UPPER RIDEAU LAKE

WATER QUALITY MONITORING REPORT

2003

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INTRODUCTION
This report was written to present the findings of water quality monitoring conducted on Upper Rideau Lake from July 2003 through October 2003.

BACKGROUND
Water quality is an excellent diagnostic tool for evaluating the health of a lake. In the aquatic environment, nutrients act as fertilizers, promoting aquatic plant and algae growth. When the plants and algae die, they settle to the bottom stimulating microbial breakdown processes that require oxygen. Decomposition of this biomass eventually depletes the dissolved oxygen, affecting habitat for fish and other aquatic life. Algae blooms and proliferation of aquatic plants also makes navigation more difficult and recreation activities less enjoyable. Nutrient enrichment, and its impacts, are therefore important to monitor in order to assess the health of a water body.

Lake Dynamics
As warmer water is less dense than colder water, deeper lakes tend to stratify based on temperature differences during the summer months (Figure 1). As the summer sun heats up surface waters, the warmer water will remain on top, 'floating' on colder, denser waters below. The depth where the temperature change is greater than 1^0C per metre is called the thermocline. The epilimnion is the area found above the thermocline and the area found below is known as the hypolimnion.

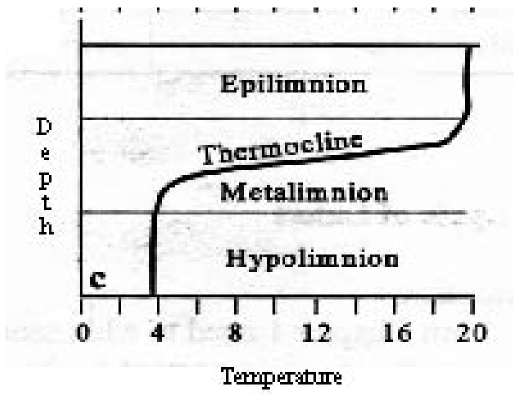


Figure 1: Thermal stratification (Mackie 1999)

Mixing does occur twice a year as air temperatures change in the spring and fall in what is called 'turn over'. In the fall, when the air cools, the surface of the lake will also cool. Water reaches its maximum density at 4ºC, so as the surface temperature drops to 4ºC, it will sink. Surface water will continue sinking until the whole lake is uniform in density and temperature (4ºC) The surface will continue to cool and eventually freeze. The lake turns over again in the spring as the ice melts and the surface warms to 4ºC, creating a uniform temperature from top to bottom. This allows wind and wave action to mix the entire lake.

Trophic Status (Nutrients and Effects of Nutrients)
Trophic status characterizes a lake as oligotrophic (low nutrient levels), mesotrophic (moderate levels of nutrients) or eutrophic (high levels of nutrients). This status is most commonly defined by chemical analysis of nutrients such as phosphorus and nitrogen that directly relate to a lake's ability to support biological growth. Secchi depth (measure of water clarity associated with algae growth) and chlorophyll (pigment in algae) indicate the presence of algae, and therefore the availability of nutrients for growth. Dissolved oxygen concentrations can also be used to determine trophic status, as they provide a measure of the impact of eutrophication (due to biological growth and decay as described above).

Phosphorus
Phosphorus is generally recognized as the limiting nutrient in freshwater ecosystems, and the major contributor to eutrophication in these environments. Limiting nutrient means that all the other components necessary for growth are available, but a lack of a specific (limiting) nutrient controls (limits) plant growth. When the limiting nutrient is added to the system, accelerated algae and plant growth can occur.

Because phosphorus is often the limiting nutrient in freshwater systems, it is an excellent indicator of trophic status. Total phosphorus (TP), which represents all chemical forms of phosphorus, is the most common phosphorus measurement reported. Oligotrophic lakes are characterized by an average TP concentration less than 10 ug/L, mesotrophic lakes have between 10 and 20 ug/L and eutrophic lakes have an average TP level greater than 20 ug/L. (1 mg/L = 1000 ug/L)

The location of sampling is very important. Samples taken close to shore are chosen to reflect processes that are happening on land (run-off from fertilizers, stormwater runoff, erosion, agriculture). Samples taken mid lake better represent the concentrations of phosphorus