phosphorus that can degrade water quality and impact on aquatic biota.

Other human activities such as agriculture, forestry practices, and marine construction can also have an impact on the lake and its environment. Lake Capacity Assessment does not address these environmental and social issues nor does Lake Capacity Assessment consider social factors such as the loss of wilderness habitat, noise and traffic resulting from increased boat usage or shoreline crowding and density issues. These types of concerns are better addressed by other types of regulatory approaches and planning mechanisms.

Land Use Planning

Land use planning is a network of legislation, policies and planning procedures, which provide a framework for managing Ontario's land use and development. Under Section 3 of the *Planning Act,* the province issues the Provincial Policy Statement (PPS). The PPS provides direction on matters of provincial interest related to land use planning and development. In exercising their authority, upper and lower-tier planning authorities must ensure that the policies in the PPS are met in any planning decisions that are made.

The PPS includes natural heritage policies to protect lake trout habitat and water policies to protect water quality and quantity which are relevant to Lake Capacity Assessment.

Use of the Lake Capacity Assessment approach and consideration of the results for individual lakes is important to ensure that these natural heritage features are protected and that lake water quality is not degraded.

It is important to note that the 2014 PPS contains the following specific policy which speaks to environmental lake capacity.

Planning authorities shall protect, improve or restore the quality and quantity of water by:

"g) ensuring consideration of environmental lake capacity, where applicable" and includes a reference to the importance of "shoreline areas."

One method of ensuring this is to have municipalities include policies in Official Plans (OP) for protection of water quality and fish habitat. Another method is through the education of residents, cottagers and the general public about water quality and fish habitat protection. This can be achieved through best management practices such as: having a properly functioning septic system, provision of adequate set-backs in accordance with OP and zoning by-law requirements, maintenance of vegetation and tree cover in the setback buffer and the elimination of pesticide and fertilizer applications for aesthetic purposes.

OP policies should include appropriate setbacks for septic systems, buildings and other structures and require non-disturbance of soils and vegetation within the setback area except for minor pathways for access and beach usage.

Policies are also recommended requiring a municipality to use Lakeshore Capacity Assessment to determine the amount of development a lake can sustain. In the event that municipal planning decisions based on lake capacity assessments are challenged in the future, the Province will support the municipality before the Ontario Municipal Board.

Amendments to the *Planning Act* in 1996 delegated approval authority to most municipal governments. As a delegated authority, the County of Renfrew is now responsible for approving site specific applications such as subdivisions and severances, and for providing input to lower tier municipalities on zoning matters.

Upper-tier Official Plans are approved by the Ministry of Municipal Affairs through a one-window system whereby partner ministry comments are coordinated into a Provincial response. Both the Ministry of the Environment and Climate Change and the Ministry of Natural Resources and forests are part of the one-window planning system.

The County of Renfrew has an approved Official Plan which includes policies that meet the PPS, as required by the Planning Act. To support the County's Official Plan policies and to ensure that provincial interests are protected in matters related to shoreline development, the Eastern Region of the Ministry of the Environment carried out a water quality assessment for each of the lake trout lakes in the County.

Recommendations

The following recommendations provide the basis for developing Official Plan policies for each lake trout lake in the County of Renfrew and describe best management practices (BMPs) aimed at reducing the input of nutrients to water bodies and minimizing the impacts of shoreline development. Many of these BMPs can be implemented through local zoning by-laws or site plan control for consideration during the planning and construction phase of shoreline development, or are intended as practical and instructive methods that individual shoreline owners can use to minimize their impacts to water quality and fish habitat.

1. ***Lakes deemed to be at-capacity***

   - No new shoreline development shall be permitted which will result in increased phosphorus loadings. The 300 metre zone from the high water mark of the lake shall be used as the influence area to assess impacts from new development or redevelopment.

   - New development may be supported if site-specific hydrogeological/soil information studies demonstrate, to the satisfaction of the MOECC, that sewage phosphorus will be attenuated in the long-term by native soils. The MOE should be consulted early in this process to assist in the development of an appropriate term of reference for the study design.

2. ***Lakes deemed to have additional development capacity***

   - On these lakes additional development capacity exists. The development of existing registered vacant lots of record and limited new shoreline severances may be permitted. Caution must be exercised in approving large scale development proposals (i.e. subdivisions) or cumulatively a large number of severance applications until such time as more detailed modeling has been undertaken to determine an acceptable nutrient load.

   - The planning authority should maintain a detailed inventory of existing development, usage, and vacant registered lots on each lake. This information is essential in order to track, manage and properly allocate the remaining development capacity.

- Local Councils should establish through their Zoning Bylaws a setback for all structures (excluding docks) of at least 30 metres horizontally from the water's edge. A setback for buildings will discourage other physical improvements such as tile beds, lawns and gardens near the shoreline, thereby widening the buffer of natural vegetation and soil along the lake's edge. The setback also complements fisheries management objectives by minimizing impacts of shoreline activities on the important littoral zone.

3. ***Recommendations applicable to all lakes***

- OP policies should include appropriate setbacks for septic systems, buildings and other structures and require non-disturbance of soils and vegetation within the setback area except for minor pathways for access and beach usage.

- All lots should be of sufficient size and lake frontage to accommodate the safe installation and construction of a well, septic system, and dwelling. The topography, native soil depth and slope of lots should be conducive to development. Development on lands which are bare bedrock, swampy or low-lying should be prohibited.

- All sewage waste should be discharged into an appropriate septic tank/tile bed system or equivalent system under the Ontario Building Code.

- All property owners should have their sewage disposal systems inspected to ensure the system meets current standards. Septic systems should be pumped out every three to five years to remove solids and scum. In those cases where a system requires upgrades or replacement, all efforts should be made to relocate the system further from the lake to protect water quality (i.e. minimum of 30 metres).

- The municipality should develop an administrative mechanism to ensure all septic tanks and holding tanks are maintained and pumped on a frequent schedule.

- Water conservation measures are encouraged to extend the life of a septic tank tile bed system.

- All practical measures should be taken to reduce further nutrient loadings from existing sources. This is an important consideration for the redevelopment of existing lots.

- Building, site preparation and construction activities should be carried out in a manner that minimizes disruption to the soil and vegetation on the property. All areas that are exposed during construction should be replanted as soon as possible. Hardening of a lot by paved walkways or asphalt driveways, concrete ramps and lawns should be kept to a minimum to reduce storm water runoff and erosion.

- Maintain a zone of natural vegetation (trees and shrubs) as a protective buffer between lawns and the lake or leave your entire lot in a natural state. If you must have a lawn or garden, do not fertilize it as the runoff will add excessive nutrients into the lake.

- The shallow, near-shore, "littoral" zone supports most of the plant and animal life in a lake. Disruption of any part of this ecosystem threatens the entire cycle of life in the lake. In particular, fish habitat and wildlife may be destroyed, and nutrients may be resuspended from the lake sediments. All property owners should contact the Ministry of Natural Resources and Forestry and the local Conservation Authority before undertaking any dredging or filling activities within the littoral zone.

- All projects in and around water which may alter fish habitat should be referred to the Federal Department of Fisheries and Oceans, or their agent, for review and assessment of potential harmful alteration, disruption, or destruction (HADD) of fish habitat. It is an offense to destroy fish habitat and is subject to prosecution under the *Fisheries Act*.

- Where subdivision developments are proposed, back shore lot designs generally offer the best means to minimize impacts upon the lake environment. In these situations, the shore-land should be maintained as a natural buffer and deeded either to the municipality or registered to all owners of the development as a common block. Large development proposals should incorporate storm water management controls.

- Ongoing water quality monitoring is necessary to assess changes in lake water quality and provide valuable data that can be used in future modeling exercises. All property owners are encouraged to form a lake association to promote lake improvement programs that will assist in maintaining a quality lake environment. Cottage associations and/or individuals can participate in lake water quality monitoring through the Ministry's Lake Partner Program. For more information, please call 1-800-470-8322.

GLOSSARY OF TERMS

Underlined terms in definitions are also provided in this glossary.

Aerobic: With oxygen.

Anaerobic: Without oxygen

Alkalinity (Alk): Alkalinity is a measurement of a lake's ability to buffer acidic (pH) inputs from rain, snow or groundwater. It is linked to the amount of bicarbonate or carbonate in a lake.

Ammonia (NH_3-N): Unpolluted waters are very low in ammonia. Ammonia arises from the aerobic or anaerobic decomposition of nitrogenous organic matter. Higher levels of ammonia are associated with natural wetland areas because they contain lots of organic material. It is also a common constituent of untreated sewage. Ammonia can also be found in fertilizers as soluble ammonia and ammonium salts. There is no PWQO for ammonia but there is for its more toxic form un-ionized ammonia.

Bathymetry: Detailed topography or contour profile of the bottom of a lake or river.

Calcium (Ca): Used for the calculation of water hardness.

Composite Sample: Samples were obtained from the euphotic zone by using a 1 litre bottle secured in a weighted metal case. There were two small plastic tubes in the bottle cap. The bottle was lowered to the bottom of the euphotic zone and then raised to the surface so that water gradually entered into the bottle as air escaped. In this way representative samples from all depths of the euphotic zone (i.e. a composite sample) were obtained.

Conductivity (Cond): Conductivity is the ability for water to pass an electrical current over a distance and is related to the amount of dissolved ions and temperature. Higher temperatures raise conductivity values substantially. The higher the conductivity the more dissolved ions present in the water and therefore conductivity can provide a good indication of changes in water composition.

Dissolved Inorganic Carbon (DIC): DIC is a major nutrient used in photosynthetic metabolism by algae and submerged larger plants (macrophytes). There is no PWQO for DIC.

Dissolved Organic Carbon (DOC): DOC is largely present as a by-product of photosynthesis and organic inputs from the watershed. It can therefore be an indicator of how productive a lake may be. There is no PWQO for DOC.

Emergent Vegetation: Aquatic vegetation that has a substantial amount of mass that grows above the lake surface. e.g. Cattail.

Epilimnion: see Thermal Stratification.

Euphotic zone (EUP): The euphotic zone is the zone of water to which light penetrates. The presence of light supports photosynthesis by algae and larger plants at these depths. In this study, the euphotic zone was defined as twice the Secchi depth.

***E. coli*:** An indicator of fecal contamination from human or animal wastes. The PWQO is less than 100 fecal coliform counts per 100 milliliters of water based on a geometric mean of at least 5 samples for swimming areas.

Fetch: Longest distance of water in which wind can blow unimpeded between two points on a lake.

Hardness (Hard): Water hardness is a traditional measure of the capacity of water to react with soap. Hard water requires a considerable amount of soap to produce lather, and it also leads to scaling of hot water pipes, boilers and other household appliances. Water hardness is caused by dissolved polyvalent metallic ions. In fresh waters, the principal hardness-causing ions are calcium and magnesium. Strontium, iron, barium and manganese ions also contribute.

Hypolimnion: The area of the lake below the thermocline where water temperature changes less than 1 °C per metre of depth.

Inorganic: Substance that does not contain carbon.

Kemmerer Bottle: A brass or plastic tube with sealing devices at each end. When lowered to specific depth, the tube can be triggered to seal shut so that only water from the desired depth is collected.

Leachate: A term used to designate liquid waste that leaks from septic systems and landfill sites.

Limiting nutrient: The nutrient that is most in demand for maximum growth of plants such as algae and macrophytes. In most natural lakes total phosphorus is the most limiting nutrient.

Magnesium (Mg): Used for the calculation of water hardness.

Metre Over Lake Bottom (MOB): Sampling occurs one metre over the bottom of the lake.

Nitrate (NO_3-N): A molecule containing nitrogen and oxygen (NO_3) that represents the final oxidation product of ammonia. Nitrates stimulate growth of algae and larger aquatic plants which can contribute to a reduction in oxygen. A high concentration of nitrates may indicate contamination by treated sewage or fertilizers. There is no PWQO for NO_3. Surface waters rarely contain more than 5 mg/L nitrate. Nitrate concentrations tend to be higher in winter and after spring runoff.

Nitrite (NO_2-N): Nitrite is a chemical form of nitrogen that is found in minute quantities in surface waters. The presence of nitrites in water indicates active biological processes influenced by organic inputs. There are no PWQO guidelines for nitrites.

Oligotrophic Lake: A category of lake that is defined as having a deep basin which is thermally stratified (thermal stratification).

Organic: Substance that contains carbon.

pH: pH is a measurement of acidity using a logarithmic scale. For example pH 6 is 10 times more acidic than pH 7 and pH 5 is 100 times more acidic than pH 7. A pH of 7 is neutral, pH's below 7 are acidic and above 7 are basic (alkaline). The PWQO for pH is 6.5-8.5.

Provincial Water Quality Objectives (PWQO): PWQO are standards set for surface water quality whose goal is to ensure that the water quality is satisfactory for aquatic life and recreation.

Secchi Depth: A Secchi disk is a 20 cm diameter disk divided into black and white quadrants. The disk is lowered into the water and the maximum depth at which it is still visible is recorded. The Secchi depth gives a working estimate of water clarity.

Submergent Vegetation: Aquatic vegetation that grows below the surface water level.

Thermocline: The thermocline is the zone in the lake where water temperature rapidly decreases with depth. It is usually defined as the area of a lake where water temperature decreases at a rate greater than 1°C per metre depth.

Thermal Stratification: Most deep lakes stratify thermally during the summer months, setting up important biological and physical processes. By late spring as lakes warm up most lakes have established thermal stratification. A warm layer (the epilimnion) then exists in the surface area of a lake usually to a depth of 4 to 5 metres. The middle layer of water is called the thermocline or metalimnion. The bottom layer of water (the hypolimnion) contains cold water (4 - 7 °C) where light rarely penetrates. During late summer, the upper layer of water begins to cool off as air temperatures drop. As water cools it becomes heavier, and this allows the upper waters to mix with deeper waters. As temperatures drop in October, the lake once again becomes the same temperature from top to bottom. This allows all the waters to mix, replenishing much needed oxygen to the bottom of the lake to allow organisms there to survive winter. The thermal stratification process repeats when the ice melts.

Total Kjeldahl Nitrogen (TKN): TKN measures the amount of ammonia and organic nitrogen. Both of these forms of nitrogen are present in nitrogen containing organic detritus from natural biological activities. There is no PWQO for TKN.

Total Dissolved Solids (TDS): TDS is a measure of the combined content of all inorganic and organic substances contained in water in a suspended form. Total dissolved solids are normally discussed only for freshwater systems, as salinity comprises some of the ions constituting the definition of TDS. The principal application of TDS is in the study of water quality for streams, rivers and lakes, although TDS is not generally considered a primary pollutant (e.g. it is not deemed to be associated with health effects) it is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants.

Total Phosphorus (TP): Phosphorus is an essential plant nutrient. It is the limiting nutrient that affects the amount of plant growth in a lake. TP includes all of the forms of phosphorus, both organic and inorganic. Sources of phosphorus include weathering from igneous rocks, decomposition of organic matter, domestic sewage, agricultural drainage and industrial effluents.

Total Suspended Solids (TSS): Solid organic or inorganic particles that are held in suspension in a solution.

Un-ionized Ammonia: The toxic fraction of ammonia that is often used as an indicator of septic system leachate. The amount of un-ionized ammonia relative to total ammonia is dependent on pH and temperature. The PWQO for un-ionized ammonia is 20µg/L.

Watershed: Area of land drained by a single river and its tributaries or creeks.

APPENDIX 1

Temperature and Dissolved Oxygen Concentration Profiles

Appendix 1a. Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles for Renfrew County, 2011.

Depth (m)	Bark Lake		Big Gibson				Big Limestone				Burns-Griffith	
	Basin 2		Basin 1		Basin 1		Basin 1		Basin 1		Basin 1	
	14-Sep-11		2-Aug-11		12-Sep-11		9-Aug-11		20-Sep-11		19-Jul-11	
	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0	19.42	8.69	25.8	7.5	20.5	8.9	24.1	7.9	17.9	9	26.23	8.11
1	19.41	8.58	25.4	7.3	20.3	8.9	24.1	7.9	17.9	8.9	24.74	8.39
2	19.38	8.54	24.9	7.6	20.2	8.6	24.1	7.7	17.8	8.7	24.50	8.40
3	19.34	8.52	22.3	7.5	19.7	8.3	24.1	7.8	17.8	8.6	24.40	8.41
4	19.33	8.49	16.2	8.5	17.5	7.7	24	7.9	17.8	8.6	24.19	8.42
5	19.27	8.49	11.7	7.4	13.2	7	18.4	12.9	17.7	8.7	22.86	8.84
6	19.23	8.43	9	6.9	9.7	5.9	13.2	13.9	17.4	8.6	15.96	14.73
7	19.18	8.40	7.6	6.7	8.3	5.4	9.4	12.1	12.3	11.2	12.78	15.48
8	18.60	8.38	7.1	6.6	7.6	5.2	7.7	11.1	9.3	10.3	9.90	15.04
9	18.03	8.33	6.8	6.6	7.3	5.1	6.5	9.1	7.5	8.3	8.45	13.72
10	15.62	8.33	6.6	6.6	7	5.1	5.7	7.9	6.3	7	7.52	12.32
11	11.44	8.30	6.1	6.7	6.6	5.2	5.3	7.1	5.8	5.7	6.96	11.52
12	10.39	7.99	5.7	6.9	6	5.4	4.9	6.3	5.3	5.2	6.57	10.19
13	9.65	8.03	5.5	7	5.6	5.7	4.6	5.3	4.9	4.2	6.31	9.80
14	9.29	8.07	5.2	7.1	5.3	6	4.4	4.2	4.6	3.5	6.06	8.88
15	9.03	8.11	4.9	7.2	5.1	6.2	4.2	3.1	4.5	2.9	5.88	8.53
16	8.50	8.31	4.7	7.2	4.8	6.3	4.1	2.6	4.3	2	5.74	8.23
17	8.42	8.36	4.4	7	4.6	6.3	4	2.3	4.2	0.9	5.60	8.04
18	7.92	8.50	4.3	6.9	4.4	6.1	4	1.8	4.1	0.5	5.51	7.94
19	7.53	8.64	4.2	6.7	4.3	5.9	4	1.2	4.1	0.3	5.42	7.76
20	7.36	8.76	4.1	6.9	4.1	5.8	3.9	0.7	4	0.2	5.38	7.45
21	7.20	8.81	4	6.9	4.1	5.7	3.9	0.5	4	0.2	5.37	7.10
22	6.93	8.89	4	6.6	4.1	5.6	3.9	0.4	4	0.2	5.28	7.00
23	6.56	9.11	4	5.7	4	5	3.9	0.3	4	0.2	5.24	6.77
24	6.45	9.16	4	5.1	4	3.7	3.9	0.2	4	0.2	5.23	6.71
25	6.35	9.20	4	4.3	4	3.1	3.9	0.2	4	0.2	5.20	6.65
26	6.28	9.23	4	3.5	4	2.2	3.9	0.2	3.9	0.2	5.18	6.44
27	6.23	9.24	4	2.2	4	1.6	3.9	0.2	3.9	0.1	5.18	6.15
28	6.09	9.29	4	1.7	4	0.8	3.9	0.2	3.9	0.1	5.17	5.99
29	6.02	9.32	4	1.3	4	0.5	3.9	0.2	3.9	0.1	5.16	5.87
30	5.92	9.38	4	1.1	4	0.3	3.9	0.2	3.9	0.1	5.15	5.66
31	5.89	9.42	4	0.3	4	0.3	3.9	0.2	3.9	0.1	5.15	5.53
32	5.79	9.47	4.1	0.2	4.1	0.2	3.9	0.1	3.9	0.1	5.15	5.45
33	5.66	9.50	4.1	0.2	4.2	0.2	3.9	0.1	3.9	0.1	5.14	5.34
34	5.60	9.51	4.2	0.2	4.2	0.2	4	0.1	4	0.1	5.14	5.29
35	5.54	9.52	4.2	0.1	4.3	0.2	4	0.1	4	0.1	5.13	5.18
36	5.47	9.55										
37	5.44	9.56										
38	5.42	9.53										
39	5.38	9.51										

Appendix 1a (cont). Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles for Renfrew County, 2011.

	Bark Lake		Big Gibson				Big Limestone				Burns-Griffith	
	Basin 2		Basin 1		Basin 1		Basin 1		Basin 1		Basin 1	
	14-Sep-11		2-Aug-11		12-Sep-11		9-Aug-11		20-Sep-11		19-Jul-11	
Depth (m)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
40	5.35	9.55										
41	5.30	9.56										
42	5.27	9.56										
43	5.22	9.56										
44	5.16	9.58										
45	5.14	9.59										
46	5.11	9.60										
47	5.09	9.62										
48	5.04	9.64										
49	5.02	9.63										
50	5.01	9.61										
51	4.98	9.61										
52	4.96	9.63										
53	4.93	9.65										
54	4.91	9.66										
55	4.89	9.67										
56	4.88	9.68										
57	4.88	9.67										
58	4.88	9.67										
59	4.85	9.64										
60	4.83	9.66										
61	4.80	9.66										
62	4.80	9.64										
63	4.79	9.59										
64	4.75	9.62										
65	4.75	9.63										
66	4.71	9.62										
67	4.69	9.62										
68	4.67	9.54										
69	4.67	9.51										
70	4.64	9.48										
71	4.63	9.52										
72	4.61	9.58										
73	4.61	9.58										
74	4.60	9.48										
75	4.59	9.43										
76	4.58	9.33										
77	4.56	9.28										
78	4.56	9.27										
79	4.55	9.26										

Appendix 1a (cont). Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles for Renfrew County, 2011.

	Bark Lake		Big Gibson				Big Limestone				Burns-Griffith	
	Basin 2		Basin 1		Basin 2		Basin 1		Basin 1		Basin 2	
	14-Sep-11		2-Aug-11		12-Sep-11		9-Aug-11		20-Sep-11		19-Jul-11	
Depth (m)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
80	4.54	9.24										
81	4.52	9.21										
82	4.52	8.97										
83	4.52	8.93										
84	4.52	8.88										
85	4.52	8.81										
86	4.51	5.34										
87	4.49	3.85										

Appendix 1b. Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles for Renfrew County, 2011.

	Burns-Griffith		Carson				Charlotte		Diamond			
	Basin 1		Basin 1		Basin 1		Basin 1		Basin 1		Basin 1	
	12-Sep-11		20-Jul-11		13-Sep-11		12-Sep-11		18-Jul-11		12-Sep-11	
Depth (m)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0	20.50	9.00	26.18	8.34	19.90	8.89			26.44	8.25		
1	20.15	9.10	26.16	8.35	19.92	8.89	19.8	8.24	26.34	8.25	19.6	7.78
2	19.86	9.11	26.08	8.35	19.92	8.87	19.7	8.1	26	8.27	19.5	7.83
3	19.72	9.09	25.82	8.37	19.92	8.87	19.7	8.14	25.94	8.26	19.5	7.99
4	19.64	9.08	23.22	9.14	19.91	8.86	19.6	8.07	20.05	9.22	19.5	8.06
5	19.56	9.07	18.16	11.99	19.86	8.85	19.6	8.18	16.7	9.81	18.5	8.03
6	19.45	9.07	14.21	13.06	18.98	9.02	19.5	8.21	14.51	10.18	16.5	8.83
7	19.18	9.13	9.73	12.60	15.65	10.20	19.4	8.04	10.48	11.24	10.9	11.11
8	14.90	12.52	8.51	12.34	10.41	11.99	18.6	7.74	7.81	10.47	8.6	10.37
9	11.16	12.87	7.55	11.90	8.22	11.56	13.4	7.16	7.09	9.11	7.7	8.3
10	9.11	11.66	7.03	11.61	6.76	11.19	11.8	6.3	6.66	8.77	6.8	7.16
11	7.82	10.35	6.34	11.31	6.42	10.55	11.1	5.87	6.35	8.7	6.5	7.07
12	7.18	8.38	5.99	10.69	6.10	9.78	9.3	3.86	6.19	8.69	6.1	6.89
13	6.69	7.20	5.75	10.63	5.84	9.28	8.6	3.43	5.99	8.69	5.9	7.06
14	6.40	6.62	5.59	10.60	5.64	9.02	8	1.56	5.83	8.66	5.6	7.29
15	6.13	6.35	5.46	10.56	5.50	8.93	7.7	1.19	5.7	8.61	5.4	7.45
16	5.93	5.96	5.32	10.53	5.39	8.92	7.4	0.59	5.5	8.57	5.3	7.55
17	5.77	5.58	5.22	10.45	5.24	8.89	7.3	0.21	5.38	8.51	5.1	7.22
18	5.68	5.20	5.12	10.38	5.12	8.90			5.23	8.36	5.1	7.21
19	5.54	4.73	5.08	10.36	5.04	8.90			5.14	8.33	5	7.04
20	5.44	4.47	5.05	10.26	5.01	8.88			5.04	8.29	5	7.02
21	5.41	4.26	4.99	10.21	4.99	8.87			4.96	8.26	4.9	7.01
22	5.36	3.96	4.96	10.13	4.95	8.83			4.87	8.26	4.8	6.87

Appendix 1b (cont). Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles for Renfrew County, 2011.

	Burns-Griffith		Carson				Charlotte		Diamond			
	Basin 1		Basin 1		Basin 1		Basin 1		Basin 1		Basin 1	
	12-Sep-11		20-Jul-11		13-Sep-11		12-Sep-11		18-Jul-11		12-Sep-11	
Depth (m)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
23	5.35	3.76	4.92	10.10	4.93	8.77			4.83	8.22	4.7	6.84
24	5.34	3.70	4.90	10.02	4.90	8.74			4.77	8.14	4.7	6.44
25	5.29	3.27	4.87	9.88	4.88	8.67			4.74	8.05	4.7	6.32
26	5.27	2.94	4.87	9.68	4.86	8.46			4.71	7.94	4.6	6.3
27	5.25	2.31	4.85	9.61	4.84	8.41			4.69	7.88	4.6	6.13
28	5.23	2.02	4.84	9.55	4.84	8.36			4.67	7.86	4.6	6.05
29	5.23	1.76	4.82	9.55	4.80	8.27			4.67	7.81	4.6	5.98
30	5.22	1.62	4.81	9.53	4.79	8.09			4.64	7.64	4.6	5.81
31	5.22	1.47	4.79	9.43	4.78	7.88			4.63	7.6	4.6	8.79
32	5.22	1.20	4.77	9.41	4.76	7.81			4.62	7.54	4.6	5.68
33	5.22	0.96	4.77	9.30	4.76	7.60			4.62	7.5	4.6	5.56
34			4.75	9.24	4.74	7.50			4.62	7.41	4.6	5.3
35			4.74	9.16	4.73	7.41			4.6	7.33	4.6	5.24
36			4.73	9.11	4.72	6.94			4.6	7.27	4.6	5.22
37			4.72	9.07	4.72	6.69			4.59	7.24	4.6	5.13
38			4.7	8.85					4.58	7.2	4.6	5.02
39			4.69	8.81					4.58	7.04	4.6	5.01
40			4.68	8.48					4.57	6.8	4.6	4.83
41			4.67	8.3							4.5	3.93
42			4.67	7.81							4.5	0.17

Appendix 1c. Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles for Renfrew County, 2011.

Depth (m)	Green- Brougham		Kamaniskeg								Lake Clear	
	Basin 1		Basin 1				Basin 2				Basin 1	
	14-Sep-11		19-Jul-11		14-Sep-11		19-Jul-11		12-Sep-11		12-Sep-11	
	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0			24.9	8.91	20.7	0.213	25.85	8.98	19.2	0.324	20.89	8.98
1	19.7	8.35	24.77	8.93	20.69	0.874	25.81	8.75	19.35	0.886	20.84	9.08
2	19.8	8.17	24.52	8.96	20.46	1.936	25.66	8.74	19.39	1.852	20.54	9.13
3	19.9	8.31	24.18	9.01	20.18	2.881	25.56	8.67	19.42	2.812	20.12	9.19
4	19.9	8.28	24	8.99	20.02	3.877	25.03	8.76	19.4	3.771	20.02	9.16
5	19.9	8.24	22.02	8.97	19.91	4.927	19.45	8.93	19.38	4.863	19.98	9.12
6	19.9	8.35	20.5	8.89	19.73	5.874	16.46	8.44	19.36	5.85	19.93	9.10
7	19.9	8.11	18.94	8.66	19.46	6.813	14.66	8.42	19.36	6.933	19.86	9.11
8	17.5	12.48	16.81	8.65	19.31	7.935	12.86	7.92	19	7.768	19.76	9.01
9	13.9	12.69	14.76	8.62	18.34	8.729	11.46	7.88	15.27	8.875	19.68	8.97
10	11	11.51	14.35	8.53	16.89	9.862	10.92	7.89	12.29	9.855	19.66	8.92
11	9.6	10.17	13.31	8.79	14.99	10.942	10.02	7.99	11.4	10.823	19.22	8.78
12	8.4	8.6	12.46	9.04	13.19	11.846	9.83	8	11.21	11.792	14.42	8.11
13	7.4	7.38	11.08	9.43	10.88	12.857	9.5	8.01	10.29	12.914	12.01	7.47
14	6.7	6.2	9.54	9.84	9.97	13.902	9.29	8.04	9.91	13.904	10.65	6.82
15	6.2	5.35	8.83	10.05	9.63	14.893	9.12	8.05	9.79	14.863	10.01	6.00
16	5.8	4.28	8.27	10.32	9.3	15.864	9.02	8.02	9.58	15.889	9.62	5.15
17	5.4	3.75	8.05	10.37	8.45	16.832	8.94	7.98	9.45	16.82	9.22	4.34
18	5.2	3	7.84	10.39	8.04	17.887	8.9	7.91	9.41	17.88	9.07	3.92
19	5	2.53	7.71	10.4	7.77	18.925	8.82	7.91	9.32	18.93	8.96	3.44
20	4.8	2.22	7.5	10.45	7.52	19.938	8.77	7.84	9.29	19.91	8.87	3.22
21	4.7	1.9	7.37	10.5	7.38	20.853	8.74	7.82	9.25	20.911	8.77	3.16
22	4.6	1.57	7.22	10.57	7.27	21.865	8.68	7.8	9.17	21.81	8.66	3.00
23	4.6	1.44	7.09	10.63	7.14	22.885	8.65	7.74	9.11	22.735	8.55	2.89
24	4.5	0.95	6.98	10.66	7.07	23.877	8.64	7.71	9.08	23.82	8.49	2.79
25	4.5	0.76	6.89	10.66	7.03	24.874	8.63	7.69	9.05	24.878	8.39	2.74
26	4.5	0.69	6.8	10.69	7	25.831	8.61	7.67	9.04	25.887	8.31	2.66
27	4.4	0.89	6.73	10.71	6.92	26.856	8.6	7.65	9.03	26.889	8.19	2.29
28	4.4	0.77	6.67	10.73	6.86	27.813	8.6	7.64	9.02	27.886	8.14	2.19
29	4.3	0.29	6.62	10.73	6.81	28.864	8.6	7.63	9.01	28.862	8.06	2.02
30	4.3	0.13	6.54	10.75	6.79	29.819	8.6	7.6	9.01	29.885	7.98	1.86
31	4.3	0.01	6.51	10.66	6.76	30.849	8.59	7.61	9.01	30.797	7.86	1.71
32	4.2	0.01	6.47	10.61	6.73	31.927	8.59	7.62	9	31.859	7.69	1.56
33	4.2	0.1	6.4	10.61	6.7	32.887	8.59	7.62	9	32.91	7.63	1.31
34	4.2	0.1	6.36	10.57	6.67	33.891	8.59	7.61	9	33.87	7.59	0.85
35			6.31	10.54	6.65	34.885	8.59	7.6	9	34.813	7.58	0.66
36			6.28	10.53	6.62	35.86	8.58	7.59	9	35.837	7.54	0.50
37			6.25	10.51	6.61	36.972	8.57	7.57	8.99	36.885		
38			6.21	10.43	6.6	37.869	8.57	7.57	8.99	37.884		
39			6.19	10.32	6.58	38.892			8.99	38.82		
40			6.17	10.21	6.58	39.24			8.99	39.519		

Appendix 1d. Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles for Renfrew County, 2011.

Depth (m)	McSourley				Morrow							
	Basin 1				Basin 1				Basin 2			
	8-Aug-11		19-Sep-11		19-Jul-11		14-Sep-11		18-Jul-11		14-Sep-11	
	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0	26.0	8.1	17.2	8.9	25.94	8.47	20.03	9.12	25.69	8.28	19.99	9.06
1	25.7	8.1	17.2	8.9	25.6	8.46	20.02	9.08	25.45	8.27	19.99	9.07
2	25.4	8.0	17.1	8.7	25.47	8.41	19.97	9.06	25.26	8.23	19.93	9.08
3	22.5	8.8	17	8.8	24.48	8.6	19.91	9.05	24.4	8.52	19.91	9.08
4	16.8	12.3	17	8.7	18.36	9.98	19.78	9.03	17.58	10.27	19.85	9.08
5	12.2	12.0	13.9	9.6	13.48	10.13	18.49	9.54	12.21	10.33	17.53	9.82
6	8.8	10.6	10	8.7	10.61	8.16	13.73	8.54	8.61	9.73	11.95	9.72
7	7.3	9.4	8.1	7.2	8.91	6.42	10.77	3.62	7.21	9.27	8.46	8.83
8	6.4	8.6	6.8	6.7	7.98	4.65	8.98	1.36	6.33	8.94	6.95	8.29
9	5.5	8.3	5.9	6.4	7.28	2.37	8.12	0.74	5.85	8.83	6	8.38
10	4.9	7.2	5.3	5.9	6.47	0.4	7.62	0.56	5.38	8.69	5.44	8.91
11	4.7	6.4	4.9	5.4			7.25	0.51	5	8.68	4.9	8.64
12	4.4	6.5	4.7	5.3					4.79	8.43	4.64	7.59
13	4.3	6.5	4.5	5.4					4.56	7.02	4.48	6.38
14	4.2	6.2	4.4	5.3					4.43	5.76	4.32	4.67
15	4.1	6.2	4.2	5.2					4.31	4.83	4.22	3.5
16	4.1	6.2	4.1	5.2					4.18	3.66	4.14	2.17
17	4.0	6.1	4.1	5.1					4.09	2.11	4.11	1.49
18	4.0	6.1	4	5.1					4.03	1.33	4.04	1.08
19	4.0	6.0	4	5					3.96	0.56	4.02	0.83
20	3.9	5.7	3.9	4.8					3.93	0.38	3.97	0.66
21	3.9	5.7	3.9	4.6					3.92	0.33	3.96	0.59
22	3.9	5.6	3.9	4.3								
23	3.8	5.5	3.9	4.1								
24	3.8	5.2	3.8	3.8								
25	3.8	4.8	3.8	3.5								
26	3.8	4.5	3.8	2.9								
27	3.8	3.8	3.8	2.5								
28	3.7	3.2	3.8	2								
29	3.7	1.5	3.8	1.8								
30	3.7	1.1	3.8	1.4								
31	3.8	0.6	3.8	0.5								
32	3.8	0.3	3.8	0.3								
33	3.8	0.3	3.8	0.2								
34	3.8	0.3										
35	3.8	0.3										

Appendix 1e. Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles for Renfrew County, 2011.

Depth (m)	Muskrat											
	Basin 1						Basin 2		Basin 3			
	19-Jul-11		12-Sep-11		19-Jul-11		12-Sep-11		19-Jul-11		12-Sep-11	
	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0	24.64	9.23	22.54	8.2	25.67	8.83	21.63	9.72	26.09	8.96	22.49	8.26
1	24.57	9.24	21.08	7.73	25.14	8.81	20.98	9.61	25.48	9.37	20.98	8.61
2	24.28	8.95	20.87	7.87	24.84	8.63	20.74	8.84	25.18	9.31	20.52	9.56
3	23.85	8.26	20.79	7.8	24.57	8.51	20.42	8.13	25.06	8.93	20.47	9.55
4	22.8	7.65	20.73	7.78	24.35	8.19	20.23	7.54	24.67	4.93		
5	22.28	7.32	20.62	7.49	23.09	6.51	20.09	7.02				
6	21.6	6.86	20.37	6.94	20.92	5.78	20.05	6.73				
7	20.27	6.11	20.02	6.59	19.43	5.14	20	6.45				
8	18.05	5.38	19.97	6.43	18.35	4.97	19.92	6.11				
9	15.04	5.19	19.82	6.17	14.73	5.36	19.54	5.53				
10	10.86	5.93	18.04	5.11	13.05	6.08	17.36	4.06				
11			12.64	3.13	11.52	6.39	14.06	2.57				
12			10.49	2.58	10.98	6.61	12.43	2.63				
13			9.62	2.58	10.1	7.25	10.36	3.26				
14			9.08	3.07	9.66	7.36	9.77	3.8				
15			8.78	3.2	9.22	7.47	9.34	4.58				
16			8.45	3.26	8.77	7.66	8.61	5.26				
17			8.31	3.21	8.45	7.76	8.37	5.44				
18					8.25	7.75	8.17	5.58				
19					8.01	7.76	7.79	5.57				
20					7.84	7.7	7.63	5.51				
21					7.69	7.73	7.39	5.49				
22					7.51	7.75	7.32	5.52				
23					7.32	7.66	7.2	5.4				
24					7.09	7.49	7.11	5				
25					6.98	7.3	6.93	4.92				
26					6.86	7.1	6.84	4.8				
27					6.78	6.89	6.79	4.59				
28					6.62	6.42	6.64	4.43				
29					6.45	6.41	6.57	3.77				
30					6.42	6.29	6.54	3.45				
31					6.38	6.14	6.5	3.33				
32					6.36	6.09	6.46	2.87				
33					6.35	6.03	6.46	2.64				
34					6.34	5.98	6.43	2.36				
35					6.35	5.67	6.41	1.98				
36					6.33	5.47	6.4	1.85				
37					6.29	5.33	6.39	1.63				
38					6.29	5.13	6.39	1.41				
39					6.27	4.88	6.38	1.31				

Appendix 1e (cont). Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles for Renfrew County, 2011.

Depth (m)	Muskrat											
	Basin 1						Basin 2		Basin 3			
	19-Jul-11		12-Sep-11		19-Jul-11		12-Sep-11		19-Jul-11		12-Sep-11	
	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
40					6.25	4.81	6.38	1.24				
41					6.24	4.74	6.37	1.13				
42					6.23	4.64	6.37	0.91				
43					6.23	4.5	6.36	0.81				
44					6.23	4.44	6.36	0.72				
45					6.23	4.35	6.36	0.62				
46					6.23	4.14	6.36	0.53				
47					6.23	3.84	6.36	0.5				
48					6.22	3.41	6.36	0.47				
49					6.22	2.74	6.35	0.43				
50					6.22	1.79	6.35	0.39				
51					6.21	1.04	6.35	0.33				
52					6.2	0.45	6.34	0.28				
53					6.2	0.42	6.34	0.23				
54							6.33	0.22				

Appendix 1f. Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles for Renfrew County, 2011.

Depth (m)	Paugh				Raglan (White)		Round		Trout (Stubbs)			
	Basin 1				Basin 1		Basin 1		Basin 1			
	20-Jul-11		14-Sep-11		12-Sep-11		13-Sep-11		20-Jul-11		13-Sep-11	
	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0	26.33	8.19	19.10	9.11			20.28	8.95	26.69	8.1		
1	26.34	8.25	19.22	8.99	20.9	7.63	20.28	8.94	26.56	8.13	20.07	8.93
2	26.16	8.28	19.22	8.99	20.8	4.66	20.28	8.91	25.68	8.24	20.07	8.90
3	24.84	8.5	19.22	8.98	20.8	2.8	20.26	8.91	25.3	8.32	20.07	8.90
4	23	8.8	19.22	8.95	20.8	2.63	20.22	8.9	22.97	9.0	20.05	8.89
5	21.41	8.78	19.23	8.94	20.3	2.62	20.19	8.88	17.15	11.38	19.82	8.91
6	16.75	9.06	19.21	8.89	20.1	2.14	20.06	8.85	12.43	12.56	19.21	8.97
7	13.3	9.11	18.76	8.81	19.4	2.05	19.96	8.86	9.69	12.48	15.33	9.94
8	10.84	9.12	15.44	7.56	12.5	2.06	16.41	7.88	8.21	11.73	10.28	10.43
9	9.71	9.19	11.27	7.56	10.3	2.57	12.73	6.86	7.06	10.8	8.18	10.34
10	9.02	9.29	9.27	7.71	8.6	2.7	11.58	6.84	6.7	10.52	7.53	10.05
11	8.05	9.53	8.61	7.88	7.7	3	10.48	7.12	6.41	10.26	7.07	9.39
12	7.72	9.57	8.04	8.08	7.3	2.98	9.71	7.45	6.19	10.16	6.81	9.21
13	7.49	9.57	7.66	8.16	6.6	3.15	9.54	7.56	6.09	10.07	6.58	8.96
14	7.31	9.6	7.21	8.33	6.1	2.71	9.21	7.69	5.99	10.06	6.41	8.85
15	7.04	9.69	7.13	8.38	5.9	2.57	8.92	7.77	5.89	9.93	6.13	8.61

Appendix 1f (cont). Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles for Renfrew County, 2011.

Depth (m)	Paugh				Raglan White		Round		Trout (Stubbs)			
	Basin 1				Basin 1		Basin 1		Basin 1			
	20-Jul-11		14-Sep-11		12-Sep-11		13-Sep-11		20-Jul-11		13-Sep-11	
	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
16	6.82	9.82	7.03	8.42	5.8	2.34	8.75	7.82	5.81	9.9	6.07	8.58
17	6.71	9.87	6.92	8.48	5.7	2.28	8.54	7.9	5.75	9.89	6.02	8.58
18	6.58	9.9	6.80	8.54	5.6	2.24	8.25	7.98	5.69	9.88		
19	6.49	9.93	6.65	8.61	5.5	2.01	8.08	8.01	5.63	9.86	5.84	8.50
20	6.38	9.92	6.59	8.66	5.5	1	7.98	8.03	5.56	9.88	5.79	8.49
21	6.34	9.92	6.55	8.70			7.97	8.04	5.5	9.89	5.54	8.60
22	6.24	9.92	6.46	8.74			7.92	8.04	5.39	9.91		
23	6.18	9.93	6.33	8.83			7.87	8.05	5.34	9.92	5.34	8.71
24	6.08	9.95	6.24	8.87			7.83	8.05	5.3	9.89	5.27	8.69
25	6.03	9.94	6.16	8.89			7.81	8.06	5.23	9.87	5.25	8.68
26	5.99	9.93	6.11	8.89			7.77	8.06	5.2	9.86	5.22	8.62
27	5.96	9.94	6.06	8.88			7.75	8.05	5.17	9.82	5.20	8.60
28	5.93	9.94	6.04	8.87			7.73	8.03	5.12	9.8	5.17	8.58
29	5.9	9.91	6.02	8.86			7.69	8	5.09	9.8	5.15	8.59
30	5.86	9.89	5.99	8.84			7.67	7.98	5.03	9.8	5.12	8.59
31	5.84	9.87	5.96	8.79			7.66	7.95	5.01	9.62	5.09	8.52
32	5.82	9.83	5.95	8.72			7.65	7.91	4.99	9.52	5.07	8.43
33	5.82	9.77	5.93	8.67			7.63	7.91	4.98	9.44	5.06	8.34
34	5.81	9.72	5.90	8.61			7.61	7.86	4.96	9.32	5.04	8.26
35	5.79	9.7	5.89	8.56					4.95	9.26	5.03	8.15
36	5.77	9.66	5.88	8.51					4.94	9.19	5.02	8.02
37	5.77	9.42	5.88	8.44					4.94	9.09	5.01	7.91
38									4.93	9.02		
39									4.9	8.85		
40									4.9	8.51		
41									4.89	8.37		
42									4.9	8.03		

Appendix 1g. Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles for Renfrew County, 2011.

Depth (m)	Valiant				Wabun				Wadsworth			
	Basin 1				Basin 1				Basin 1			
	8-Aug-11		13-Sep-11		19-Jul-11		12-Sep-11		18-Jul-11		13-Sep-11	
	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0	25.2	7.2	20.5	8.5	26.56	9.01	21.19	9.43	27.11	8.11	19.8	7.98
1	24.90	7.30	20.5	8.5	25.72	9.04	21.14	9.51	27.11	8.05	19.7	8.09
2	24.70	7.30	20.4	8.4	25.52	8.94	21.08	9.61	27.06	8.03	19.7	8.07
3	22.30	8.40	20.3	8.3	24.71	9.58	21.05	9.64	26.66	8.05	19.6	8.15
4	15.10	9.10	18.2	8	22.74	10.96	20.53	9.73	19.64	10.01	19.2	7.93
5	10.50	6.50	12	4.8	16.37	11.52	20.14	9.75	15.34	9.96	18.2	7.75
6	8.40	5.00	8.9	3.1	12.68	9.63	15.3	9.49	11.72	9.75	15	7.22
7	6.90	4.20	7.4	3.2	10.37	8.97	11.46	8.89	9.73	9.09	9.7	6.77
8	6.10	4.30	6.3	3	8.6	7.55	9.27	7.3	8.54	8.63	7.7	6.01
9	5.50	4.60	5.8	2.2	7.42	6.65	7.99	5.66	7.76	8.44	7	5.91
10	5.20	4.10	5.2	1.6	6.75	5.6	7.23	4.02	7.15	8.17	6.4	5.55
11	4.90	3.20	5	1.4	6.47	5.15	6.57	3.27	6.77	7.9	6.2	5.58
12	4.80	1.60	4.8	0.4	5.96	3.89	6.14	2.97	6.31	7.74	6.1	5.65
13	4.70	1.30	4.7	0.3	5.78	3.31	5.88	2.74	5.89	7.39	5.8	5.51
14	4.70	0.40	4.7	0.2	5.62	2.94	5.64	2.58	5.64	7.15	5.5	5.22
15	4.60	0.30	4.6	0.2	5.43	2.82	5.48	2.56	5.53	7.01	5.3	4.77
16	4.60	0.20	4.6	0.2	5.28	2.47	5.33	2.15	5.49	6.87	5.3	4.37
17	4.50	0.20	4.6	0.2	5.18	2.01	5.23	0.99	5.44	6.72	5.3	4.1
18	4.6	0.2	4.6	0.1	5.08	1.39	5.11	0.61	5.37	6.53	5.3	1.51
19	4.60	0.20	4.7	0.1	5.0	0.98	5.04	0.53	5.34	6.3		
20	4.60	0.20			4.96	0.63	4.9	0.49	5.33	6.12		
21					4.91	0.53	4.87	0.47				
22					4.82	0.39	4.79	0.45				
23					4.78	0.35	4.75	0.44				
24					4.76	0.32	4.7	0.44				
25					4.75	0.3	4.63	0.44				
26							4.62	0.46				
27							4.62	0.47				

Appendix 1h. Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles for Renfrew County, 2011.

Depth (m)	Wadsworth Basin 2				Waterloo Basin 1				Wendigo Basin 1			
	18-Jul-11		13-Sep-11		4-Aug-11		13-Sep-11		2-Aug-11		12-Sep-11	
	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0	26.5	8.21			24.6	7.8	19.83	8.1	24.4	7.8	19.7	8.7
1	26.56	8.11	20.2	7.63	24.3	7.8	19.8	8	24.4	7.8	19.4	8.6
2	26.52	8.08	20.2	7.92	24.2	7.8	19.7	7.9	24.4	7.8	19.2	8.4
3	24.78	8.35	20.1	7.97	24.1	7.7	19.4	7.8	23.7	8	19.1	8.3
4	19.79	9.81	19.8	7.92	20	6.8	18.7	7.4	21.6	7.9	19	8.3
5	14.98	10.2	18.9	7.87	14.7	5.8	16.6	4.5	14.5	6.7	18.2	8.3
6	10.86	8.65	13.9	6.61	11.2	5.7	12.1	3.4	12.2	6.2	16.5	6.1
7	9.24	8.06	10.1	5.71	9.1	5.8	9.6	3.4	11.1	6.1	13	4.5
8	8.41	7.74	8.7	5.52	7.7	6.8	8.1	4	9	7.4	10.6	4.7
9	7.54	7.67	8.1	5.76	7.3	6.8	7.3	4.5	8.2	7.2	8.9	5
10	7.12	7.6	7.1	5.66	6.7	7.2	6.7	4.8	7.5	7	8	5.2
11	6.84	7.55	6.8	5.57	6.3	7.3	6.4	5	7.1	7.4	7.6	5.1
12	6.55	7.5	6.6	5.49	5.9	7	6.1	4.9	6.9	7.1	7.3	5
13	6.4	7.42	6.3	5.26	5.7	7.1	5.8	4.9	6.8	7	7.1	4.9
14	6.29	7.39	6.2	5.28	5.5	6.9	5.6	4.7	6.6	6.9	6.9	4.6
15	6.08	7.3	6.1	5.22	5.4	6.6	5.5	4.4	6.5	6.6	6.8	4.2
16	5.91	7.17	5.9	4.93	5.3	5.6	5.4	3.6	6.4	6.4	6.7	4.1
17	5.73	7.01	5.8	4.78	5.2	4.9	5.3	3	6.4	6.4	6.6	3.9
18	5.62	6.77	5.7	4.58	5.1	4.5	5.3	2.6	6.4	6.2	6.6	3.7
19	5.59	6.67	5.6	4.43	5.1	4.1	5.3	2.4	6.3	6	6.5	3.6
20	5.55	6.61	5.6	4.39	5	3.3	5.2	2.1	6.3	5.9	6.5	3.1
21	5.46	6.49	5.5	4.16	5	2.5	5.2	1.9	6.3	5.6	6.4	2.7
22	5.45	6.34	5.5	4.09	5	1.3	5.2	0.8	6.3	5.5	6.4	2.6
23	5.43	6.24	5.5	3.91			5.2	0.3	6.3	5.2	6.4	0.4
24	5.39	6.2	5.5	3.71							6.4	0.3
25			5.5	6.65								
26			5.4	2.67								
27			5.4	1.03								

APPENDIX 2

Lake Chemistry Summaries

Bark

Total Phosphorus concentrations for the euphotic zone in 2011 ranged from 0.002 mg/L in May (Basins 1 and 2) to 0.005 mg/L in September (Basin 2). Historical data from 2001-2003 showed total phosphorus concentrations ranged from 0.004 mg/L in May 2001 to 0.008 mg/L in May 2003. When total phosphorus concentrations exceed 0.02mg/L, there is an increased likelihood of nuisance algal blooms occurring.

All other chemical parameters in 2011 were within the historical 2001-2003 ranges.

In the most recent sampling event, Secchi disc depth visibility ranged from 3m in September 2010 (Basin 3) to 4.5m in May 2011 (Basin 2). This indicates that Bark Lake has good to moderate water clarity. Historical data from 2001-2003 showed that Secchi measurements range from 3.8m in July 2001 to 6.5m in May 2001.

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen (MVWHDO) in Basin 2 was 9.1 mg/L. Basins 1 and 3 were not sampled in 2011, but the 2010 MVWHDO was 9.58 mg/L in Basin 1, 9.79 mg/L in Basin 2 and 9.14 mg/L in Basin 3. Under these conditions, lake trout in this lake are not likely to be under stress. Historical data from 2003 showed that the MVWHDO was 10.3 mg/L, suggesting that it is consistently above the 7.0 mg/L threshold.

Big Gibson

Please refer to the Lake Data Sheet in Appendix 3.

Big Limestone

Please refer to the Lake Data Sheet in Appendix 3.

Burns - Griffith

Total Phosphorus concentrations for the euphotic zone in 2011 ranged from 0.002 mg/L in May to 0.006 mg/L in August. Historical data from 2003 shows a range of 0.007 mg/L in May 2003 to 0.008 mg/L in August 2003. When total phosphorus concentrations exceed 0.02mg/L, there is an increased likelihood of nuisance algal blooms occurring. Ammonia concentrations in 2011 were higher than the historical range; 2011 data shows a range of 0.026 mg/L in July to 0.041 mg/L in May. The 2003 historical data for ammonia concentrations show a range of 0.019 mg/L in May 2003 to 0.026 mg/L in September 2003.

All other chemical parameters in 2011 were within the historical 2001-2003 ranges.

Secchi disc depth visibility in 2011 ranged from 5.5 m in May to 6.65 m in July. This indicates that Burns Lake has excellent water clarity. Historical data from 2003 shows Secchi visibility ranged from 5.7 m in May 2003 to 7.0 m in August 2003.

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen (MVWHDO) was 5.87mg/L. Under these conditions, lake trout in this lake are likely to be under stress. In 2003, this value was 6.32 mg/L, which indicates that Burns Lake regularly experiences MVWHDO concentrations of less than 7 mg/L during the critical late summer period. No profiles were taken between 2003 and 2011.

Carson

Total Phosphorus concentrations for the euphotic zone in 2011 ranged from 0.002 mg/L in May to 0.006 mg/L in July. Historical data from 2001 to 2003 show that total phosphorus ranged from 0.004 mg/L in May 2001 to 0.008 mg/L in May 2003. Ammonia concentrations in 2011 ranged from 0.021mg/L in July to 0.034 mg/L in May; these values are higher than the historical range of 0.011mg/L in May 2003 to 0.020mg/L in July 2003.

All other chemical parameters in 2011 were within the historical 2001-2003 ranges.

Secchi disc depth visibility in 2011 ranged from 5 m in July to 5.6 m in September. This indicates that Carson Lake has good water clarity. Historical data from 2001-2003 showed that Secchi visibility ranged from 3.825m in July 2001 to 6.5m in September 2003.

The late 2011 summer critical period mean volume-weighted hypolimnetic dissolved oxygen (MVWHDO) was 9.23 mg/L. Under these conditions, lake trout in this lake are not likely to be under stress. Historical data show values of 10.1 mg/L in 2003. This data indicates that the MVWHDO in Carson Lake tends to fluctuate above and slightly below the 7.0 mg/L threshold.

Charlotte

Total Phosphorus concentrations for the euphotic zone in 2011 ranged from 0.007 mg/L in September to 0.008 mg/L in May. When total phosphorus concentrations exceed 0.02 mg/L, there is an increased likelihood of nuisance algal blooms occurring. Historical data from 2003 shows that total phosphorus concentrations ranged from 0.008mg/L in August 2003 to 0.011mg/L in May 2003.

All other chemical parameters in 2011 were within the historical 2001-2003 ranges.

Secchi disc depth visibility in 2011 ranged from 3.5m in September to 10.2m in May. Historical data from 2003 shows a range of 6.3m in July 2003 to 7.75m in May 2003.

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen (MVWHDO) was 3.38 mg/L. Under these conditions, lake trout in this lake are likely to be stressed. In 2003 this value was 2.48 mg/L, which indicates that Charlotte Lake regularly experiences MVWHDO concentrations well below the 7 mg/L threshold during the critical late summer period.

Diamond

Total Phosphorus concentrations for the euphotic zone in 2011 ranged from 0.005 mg/L in September to 0.014 mg/L in May. Historical data from 2003 shows that total phosphorus ranged from 0.008 mg/L in August 2003 to 0.016 mg/L in July 2003. Ammonia concentrations in 2011 ranged from 0.022 mg/L in July to 0.037 mg/L in May; this is higher than the 2003 historical range of 0.002 mg/L in August 2003 to 0.013 mg/L in July 2003.

All other chemical parameters in 2011 were within the historical 2001-2003 ranges.

Secchi disc depth visibility in 2011 ranged from 2.6m in May to 4 m in July. This indicates that Diamond Lake has good to moderate water clarity. Historical data from 2003 showed that Secchi visibility ranged from 3.0m in July 2003 to 4.5m in August 2003.

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen (MVWHDO) was 7.31 mg/L. Under these conditions, lake trout in this lake are not likely to be under stress. Historical MVWHDO values were 5.48 mg/L in 2006, 5.9 mg/L in 2004 and 6.9 mg/L in 2003. This data indicates that the MVWHDO in Diamond Lake tends to fluctuate.

Green-Brougham

Total Phosphorus concentrations for the euphotic zone in 2011 ranged from 0.004 mg/L in May to 0.005 mg/L in September. Historical data from 2003 showed that total phosphorus ranged from 0.006 mg/L in May 2003 (Basins 1 and 2) to 0.008 mg/L in September 2003 (Basins 1 and 2). Nitrate concentrations in 2011 ranged from 0.031 mg/L in May to 0037 mg/L in September. Historical data from 2003 showed that nitrate concentrations ranged from 0.001 mg/L in July 2003 (Basin 2) to 0.006 mg/L in May 2003 (Basin 1).

All other chemical parameters in 2011 were within the historical 2001-2003 ranges.

Secchi disc depth visibility ranges from 6.5 m in May to 6.7 m in September. This indicates that Green Lake has good water clarity. Historical data from 2003 showed that Secchi visibility ranged from 6.0 m in July 2003 (Basin 1) to 7.4 m in May 2003 (Basin 1).

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen (MVWHDO) was 3.52 mg/L. Under these conditions, lake trout in this lake are likely to be highly stressed. Historical MVWHDO values were 3.32 mg/L in 2006 and 4.91mg/L in 2003. This data indicates that Green Lake regularly experiences MVWHDO concentrations well below the 7 mg/L threshold during the critical late summer period.

Kamaniskeg

Total Phosphorus concentrations for the euphotic zone in 2011 ranged from 0.002 mg/L in May (Basin 2) to 0.014 mg/L in July (Basin 1). Historical data from 2003-2006 showed a range of 0.003 mg/L in September 2006 to 0.017 mg/L in July 2006.

All other chemical parameters in 2011 were within the historical 2003-2006 ranges.

Secchi disc depth visibility ranges from 3.5 m in July 2011 (Basin 1) to 4.6 m in September (Basin 1). This indicates good to moderate water clarity. Historical data from 2003-2006 showed a range of 3.6 m in May 2006 (Basin 1) to 5.0m in September 2003 (Basin 1).

The late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen (MVWHDO) in Basin 1 (North) was 5.09 mg/L in 2011 and 5.58 mg/L in 2010. Under these conditions, lake trout in this basin are likely to be under stress. This value was 6.23 mg/L in 2003, suggesting that the MVWHDO in Basin 1 is consistently below the 7.0 mg/L threshold. Basin 2 (South) MVWHDO was 8.18 mg/L in 2011 and 8.24 mg/L in 2010. Under these conditions, lake trout in this basin are not likely to be under stress. No profiles of Basin 2 were taken in 2003.

Lake Clear

Total Phosphorus concentrations for the euphotic zone in 2011 ranged from 0.004 mg/L in May to 0.007 mg/L in September. Historical data from 2003 shows that total phosphorus ranged from 0.007 mg/L in September 2003 to 0.079 mg/L in July 2003.

All other chemical parameters in 2011 were within the historical 2003 ranges.

Secchi disc visibility in 2011 was 5.5 m in May. This indicates that Lake Clear has good water clarity. Historical data from 2003 showed that Secchi visibility ranged from 4.5 m in July 2003 to 5.0 m in September 2003.

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen (MVWHDO) was 4.59 mg/L. Under these conditions, lake trout in this lake are likely to be under stress. Historical MVWHDO values were 2.30 mg/L in 2010 and 4.23 mg/L in 2003. This data indicates that Lake Clear regularly experiences MVWHDO concentrations well below the 7 mg/L threshold during the critical late summer period.

McSourley

Please refer to the Lake Data Sheet in Appendix 3.

Morrow

Please refer to the Lake Data Sheet in Appendix 3.

Muskrat

Total Phosphorus concentrations for the euphotic zone in 2011 ranged from 0.023mg/L in July to 0.32mg/L in September. When total phosphorus concentrations exceed 0.02 mg/L, there is an increased likelihood of nuisance algal blooms occurring. Historical data from 2003-2005 shows that total phosphorus ranged from 0.012 in September 2005 to 0.64 in July 2003.

All other chemical parameters in 2011 were within the historical 2003-2005 ranges.

Secchi disc depth visibility in 2011 ranged from 2.4 m in September to 3.3 m in July. This indicates that Muskrat Lake has moderate to poor water clarity. Historical data from 2003-2005 showed that Secchi visibility ranged from 1.0 m in May 2003 to September 2003.

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen (MVWHDO) in Basin 1 was 3.05 mg/L. In Basin 2, the recorded MVWHDO profiles are 4.08 mg/L in 2011, 2.64 mg/L in 2007 and 3.22 mg/L in 2005. Under these conditions, lake trout in Basin 1 and Basin 2 are likely to be under stress.

Paugh

Total Phosphorus concentrations for the euphotic zone in 2011 ranged from 0.003 mg/L in July to 0.006 mg/L in September. Historical data from 2003 indicates a total phosphorus range of 0.006mg/L in September 2003 to 0.009 mg/L in May 2003. Ammonia concentrations from the most recent sampling events ranged from 0.004 mg/L in September 2010 to 0.032 mg/L in July 2011. Historical data from 2003 shows a range of 0.006mg/L in September 2003 to 0.027mg/L in May 2003. Nitrite concentrations of the most recent sampling events were 0.001 mg/L in September 2010 and 0.004 mg/L in September 2011. Historical nitrate concentrations from 2003 ranged from 0.004 mg/L in July 2003 to 0.008 mg/L in September 2003.

All other chemical parameters in 2011 were within the historical 2003 ranges.

Secchi disc depth visibility in 2011 ranged from 3.25m in July to 4.75m in September. This indicates that Paugh Lake has good to moderate water clarity. Historical data from 2003 indicates a Secchi visibility range of 3.75m in July 2003 to 5.6 m in September 2003.

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen (MVWHDO) was 8.43 mg/L. Under these conditions, lake trout in this lake are not likely to be under stress. Historically, this value was 7.91 mg/L in 2010 and 7.13 mg/L in 2003, suggesting that the MVWHDO in Paugh Lake is consistently above the 7.0 mg/L threshold.

Raglan (White)

Total Phosphorus concentrations for the euphotic zone in 2011 ranged from 0.005 mg/L in September to 0.011 mg/L in May. Historical data from 2003 indicates a range of total phosphorus concentrations from 0.008 mg/L in September 2003 to 0.014 mg/L in May 2003. Ammonia concentrations in 2011 ranged from 0.033 mg/L in September to 0.034mg/L in May. Historical data from 2003 indicates an ammonia concentration range of 0.017 mg/L in September 2003 to 0.028 mg/L in July 2003.

All other chemical parameters in 2011 were within the historical 2003 ranges.

Secchi disc depth visibility ranges from 3.2 m in May to 4.1 m in September. This indicates that Raglan White Lake has good to moderate water clarity. Historical data from 2003 indicates a Secchi range of 4.5 m in July 2003 to 5.75 m in May 2003.

The 2011 late summer/early fall critical period MVWHDO was 3.23 mg/L. Under these conditions, lake trout in this lake are likely to be under stress. This value was 0.88 mg/L in 2003, suggesting that Raglan (White) Lake regularly experiences MVWHDO concentrations well below the 7 mg/L threshold during the critical late summer period.

Round

Total Phosphorus concentrations for the euphotic zone in 2011 ranged from 0.002 mg/L in May to 0.005 mg/L in September. Historical data from 2003 indicates a range of 0.006 mg/L in July 2003 to 0.009 mg/L in September 2003. Ammonia concentrations in 2011 ranged from 0.029 mg/L in May to 0.033 mg/L in September. Historical ammonia concentration data from 2003 indicates a range of 0.008 mg/L in July 2003 to 0.026 mg/L in September 2003.

All other chemical parameters in 2011 were within the historical 2003 ranges.

Secchi disc depth visibility in 2011 ranged from 3.1m in September to 4.0 m in May. Historical Secchi visibility data from 2003 indicates a range of 2.7 m in May 2003 to 3.5 m in July 2003.

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen (MVWHDO) was 7.80 mg/L. Under these conditions, lake trout in this lake are not likely to be under stress. This value was 7.67 mg/L in 2010 and 7.54 mg/L in 2003, suggesting that the MVWHDO in Round Lake is consistently above the 7.0 mg/L threshold.

Trout (Stubbs)

Total Phosphorus concentrations for the euphotic zone in 2011 ranged from 0.002 mg/L in May to 0.006 mg/L in September. Historical data from 2003 shows that total phosphorus was 0.007 mg/L in the May, July, and September sampling events in 2003. Ammonia concentrations in 2011 ranged from 0.021 mg/L in May to 0.037 mg/L in September. Historical ammonia concentration data from 2003 indicates a range of 0.006 mg/L in July to 0.013 mg/L in September. Nitrate concentrations in 2011 ranged from 0.024 mg/L in July to 0.048 mg/L in September. Historical data indicates that nitrate concentrations ranged from 0.007 mg/L in July 2003 to 0.029 mg/L in September 2003.

All other chemical parameters in 2011 were within the historical 2003 ranges.

Secchi disc depth visibility in 2011 ranged from 4.5 m in July to 6.0m in September. This indicates that Trout (Stubbs) Lake has good water clarity. Historical data from 2003 indicates that Secchi visibility ranged from 5.5 m in July 2003 to 6.12 m in May 2003.

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen (MVWHDO) was 8.94 mg/L. Under these conditions, lake trout in this lake are not likely to be under stress. This value was

8.84 mg/L in 2003, suggesting that the MVWHDO in Trout (Stubbs) Lake is consistently above the 7.0 mg/L threshold.

Valiant

Please refer to the Lake Data Sheet in Appendix 3.

Wabun

Please refer to the Lake Data Sheet in Appendix 3.

Wadsworth

Total Phosphorus concentrations for the euphotic zone in 2011 ranged from 0.004 mg/L in May (Basin 1) to 0.02 mg/L in September (Basin 1). When total phosphorus concentrations exceed 0.02mg/L, there is an increased likelihood of nuisance algal blooms occurring. Historical data shows that total phosphorus ranged from 0.007 mg/L in August 2003 (Basin 1) to 0.012 mg/L in May 2003 (Basin 1).

Ammonia concentrations in 2011 ranged from 0.034 mg/L in September (Basin 1) to 0.040 mg/L in July (Basin 2). Historical ammonia concentration data from 2003 indicates a range of 0.016 mg/L in September 2003 (Basin 1) to 0.019 mg/L in May 2003 (Basin 1).

Nitrate concentrations in 2011 ranged from 0.01 mg/L in May (Basins 1 and 2) to 0.069 mg/L in July (Basin 1). Historical data indicates that nitrate concentrations ranged from 0.009 mg/L in July 2003 to 0.029 mg/L in September 2003.

All other chemical parameters in 2011 were within the historical 2003 ranges.

Secchi disc depth visibility in 2011 ranged from 2.3 m in May (Basin 1) to 3.5 m in July (Basin 1). This indicates that Wadsworth Lake has moderate water clarity. Historical data indicates a range of 4.0 m in July 2003 (Basin 1) to 7.0 m in August 2003 (Basin 1).

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen (MVWHDO) was 5.30 mg/L in Basin 1 and 5.34 mg/L in Basin 2. Under these conditions, lake trout in this lake are likely to be under stress. Historical MVWHDO data from 2003 indicates values of 6.05 mg/L in Basin 1 and 6.06 mg/L in Basin 2, suggesting that the MDO in Wadsworth Lake is consistently below the 7.0 mg/L threshold during the critical late summer period.

Waterloo

Please refer to the Lake Data Sheet in Appendix 3.

Wendigo

Total Phosphorus concentrations for the euphotic zone in 2011 ranged from 0.004 mg/L in May to 0.011 mg/L in July. Historical data shows that total phosphorus ranged from 0.004 mg/L in May 2001 to 0.009 mg/L in May 2003.

Ammonia concentrations in 2011 ranged from 0.022mg/L in September to 0.039 mg/L in July. Historical ammonia concentration data from 2001-2003 indicates a range of 0.002 mg/L in September 2001 to 0.009 mg/L in May 2003.

All other chemical parameters in 2011 were within the historical 2003 ranges.

Secchi disc depth visibility in 2011 ranged from 4m in May to 4.1 m in September. This indicates that Wendigo Lake has good water clarity. Historical data from 2001-2003 indicates a range of 3.0 m in July 2003 to 6.5m in May of 2001.

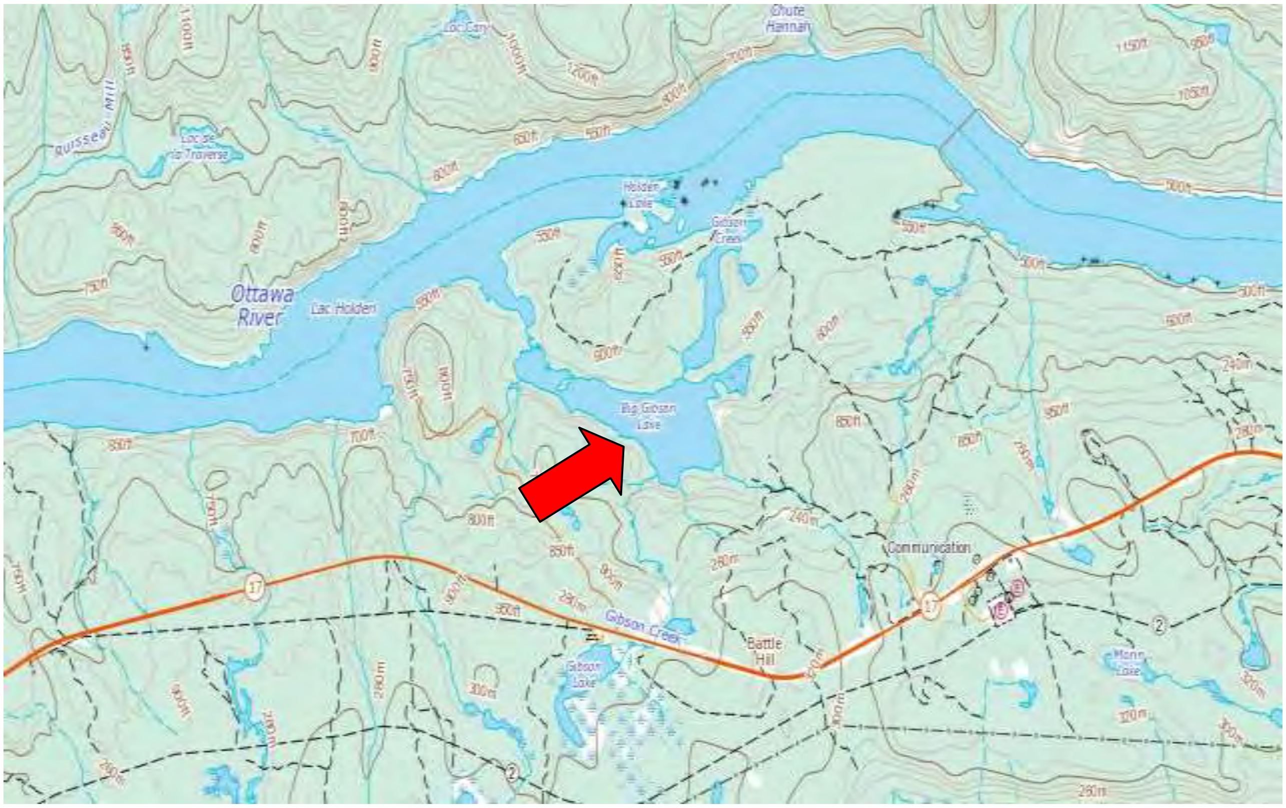
The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen (MVWHDO) was 4.78 mg/L. Under these conditions, lake trout in this lake are likely to be under stress. Historically, this value was 6.97 mg/L in 2007 and 5.57 mg/L in 2003, suggesting that the MVWHDO in Wendigo Lake is consistently below the 7.0 mg/L threshold during the critical late summer period.

APPENDIX 3

Lake Data Sheets for New Lakes

In 2011, the Ministry was able to include seven new lakes in the County of Renfrew as part of the lake trout lake monitoring program. This combined report features the lake data sheets of the new lakes. Data sheets for all of the lakes in this report are available separately upon request, and will be updated for and included in the next major report.

BIG GIBSON LAKE



LOCATION

County:..................................Renfrew
Township:............................Municipality of Head, Clara & Maria
Geographic Township:.....Maria
Watershed:............................Ottawa River
Zone:..17T
Easting:...................................0717549
Northing:................................5127061
Topographic Sheet:..........North Bay 31L8

MORPHOMETRY

Surface Area: ....78.2 ha
Watershed Area:..................7.49 Km^2
Shoreline Length:................7.74 Km
Maximum Depth:..................38.1 m
Mean Depth:........................7.22 m
Total Volume:........................475. 06 x10 m^3

No Bathymetry Map for Big Gibson Lake is available.

WATER CHEMISTRY

Table 1. Big Gibson Lake Water Chemistry, 2011 (all values mg/L unless noted).

PARAMETER	02-Aug-11		12-Sep-11	
	Basin 1		Basin 1	
	EUP	MOB	EUP	MOB
Secchi Disk (m)	2.75		3.9	
Total Phosphorous	0.008	0.032	0.006	0.038
Ammonia- Nitrogen	0.033	2.94	0.015	3.14
Nitrite-Nitrogen	0.002	0.045	0.001	0.042
Nitrate+Nitrite - Nitrogen	0.031	0.037	0.011	0.028
Total Kjeldahl Nitrogen	0.3	4	0.27	4.45
Dissolved Organic Carbon	7.4	23	7.2	23.5
Dissolved Inorganic Carbon	1.8	8	1.5	7.5
pH	7.26	7.25	7.27	7.5
Alkalinity	8.3	37.8	8.5	39.6
Conductivity (μS/cm)	124	201	122	201
Calcium	3.62	8.97	3.66	9.62
Magnesium	1.44	2.09	1.59	2.05
Hardness	15	31	16	32
Total Suspended Solids	1.3	16.5	1.1	38.4
Total Dissolved Solids	81	131	79	131

Total Phosphorus concentrations in 2011 for Big Gibson Lake are low and should preclude the formation of nuisance algal populations. Nitrogen concentrations are within the average for lakes in the Renfrew area.

Secchi disc depth visibility ranges from 2.75m to 3.9m. This indicates that Big Gibson Lake has moderate water clarity.

The euphotic DOC concentrations ranged between 7.2mg/L to 7.4 mg/L. These are high concentrations and likely indicate strong organic material input from shoreline wetlands or from tributary streams.

Based on pH and total alkalinity, Big Gibson lake is moderately sensitive to acidification by acid rain.

The oxygen and temperature profiles are presented in Table 2 and Figures 1 & 2. The temperature profiles indicate that Big Gibson Lake consistently has well-defined stratified temperature layers. The 2011 dissolved oxygen profiles show a slight decrease of oxygen concentration in the metalimnion. This type of oxygen profile develops by the decomposition of settling organic material accumulating in the metalimnion as a result of a thermally induced water density gradient. Dissolved oxygen concentrations slightly increase after this and decrease slowly until the last few meters of the hypolimnion.

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen (MVWHDO) was 5.43 mg/L. Under these conditions, lake trout in this lake are likely to be under high levels of stress.

FISHERIES SUMMARY

The fish community in Big Gibson Lake includes lake trout, northern pike, white sucker, largemouth bass, smallmouth bass and rock bass. Lake trout were initially stocked in 1962 and have been stocked regularly since then. Big Gibson Lake is managed as part of a Put-Grow-Take lake trout fishery which anglers can enjoy all year-round.

Table 2. Big Gibson Lake Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles, 2011.

Depth	02-Aug-11		12-Sep-11	
(m)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)
0	25.8	7.5	20.5	8.9
1	25.4	7.3	20.3	8.9
2	24.9	7.6	20.2	8.6
3	22.3	7.5	19.7	8.3
4	16.2	8.5	17.5	7.7
5	11.7	7.4	13.2	7
6	9	6.9	9.7	5.9
7	7.6	6.7	8.3	5.4
8	7.1	6.6	7.6	5.2
9	6.8	6.6	7.3	5.1
10	6.6	6.6	7	5.1
11	6.1	6.7	6.6	5.2
12	5.7	6.9	6	5.4
13	5.5	7	5.6	5.7
14	5.2	7.1	5.3	6
15	4.9	7.2	5.1	6.2
16	4.7	7.2	4.8	6.3
17	4.4	7	4.6	6.3
18	4.3	6.9	4.4	6.1
19	4.2	6.7	4.3	5.9
20	4.1	6.9	4.1	5.8
21	4	6.9	4.1	5.7
22	4	6.6	4.1	5.6
23	4	5.7	4	5
24	4	5.1	4	3.7
25	4	4.3	4	3.1
26	4	3.5	4	2.2
27	4	2.2	4	1.6
28	4	1.7	4	0.8
29	4	1.3	4	0.5
30	4	1.1	4	0.3
31	4	0.3	4	0.3
32	4.1	0.2	4.1	0.2
33	4.1	0.2	4.2	0.2
34	4.2	0.2	4.2	0.2
35	4.2	0.1	4.3	0.2

Figure 1. Temperature Profiles, 2011.

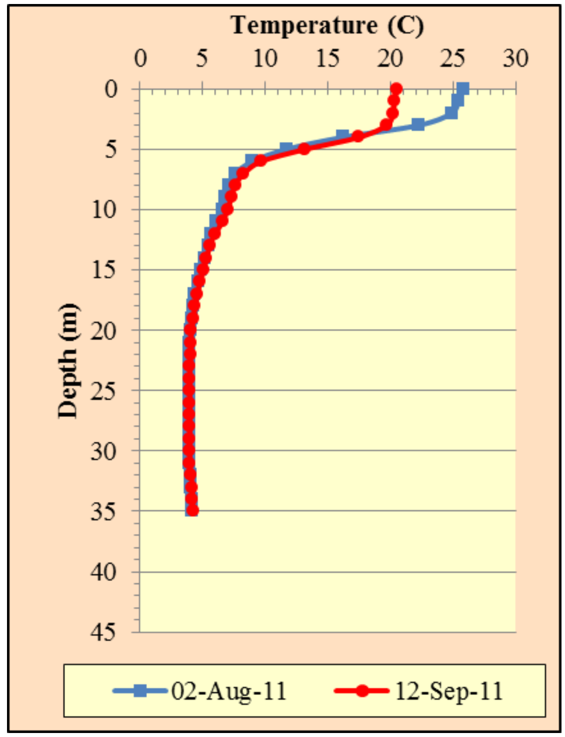
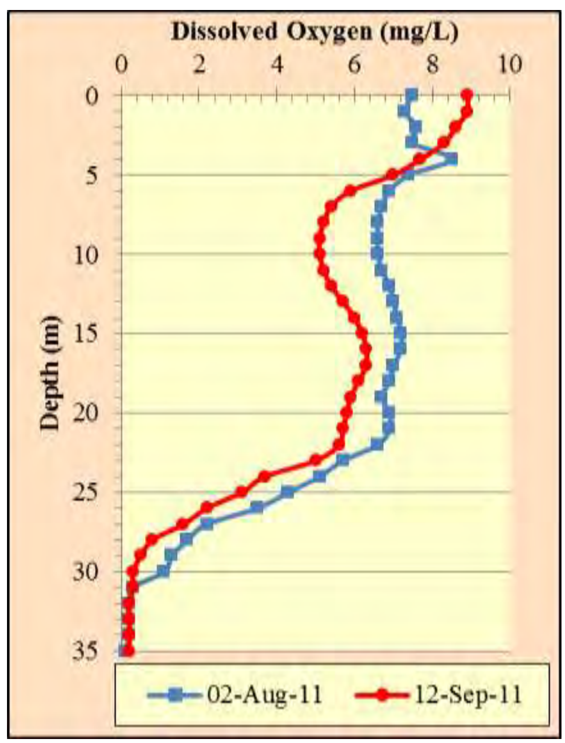


Figure 2. Dissolved Oxygen Concentration Profiles, 2011.



BIG LIMESTONE LAKE

LOCATION

County:...................................Renfrew
Township:..............................Municipality of Greater Madawaska
Watershed:............................Madawaska
Zone:.......................................18T
Easting:..................................0341841
Northing:...............................5011216
Topographic Sheet:...........Denbigh 31F3

MORPHOMETRY

Surface Area: ....31.7 ha
Watershed Area:.................. N/A
Shoreline Length:.............3.68 km
Maximum Depth:................30.0 m
Mean Depth:........................13.2 m
Total Volume:.....................418.6 x10^4 m^3

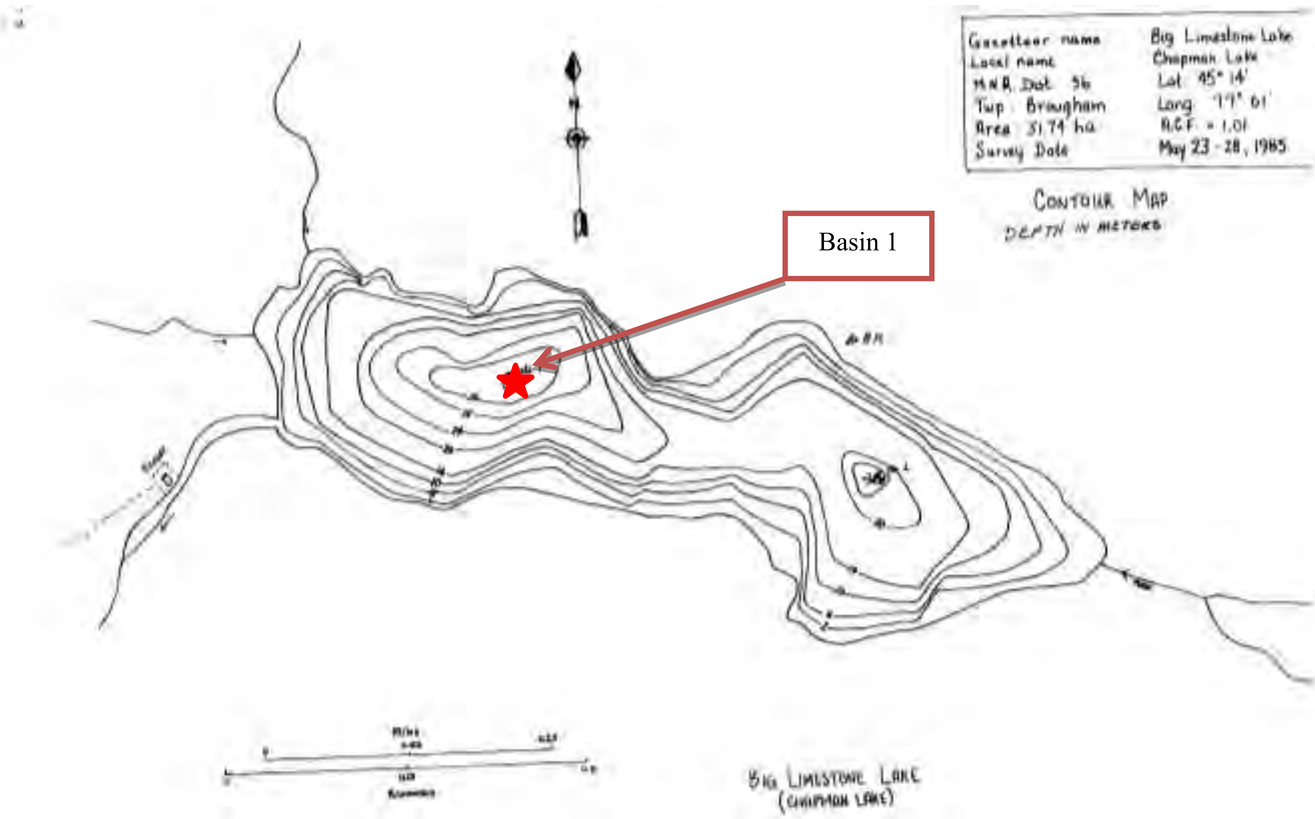


Figure 1. Big Limestone Lake Bathymetry Map.

WATER CHEMISTRY

Table 1. Big Limestone Lake Water Chemistry, 2011 (all values mg/L unless noted).

PARAMETER	09-Aug-11		20-Sep-11	
	Basin 1		Basin 1	
	EUP	MOB	EUP	MOB
Secchi Disk (m)	5.4		5	
Total Phosphorous	0.005	0.099	0.005	0.106
Ammonia- Nitrogen	0.025	0.436	0.002	0.528
Nitrite-Nitrogen	0.001	0.003	0.001	0.002
Nitrate+Nitrite - Nitrogen	0.025	0.031	0.01	0.01
Total Kjeldahl Nitrogen	0.24	1.06	0.3	1.16
Dissolved Organic Carbon	5.3	5.5	5	5.4
Dissolved Inorganic Carbon	30.1	39.6	29.2	38.5
pH	8.54	8.29	8.46	7.97
Alkalinity	124	157	125	160
Conductivity (μS/cm)	243	303	238	305
Calcium	41.6	52	44.7	55.6
Magnesium	7.7	8.97	7.51	8.33
Hardness	140	170	140	170
Total Suspended Solids	1	12.1	1.3	8.8
Total Dissolved Solids	158	197	155	198

Total Phosphorus concentrations in 2011 for the euphotic zone of Big Limestone Lake were low and should preclude the formation of nuisance algal populations. Nitrogen concentrations are within the average for lakes in the Renfrew area.

Secchi disc depth visibility ranged from 5m in September to 5.4m in August. This indicates that Big Limestone Lake has good water clarity.

The euphotic DOC concentrations ranged between 5mg/L in September and 5.3 mg/L in August. These are moderate concentrations and likely indicate some organic material input from shoreline wetlands or from tributary streams.

Based on pH and total alkalinity, Big Limestone Lake is unlikely to be impacted by acid rain.

The oxygen and temperature profiles are presented in Table 2 and Figures 2 & 3. The temperature profiles indicate that Big Limestone lake has well-defined stratified temperature layers. Dissolved oxygen profiles show oxygen enrichment in the metalimnion. This is a common variation in oxygen distribution in lakes and is likely due to thermally trapped algae that can still photosynthesize because of good water clarity.

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen concentration (MVWHDO) was 2.79 mg/L. Under these conditions, lake trout in this lake are likely to be under high levels of stress.

FISHERIES SUMMARY

The fish community in Big Limestone Lake includes lake trout, whitefish, yellow perch, and pumpkinseed. A Put-Grow-Take lake trout stocking program started on Big Limestone Lake in 1982 and has continued to present day. The lake trout season is open year-round on this lake.

Table 2. Big Limestone Lake Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles, 2011.

Depth	09-Aug-11		20-Sep-11	
(m)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)
0	24.1	7.9	17.9	9
1	24.1	7.9	17.9	8.9
2	24.1	7.7	17.8	8.7
3	24.1	7.8	17.8	8.6
4	24	7.9	17.8	8.6
5	18.4	12.9	17.7	8.7
6	13.2	13.9	17.4	8.6
7	9.4	12.1	12.3	11.2
8	7.7	11.1	9.3	10.3
9	6.5	9.1	7.5	8.3
10	5.7	7.9	6.3	7
11	5.3	7.1	5.8	5.7
12	4.9	6.3	5.3	5.2
13	4.6	5.3	4.9	4.2
14	4.4	4.2	4.6	3.5
15	4.2	3.1	4.5	2.9
16	4.1	2.6	4.3	2
17	4	2.3	4.2	0.9
18	4	1.8	4.1	0.5
19	4	1.2	4.1	0.3
20	3.9	0.7	4	0.2
21	3.9	0.5	4	0.2
22	3.9	0.4	4	0.2
23	3.9	0.3	4	0.2
24	3.9	0.2	4	0.2
25	3.9	0.2	4	0.2
26	3.9	0.2	3.9	0.2
27	3.9	0.2	3.9	0.1
28	3.9	0.2	3.9	0.1
29	3.9	0.2	3.9	0.1
30	3.9	0.2	3.9	0.1
31	3.9	0.2	3.9	0.1
32	3.9	0.1	3.9	0.1
33	3.9	0.1	3.9	0.1
34	4	0.1	4	0.1
35	4	0.1	4	0.1

Figure 2. Temperature Profiles, 2011.

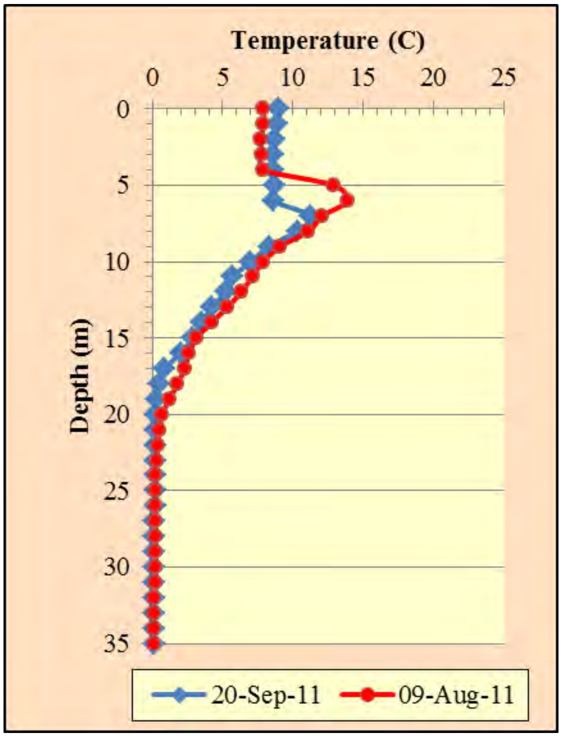
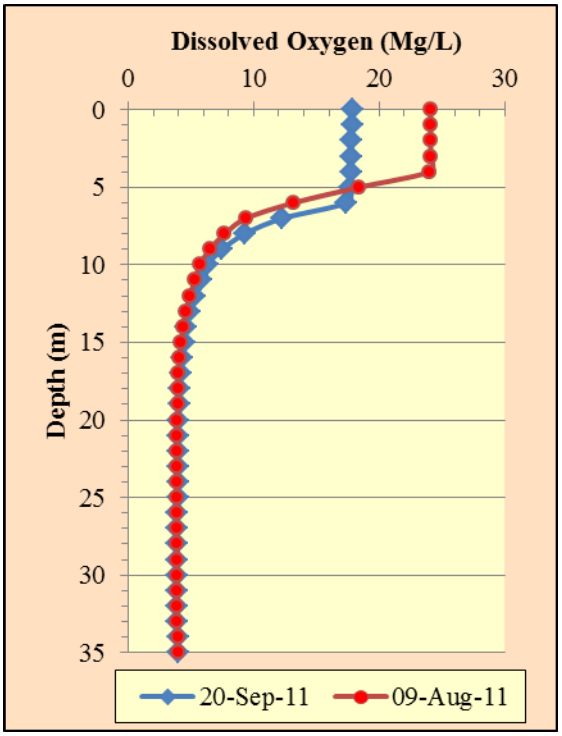
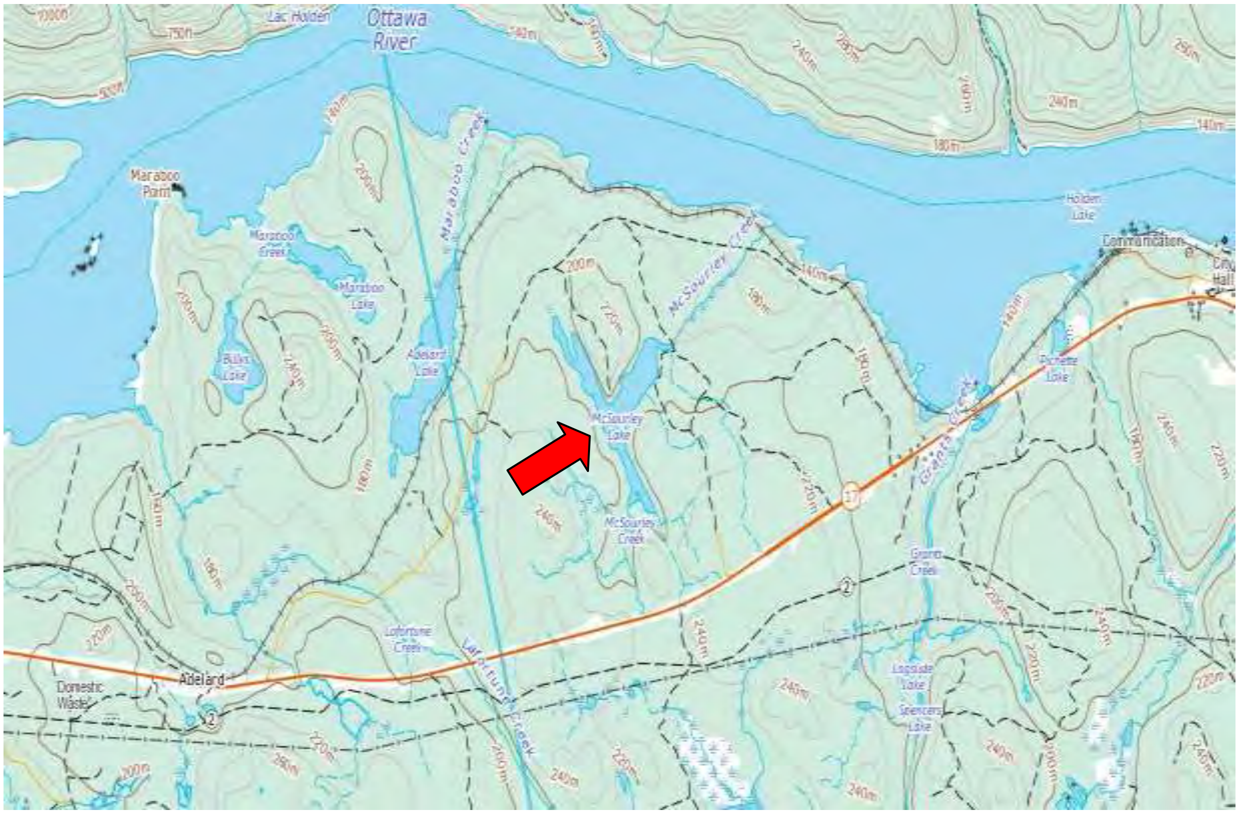


Figure 3. Dissolved Oxygen Concentration Profiles, 2011.



McSOURLEY LAKE



LOCATION

County:..........Renfrew
Township:..........Municipality of Head, Clara & Maria
Geographic Township:.....Head
Watershed:..........2KA5 Ottawa
Zone:..........18T
Easting:..........0270843
Northing:..........5122733
Topographic Sheet:..........Rolphton 31K4

MORPHOMETRY

Surface Area:..........32.9 ha
Watershed Area:..........3.91 km^2
Shoreline Length:..........6.13 km
Maximum Depth:..........36 m
Mean Depth:..........19.4 m
Total Volume:..........549.8 $x10^4$ m^3

No Bathymetry Map for McSourley Lake is available.

WATER CHEMISTRY

Table 1. McSourley Water Chemistry, 2011 (all values mg/L unless noted).

PARAMETER	11-May-11	08-Aug-11		19-Sep-11	
	Basin 1	Basin 1		Basin 1	
	EUP	EUP	MOB	EUP	MOB
Secchi Disk (m)	3	5.45		4.8	
Total Phosphorus	0.003	0.002	0.003	0.005	0.007
Ammonia- Nitrogen	0.037	0.021	0.027	0.002	0.002
Nitrite-Nitrogen	0.002	0.001	0.001	0.001	0.001
Nitrate+Nitrite - Nitrogen	0.01	0.023	0.133	0.01	0.036
Total Kjeldahl Nitrogen	0.25	0.22	0.21	0.27	0.22
Dissolved Organic Carbon	4.3	5.3	4.2	5.3	4
Dissolved Inorganic Carbon	5	5.2	6.3	5.2	6.4
pH	7.69	7.74	7.65	7.64	7.29
Total Alkalinity	21.1	21.6	25	23	24
Conductivity (µS/cm)	157	156	181	152	179
Calcium	7.9	7.21	8.71	8.11	9.33
Magnesium	2.28	2.33	2.68	2.57	2.68
Hardness	29.2	28	33	31	34
Total Suspended Solids	1.6	1.7	1.7	1.1	2.1
Total Dissolved Solids	102	101	118	99	116

Total Phosphorus concentrations in 2011 for McSourley Lake are low and should preclude the formation of nuisance algal populations. Nitrogen concentrations are within the average for lakes in the Renfrew area.

Secchi disc depth visibility ranged from 3m in May to 5.45m in August. This indicates that McSourley Lake has good to moderate water clarity.

The euphotic DOC concentrations ranged between 4.3mg/L in May to 5.3 mg/L in August. These are moderate concentrations and likely indicate some organic material input from wetlands or from tributary streams.

Based on pH and total alkalinity, McSourley Lake has low sensitivity to acidification by acid rain.

The oxygen and temperature profiles are presented in Table 2 and Figures 1 & 2. The temperature profiles indicate that McSourley has well-defined stratified temperature layers. The dissolved oxygen profiles show oxygen enrichment in the metalimnion. This is a common variation and is likely due to thermally trapped algae that can still photosynthesize because of good water clarity.

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen concentration (MVWHDO) was 4.54 mg/L. Under these conditions, lake trout in this lake are likely to be under stress.

FISHERIES SUMMARY

The fish community in McSourley Lake includes lake trout, cisco (lake herring), yellow perch, white sucker, rock bass and pumpkinseed. Lake trout were initially stocked in 1922 and have been stocked regularly since then. McSourley Lake is managed as part of a Put-Grow-Take lake trout fishery which anglers can enjoy all year-round.

Table 2. McSourley Lake Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles, 2011.

Depth	08-Aug-11		19-Sep-11	
(m)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)
0	26	8.1	17.2	8.9
1	25.7	8.1	17.2	8.9
2	25.4	8	17.1	8.7
3	22.5	8.8	17	8.8
4	16.8	12.3	17	8.7
5	12.2	12	13.9	9.6
6	8.8	10.6	10	8.7
7	7.3	9.4	8.1	7.2
8	6.4	8.6	6.8	6.7
9	5.5	8.3	5.9	6.4
10	4.9	7.2	5.3	5.9
11	4.7	6.4	4.9	5.4
12	4.4	6.5	4.7	5.3
13	4.3	6.5	4.5	5.4
14	4.2	6.2	4.4	5.3
15	4.1	6.2	4.2	5.2
16	4.1	6.2	4.1	5.2
17	4	6.1	4.1	5.1
18	4	6.1	4	5.1
19	4	6	4	5
20	3.9	5.7	3.9	4.8
21	3.9	5.7	3.9	4.6
22	3.9	5.6	3.9	4.3
23	3.8	5.5	3.9	4.1
24	3.8	5.2	3.8	3.8
25	3.8	4.8	3.8	3.5
26	3.8	4.5	3.8	2.9
27	3.8	3.8	3.8	2.5
28	3.7	3.2	3.8	2
29	3.7	1.5	3.8	1.8
30	3.7	1.1	3.8	1.4
31	3.8	0.6	3.8	0.5
32	3.8	0.3	3.8	0.3
33	3.8	0.3	3.8	0.2
34	3.8	0.3		
35	3.8	0.3		

Figure 1. Temperature Profiles, 2011.

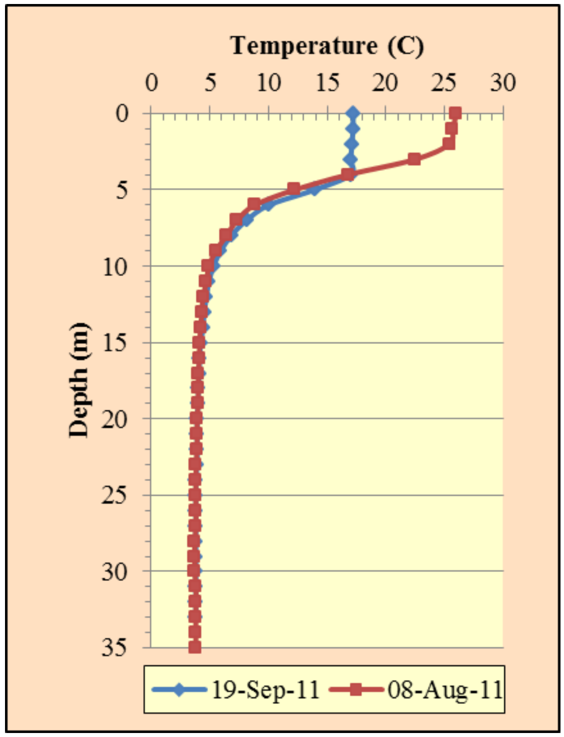
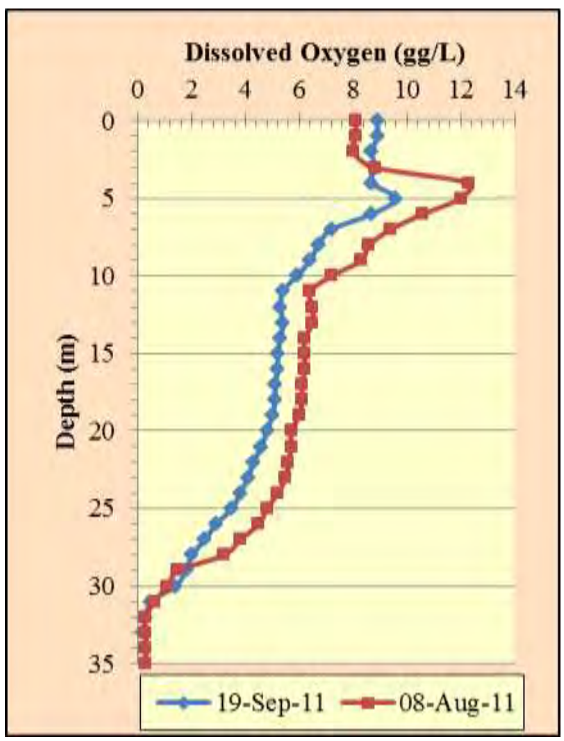
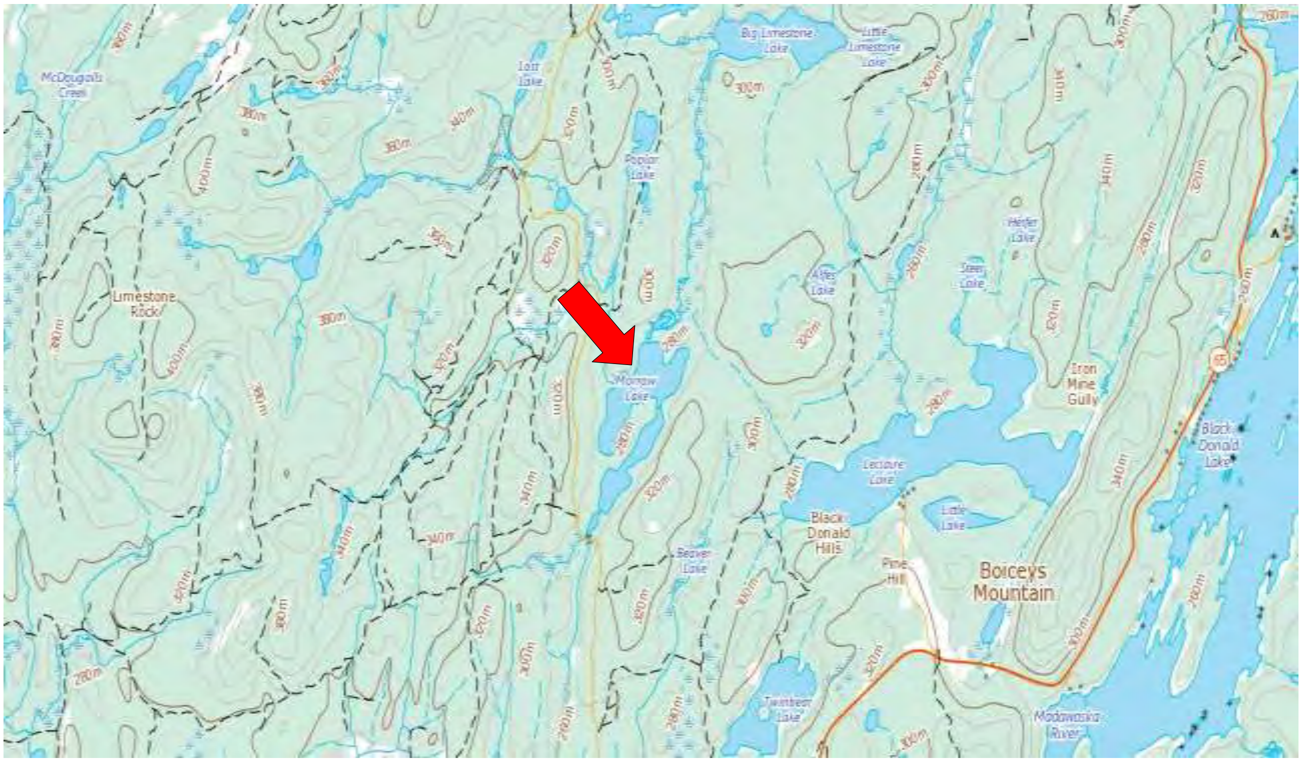


Figure 2. Dissolved Oxygen Concentration Profiles, 2011.



MORROW LAKE



LOCATION

County:..Renfrew
Township:..Municipality of Greater Madawaska
Geographic Township: ....Matawatchan
Watershed:..Madawaska River
Zone:..18T
Easting:..0340278
Northing:..5008951
Topographic Sheet:........................Denbigh 31F3

MORPHOMETRY

Surface Area: ....41.9 ha
Watershed Area:........................ N/A
Shoreline Length:........................6.53 km
Maximum Depth:........................ 22.9 m
Mean Depth:..7.5 m
Total Volume:.. 276.9 x10^4 m^3

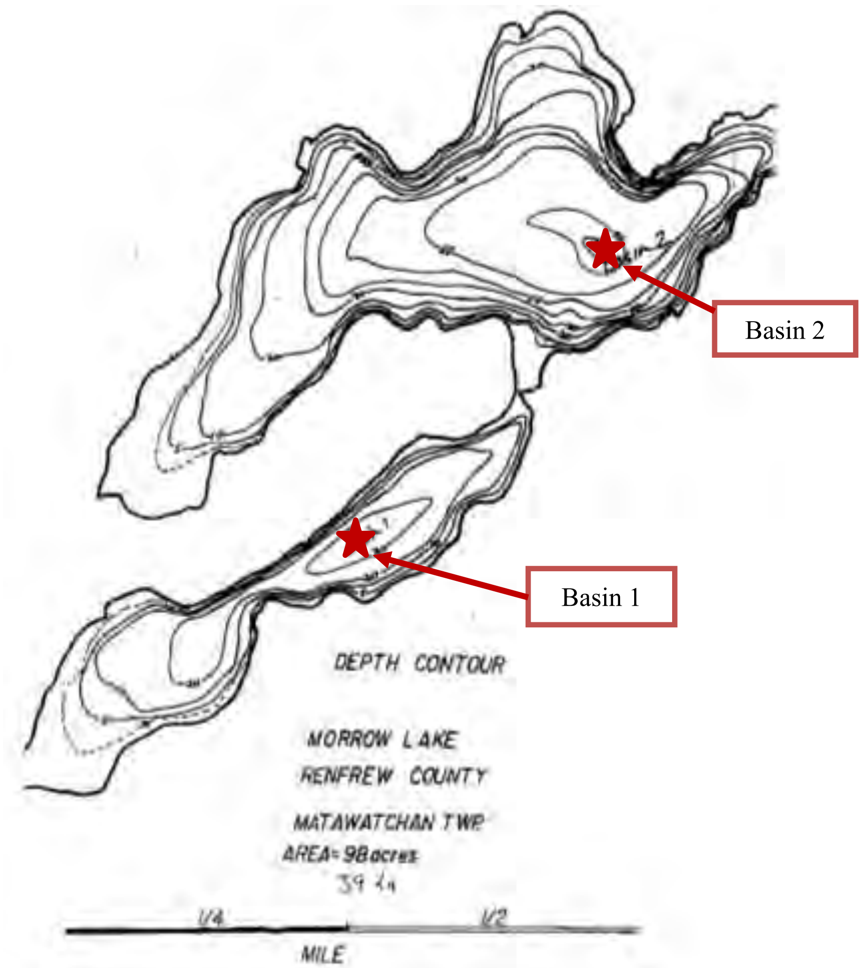


Figure 1. Morrow Lake Bathymetry Map.

WATER CHEMISTRY

Total Phosphorus concentrations in 2011 for Morrow Lake Basin 1 are low and should preclude the formation of nuisance algal populations. Total Phosphorus concentrations in Morrow Lake Basin 2 may result in the formation of nuisance algal blooms if other nutrients and water temperatures are optimal for algae production. Nitrogen concentrations are within the average for lakes in the Renfrew Area.

Secchi disc depth visibility ranged from 5m in July (Basin 2) to 6.7m in July (Basin 1). This indicates that Morrow Lake has good water clarity.

The euphotic DOC concentrations ranged from 5.6mg/L in July (Basins 1 and 2) to 5.7 mg/L in September (Basin 1). These are moderate concentrations and likely indicate some organic material input from shoreline wetlands or from tributary streams.

Based on pH and total alkalinity, Morrow Lake is unlikely to be impacted by acid rain.

Table 1. Morrow Lake Water Chemistry, 2011 (all values mg/L unless noted).

PARAMETER	19-Jul-11			14-Sep-11			
	Basin 1	Basin 2		Basin 1		Basin 2	
	EUP	EUP	MOB	EUP	MOB	EUP	MOB
Secchi Disk (m)	6.75	5		6		6	
Total Phosphorous	0.005	0.003	0.014	0.007	0.047	0.011	0.16
Ammonia- Nitrogen	0.038	0.032	0.028	0.035	0.341	0.032	0.528
Nitrite-Nitrogen	0.002	0.002	0.002	0.004	0.006	0.002	0.012
Nitrate+Nitrite - Nitrogen	0.041	0.041	0.186	0.038	0.037	0.026	0.053
Total Kjeldahl Nitrogen	0.27	0.25	0.26	0.32	0.76	0.35	0.96
Dissolved Organic Carbon	5.6	5.6	5.7	5.7	5.3	5.6	7.2
Dissolved Inorganic Carbon	23.7	25.8	28.6	24	26.1	26.7	32.6
pH	8.39	8.36	8.23	8.33	8.11	8.33	8.21
Alkalinity	94.5	102	112	98.6	103	108	137
Conductivity (µS/cm)	194	209	229	196	201	214	258
Calcium	33.1	35	38.6	34.8	35.1	38.1	43
Magnesium	5.17	5.56	6.16	5.05	5	5.61	6.22
Hardness	100	110	120	110	110	120	130
Total Suspended Solids	0.6	0.5	1.7	1.7	5.9	2.4	6.3
Total Dissolved Solids	126	136	149	128	131	139	168

The oxygen and temperature profiles are presented in Table 2 and Figures 2 & 3. The temperature profiles for Basin 1 and 2 indicate that Morrow Lake has well-defined stratified temperature layers. The dissolved oxygen profiles for Basin 1 and 2 show oxygen enrichment in the metalimnion. This is a common variation in oxygen distribution in lakes and is likely due to thermally trapped algae that can still photosynthesize because of good water clarity.

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen concentration (MVWHDO) in Basin 1 was 0.833 mg/L. The 2011 late summer/early fall critical period MVWHDO in Basin 2 was 5.90 mg/L. Under these conditions, lake trout in this lake are likely to be under stress in both basins.

FISHERIES SUMMARY

The fish community in Morrow Lake includes lake trout, lake whitefish, burbot, largemouth bass, yellow perch, white sucker, brown bullhead and pumpkinseed. Lake trout have been stocked regularly since 1986. Morrow Lake is managed as part of a Put-Grow-Take lake trout fishery which anglers can enjoy all year-round.

Table 2. Morrow Lake Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles, 2011.

Depth (m)	19-Jul-11				14-Sep-11			
	Basin 1		Basin 2		Basin 1		Basin 2	
	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)
0	25.94	8.47	25.69	8.28	20.03	9.12	19.99	9.06
1	25.60	8.46	25.45	8.27	20.02	9.08	19.99	9.07
2	25.47	8.41	25.26	8.23	19.97	9.06	19.93	9.08
3	24.48	8.60	24.4	8.52	19.91	9.05	19.91	9.08
4	18.36	9.98	17.58	10.27	19.78	9.03	19.85	9.08
5	13.48	10.13	12.21	10.33	18.49	9.54	17.53	9.82
6	10.61	8.16	8.61	9.73	13.73	8.54	11.95	9.72
7	8.91	6.42	7.21	9.27	10.77	3.62	8.46	8.83
8	7.98	4.65	6.33	8.94	8.98	1.36	6.95	8.29
9	7.28	2.37	5.85	8.83	8.12	0.74	6	8.38
10	6.47	0.40	5.38	8.69	7.62	0.56	5.44	8.91
11			5	8.68	7.25	0.51	4.9	8.64
12			4.79	8.43			4.64	7.59
13			4.56	7.02			4.48	6.38
14			4.43	5.76			4.32	4.67
15			4.31	4.83			4.22	3.5
16			4.18	3.66			4.14	2.17
17			4.09	2.11			4.11	1.49
18			4.03	1.33			4.04	1.08
19			3.96	0.56			4.02	0.83
20			3.93	0.38			3.97	0.66
21			3.92	0.33			3.96	0.59

Figure 2. Temperature Profiles, 2011.

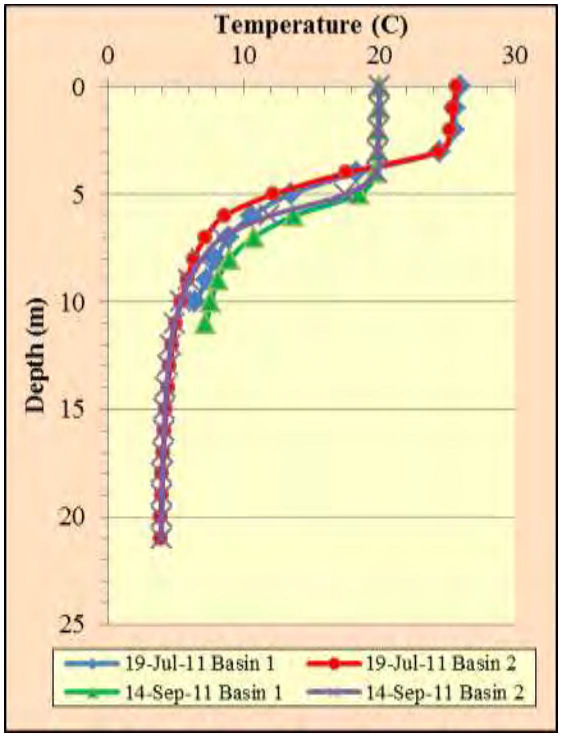
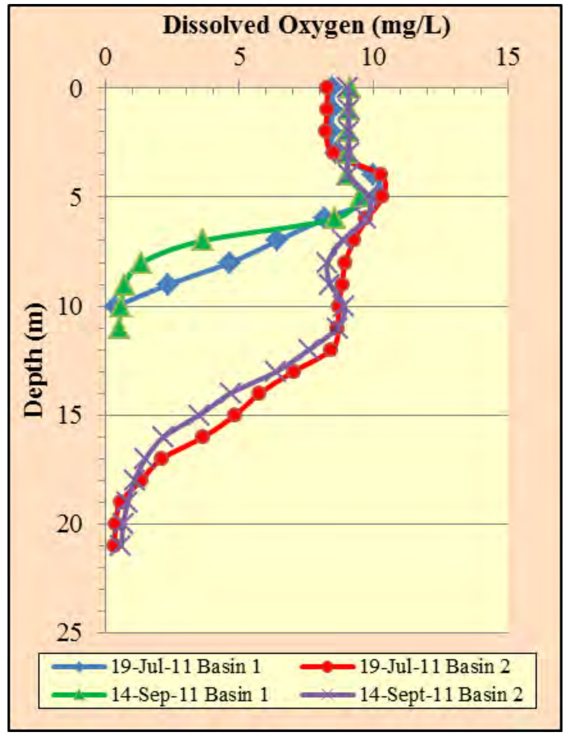
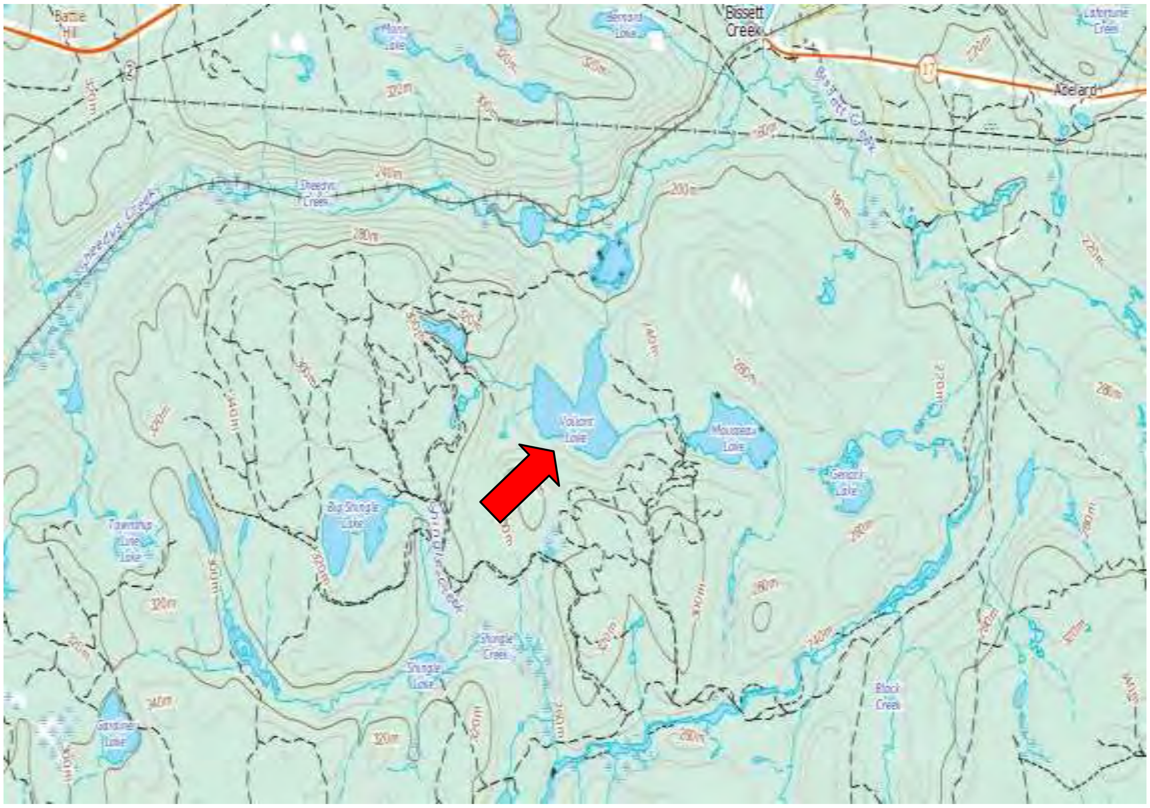


Figure 3. Dissolved Oxygen Concentration Profiles, 2011.



VALIANT LAKE



LOCATION

County:..............................Renfrew
Township: ....Municipality of Head, Clara & Maria
Geographic Township:......Maria
Watershed:..............................Ottawa River
Zone:..............................17T
Easting:..............................0723610
Northing:..............................5120862
Topographic Sheet:............Deux Rivière 31

MORPHOMETRY

Surface Area:..............................37.92 ha
Watershed Area:................ N/A
Shoreline Length:.............3.67 km
Maximum Depth:..............20 m
Mean Depth:..........................6.0 m
Total Volume:....................182.74 x10^4 m^3

No Bathymetry Map for Valiant Lake is available.

WATER CHEMISTRY

Table 1. Valiant Water Chemistry, 2011 (all values mg/L unless noted).

PARAMETER	08-Aug-11		13-Sep-11	
	Basin 1		Basin 1	
	EUP	MOB	EUP	MOB
Secchi Disk (m)	2.8		3.4	
Total Phosphorus	0.005	0.03	0.004	0.03
Ammonia- Nitrogen	0.023	0.261	0.023	0.481
Nitrite-Nitrogen	0.001	0.005	0.002	0.006
Nitrate+Nitrite - Nitrogen	0.021	0.046	0.024	0.027
Total Kjeldahl Nitrogen	0.24	0.66	0.25	0.93
Dissolved Organic Carbon	6.7	6.5	6.1	7.2
Dissolved Inorganic Carbon	0.3	2.4	0.2	3.4
pH	6.83	7.04	6.83	7.1
Total Alkalinity	3	6.5	3.2	8.5
Conductivity (µS/cm)	20	27	21	30
Calcium	1.62	2.33	1.81	2.58
Magnesium	0.535	0.724	0.634	0.909
Hardness	6.3	8.8	7.1	10
Total Suspended Solids	3.3	19.8	1.2	15.4
Total Dissolved Solids	13	17	13	19

Total Phosphorus concentrations in 2011 for Valiant Lake are low and should preclude the formation of nuisance algal populations. Nitrogen concentrations are within the average for lakes in the Renfrew area.

Secchi disc depth visibility ranged from 2.8m in August to 3.4m in September. This indicates that Valiant Lake has moderate water clarity.

The euphotic DOC concentrations ranged between 6.1 and 6.7 mg/L. These are high concentrations and likely indicate strong organic material input from shoreline wetlands or from tributary streams.

Based on pH and total alkalinity, Valiant Lake is moderately sensitive to acidification by acid rain.

The oxygen and temperature profiles are presented in Table 2 and Figures 1 & 2. The temperature profiles indicate that Valiant lake has well-defined stratified temperature layers. The summer dissolved oxygen profile shows oxygen enrichment in the metalimnion. This is a common variation of oxygen distribution found in lakes and is likely due to thermally trapped algae that can still photosynthesize because of good water clarity.

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen concentration (MVWHDO) was 1.29 mg/L. Under these conditions, lake trout in this lake are likely to be under high levels of stress.

FISHERIES SUMMARY

The fish community in Valiant Lake includes lake trout and white sucker. Lake trout were stocked sporadically between 1952 and the mid 1960's. Since 1966 to present day they have been stocked regularly as a Put-Grow-Take lake trout fishery. Brook trout have been stocked sporadically in the past and are known to be native to the tributaries of Valiant Lake. The lake trout season is open year-round for anglers to enjoy.

Table 2. Valiant Lake Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles, 2011.

Depth	08-Aug-11		13-Sep-11	
(m)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)
0	25.2	7.2	20.5	8.5
1	24.9	7.3	20.5	8.5
2	24.7	7.3	20.4	8.4
3	22.3	8.4	20.3	8.3
4	15.1	9.1	18.2	8
5	10.5	6.5	12	4.8
6	8.4	5	8.9	3.1
7	6.9	4.2	7.4	3.2
8	6.1	4.3	6.3	3
9	5.5	4.6	5.8	2.2
10	5.2	4.1	5.2	1.6
11	4.9	3.2	5	1.4
12	4.8	1.6	4.8	0.4
13	4.7	1.3	4.7	0.3
14	4.7	0.4	4.7	0.2
15	4.6	0.3	4.6	0.2
16	4.6	0.2	4.6	0.2
17	4.5	0.2	4.6	0.2
18	4.6	0.2	4.6	0.1
19	4.6	0.2	4.7	0.1
20	4.6	0.2		

Figure 1. Temperature Profiles, 2011.

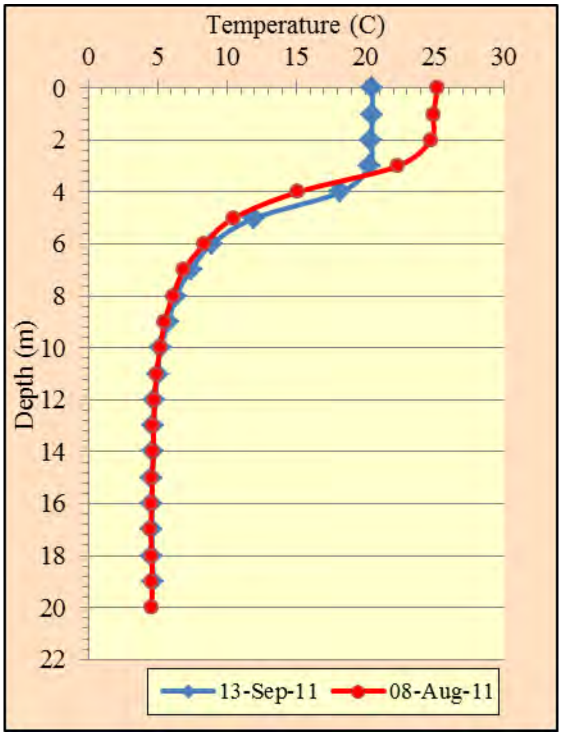
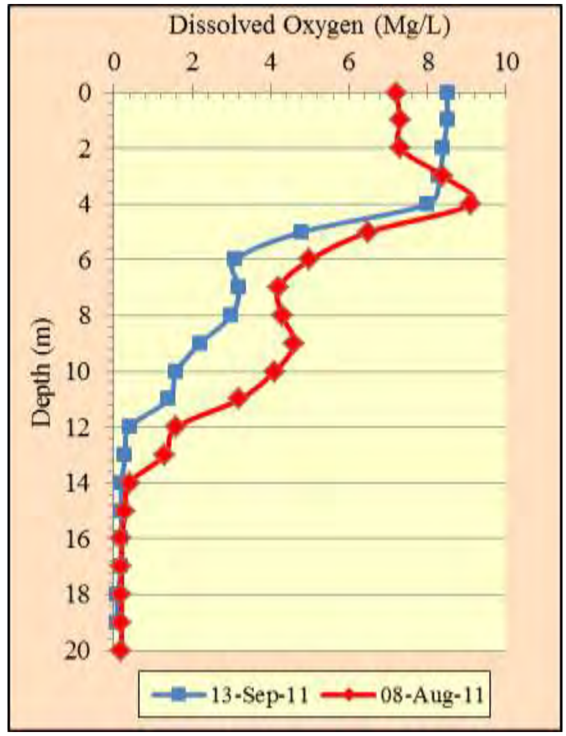
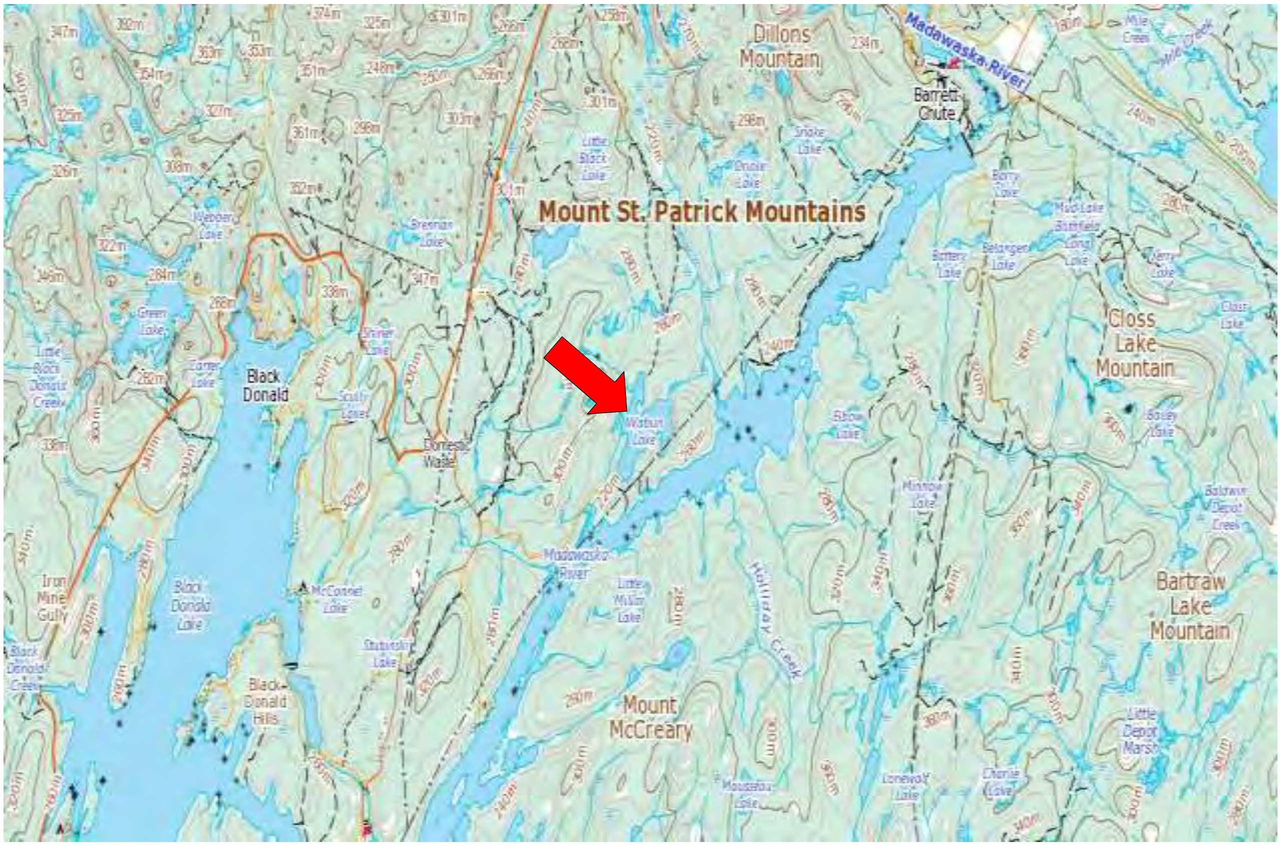


Figure 2. Dissolved Oxygen Concentration Profiles, 2011.



WABUN LAKE



LOCATION

County:.................................Renfrew
Township:.............................Municipality of Greater Madawaska
Geographic Township:.....Brougham
Watershed:...........................Madawaska River
Zone:......................................18T
Easting:.................................0356353
Northing:...............................5009789
Topographic Sheet:...........Clyde Forks 31F2

MORPHOMETRY

Surface Area: ....44.9 ha
Watershed Area:................$2.61\ km^2$
Shoreline Length:..............5.08 km
Maximum Depth:.................28 m
Mean Depth:..........................13.3
Total Volume:......................$540 \times 10^4\ m^3$

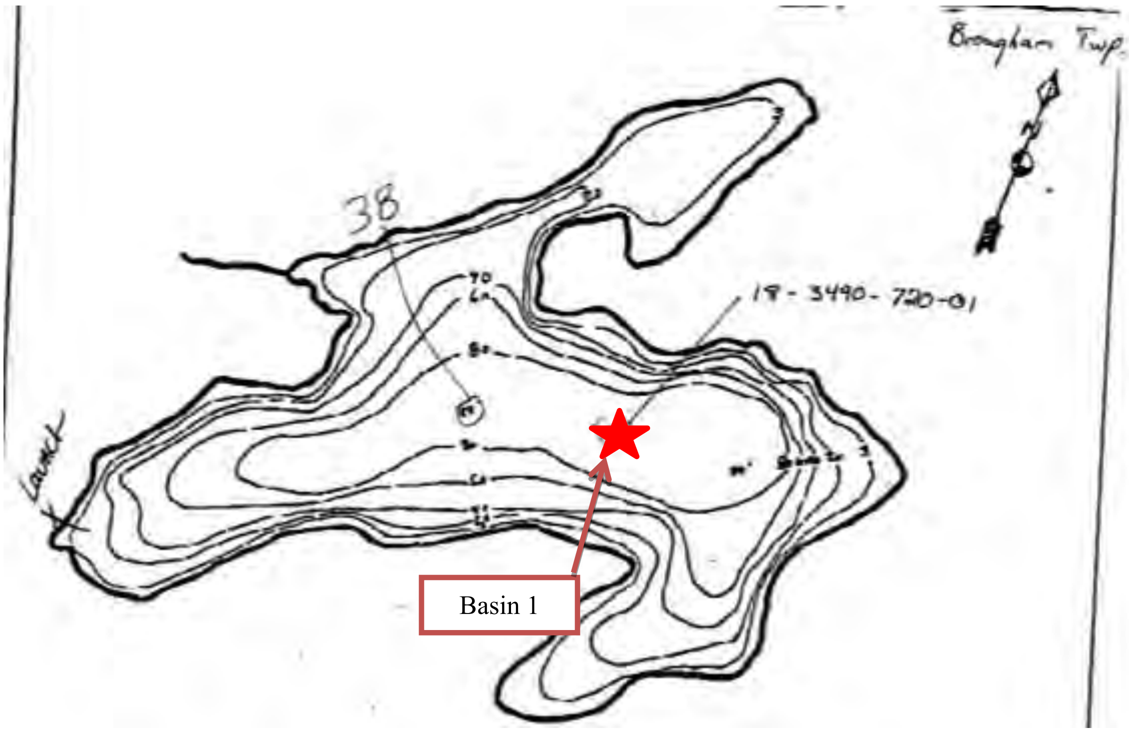


Figure 1. Wabun Lake Bathymetry Map.

WATER CHEMISTRY

Table 1. Wabun Lake Water Chemistry, 2011 (all values mg/L unless noted).

PARAMETER	19-Jul-11		12-Sep-11	
	Basin 1		Basin 1	
	EUP	MOB	EUP	MOB
Secchi Disk (m)	5.5		5.75	
Total Phosphorus	0.022	0.089	0.012	0.101
Ammonia- Nitrogen	0.041	0.203	0.033	0.207
Nitrite-Nitrogen	0.003	0.005	0.001	0.002
Nitrate+Nitrite - Nitrogen	0.053	0.089	0.046	0.066
Total Kjeldahl Nitrogen	0.36	0.54	0.31	0.57
Dissolved Organic Carbon	4.4	4.1	4.6	4
Dissolved Inorganic Carbon	14.8	16.2	15.1	17.2
pH (no units)	8.25	8.02	8.13	7.94
Total Alkalinity	59.7	63.8	61.7	65
Conductivity (µS/cm)	131	142	131	142
Calcium	21.5	22.5	22.1	24.3
Magnesium	3.6	3.5	3.26	3.29
Hardness	69	71	69	74
Total Suspended Solids	0.8	1.9	1.5	2.6
Total Dissolved Solids	85	93	85	93

Total Phosphorus concentrations in 2011 for Wabun Lake ranged from 0.022mg/L in May to 0.012mg/L in September. The spring concentration is at a level that might promote the formation of nuisance algal blooms on the lake.

Secchi disc depth visibility ranged from 5.5m in July to 5.75m in September. This indicates that Wabun Lake has good water clarity.

The euphotic DOC concentrations ranged between 4.4mg/L in July and 4.6mg/L in September. These are moderate concentrations and likely indicate some organic material input from shoreline wetlands or from tributary streams.

Based on pH and total alkalinity, Wabun Lake is unlikely to be impacted by acid rain.

The oxygen and temperature profiles are presented in Table 2 and Figures 2 & 3. The temperature profiles indicate that Wabun has well-defined stratified temperature layers. The summer dissolved oxygen profile shows oxygen enrichment in the metalimnion. This is a common variation found in dissolved oxygen distribution in lakes and is likely due to thermally trapped algae that can still photosynthesize because of good water clarity.

The 2011 late summer/early fall critical period mean volume-weighted hypolimnetic dissolved oxygen concentration (MVWHDO) was 2.27 mg/L. Under these conditions, lake trout in this lake are likely to be under high levels of stress.

FISHERIES SUMMARY

The fish community in Wabun Lake includes lake trout, smallmouth bass, largemouth bass, rock bass, pumpkinseed, yellow perch and white sucker. Lake trout were initially stocked between 1973 and 1981 and then stocking of rainbow trout occurred from 1984 until 1990. Rainbow trout are no longer present in the lake. Since 1993 to present, lake trout have been stocked annually as part of a Put-Grow-Take lake trout fishery. The lake trout season is open year-round for anglers to enjoy.

Table 2. Wabun Lake Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles, 2011.

Depth	19-Jul-11		14-Sep-11	
(m)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)
0	26.56	9.01	21.19	9.43
1	25.72	9.04	21.14	9.51
2	25.52	8.94	21.08	9.61
3	24.71	9.58	21.05	9.64
4	22.74	10.96	20.53	9.73
5	16.37	11.52	20.14	9.75
6	12.68	9.63	15.30	9.49
7	10.37	8.97	11.46	8.89
8	8.6	7.55	9.27	7.3
9	7.42	6.65	7.99	5.66
10	6.75	5.6	7.23	4.02
11	6.47	5.15	6.57	3.27
12	5.96	3.89	6.14	2.97
13	5.78	3.31	5.88	2.74
14	5.62	2.94	5.64	2.58
15	5.43	2.82	5.48	2.56
16	5.28	2.47	5.33	2.15
17	5.18	2.01	5.23	0.99
18	5.08	1.39	5.11	0.61
19	4.98	0.98	5.04	0.53
20	4.88	0.63	4.90	0.49
21	4.78	0.53	4.87	0.47
22	4.68	0.39	4.79	0.45
23	4.58	0.35	4.75	0.44
24	4.48	0.32	4.70	0.44
25	4.38	0.3	4.63	0.44
26			4.62	0.46
27			4.62	0.47

Figure 2. Temperature Profiles, 2011.

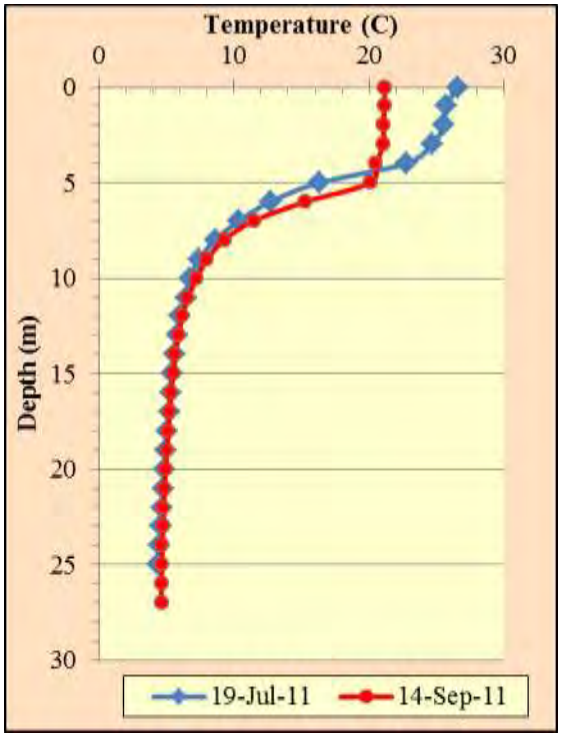
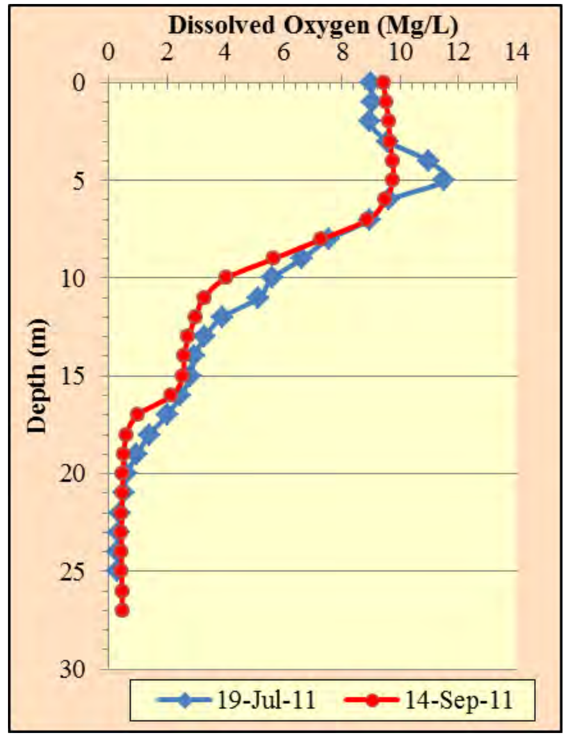
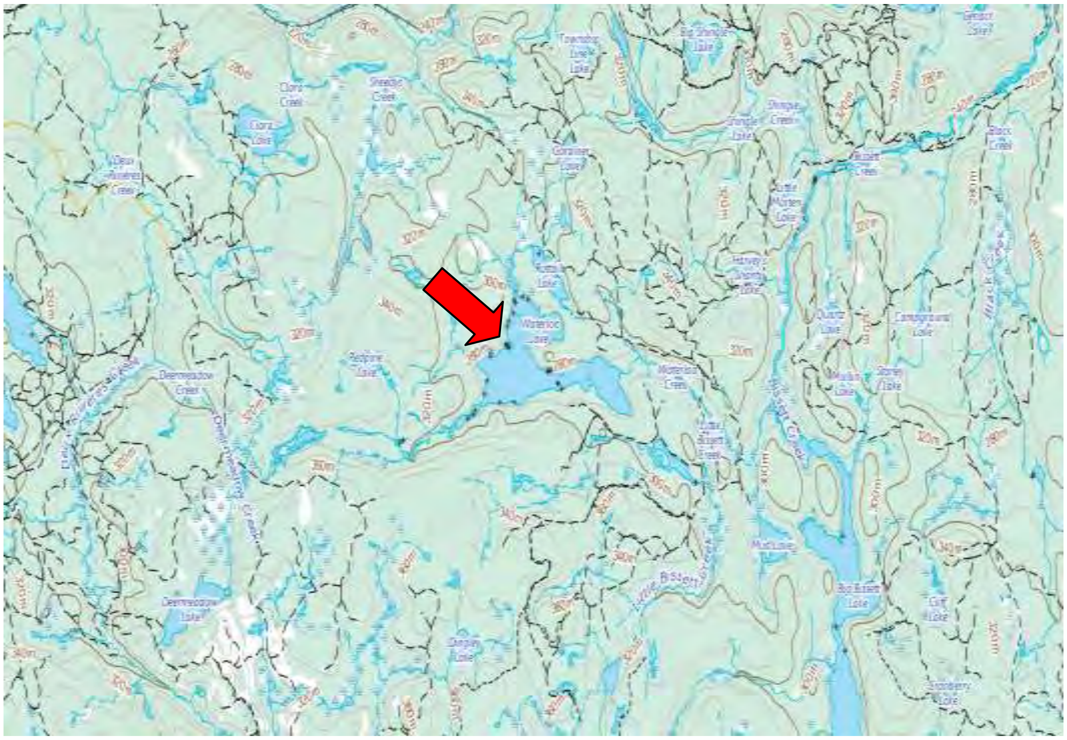


Figure 3. Dissolved Oxygen Concentration Profiles, 2011.



WATERLOO LAKE



LOCATION

County:.......................Renfrew
Township:.......................Municipality of Head, Clara & Maria
Geographic Township:.....Clara
Watershed:.......................2KA-6
Zone:.......................17T
Easting:.......................0716596
Northing:.......................5117368
Topographic Sheet:...........Brent 31L1

MORPHOMETRY

Surface Area: ....1.84 km^2
Watershed Area:.............. 23.47 km^2
Shoreline Length:..............14.51 km
Maximum Depth:..............23 m
Mean Depth:...................7.6 m
Total Volume:...................137.9 $x10^5$ m^3

No Bathymetry Map for Waterloo Lake is available.

WATER CHEMISTRY

Table 1. Waterloo Water Chemistry, 2011 (all values mg/L unless noted).

PARAMETER	04-Aug-11		13-Sep-11	
	Basin 1		Basin 1	
	EUP	MOB	EUP	MOB
Secchi Disk (m)	2.65		3.3	
Total Phosphorus	0.002	0.053	0.004	0.015
Ammonia- Nitrogen	0.031	0.039	0.017	0.018
Nitrite-Nitrogen	0.002	0.004	0.001	0.003
Nitrate+Nitrite - Nitrogen	0.037	0.215	0.015	0.15
Total Kjeldahl Nitrogen	0.29	0.6	0.25	0.27
Dissolved Organic Carbon	6.5	5.9	6.2	5.7
Dissolved Inorganic Carbon	0.6	1.2	0.5	1.2
pH (no units)	6.95	6.8	7.03	6.9
Total Alkalinity	4.1	4.3	5.3	4.3
Conductivity (µS/cm)	21	23	22	24
Calcium	1.44	1.63	1.8	1.99
Magnesium	0.716	0.768	0.899	1
Hardness	6.5	7.2	8.2	9.1
Total Suspended Solids	1.6	9.5	1.4	2.2
Total Dissolved Solids	14	15	14	15

Total Phosphorus concentrations in 2011 for Waterloo Lake are low and should preclude the formation of nuisance algal populations. Nitrogen concentrations are within the average for lakes in the Renfrew area.

Secchi disc depth visibility ranged from 2.65m in August to 3.3m in September. This indicates that Waterloo Lake has moderate water clarity.

The euphotic DOC concentrations ranged between 6.2mg/L in September and 6.5mg/L in August. These are high concentrations and likely indicate strong organic material input from shoreline wetlands or from tributary streams.

Based on pH and total alkalinity, Waterloo Lake is moderately sensitivite to acidification by acid rain.

The oxygen and temperature profiles are presented in Table 2 and Figures 1 & 2. The temperature profile indicates that Waterloo has well-defined stratified temperature layers. The dissolved oxygen profiles show a slight decrease in oxygen concentrations in the metalimnion. This type of oxygen profile develops by the decomposition of settling organic material accumulating in the metalimnion as a result of a thermally induced water density gradient. Disssolbe oxygen concentrations slightly increase after this and decrease slowly until the last few meters of the hypolimnion.

The 2011 summer critical period mean volume-weighted hypolimnetic dissolved oxygen (MDO) was 3.99 mg/L. Under these conditions, lake trout in this lake are likely to be under high levels stress.

FISHERIES SUMMARY

The fish community in Waterloo Lake includes lake trout, burbot, yellow perch and white sucker. Lake trout were initially stocked between 1958 and 1987 but have not been stocked since. Since 1987, Waterloo Lake is managed as a self-sustaining natural population with specific fishing regulations that are detailed in the Recreational Fishing Regulation Summary.

Table 2. Waterloo Lake Temperature (Temp) and Dissolved Oxygen Concentration (DO) Profiles, 2011.

Depth (m)	4-Aug-11		13-Sep-11	
	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)
0	24.6	7.8	19.83	8.1
1	24.3	7.8	19.8	8
2	24.2	7.8	19.7	7.9
3	24.1	7.7	19.4	7.8
4	20	6.8	18.7	7.4
5	14.7	5.8	16.6	4.5
6	11.2	5.7	12.1	3.4
7	9.1	5.8	9.6	3.4
8	7.7	6.8	8.1	4
9	7.3	6.8	7.3	4.5
10	6.7	7.2	6.7	4.8
11	6.3	7.3	6.4	5
12	5.9	7	6.1	4.9
13	5.7	7.1	5.8	4.9
14	5.5	6.9	5.6	4.7
15	5.4	6.6	5.5	4.4
16	5.3	5.6	5.4	3.6
17	5.2	4.9	5.3	3
18	5.1	4.5	5.3	2.6
19	5.1	4.1	5.3	2.4
20	5	3.3	5.2	2.1
21	5	2.5	5.2	1.9
22	5	1.3	5.2	0.8
23			5.2	0.3

Figure 1. Temperature Profiles, 2011.

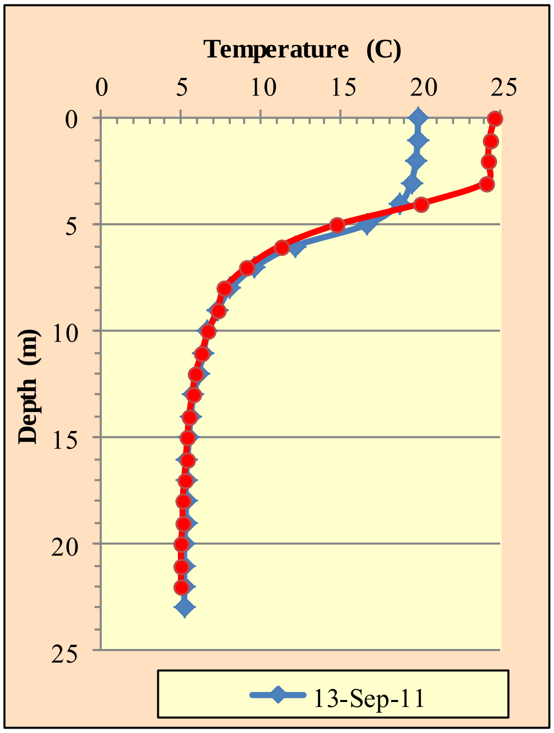


Figure 2. Dissolved Oxygen Concentration Profiles, 2011.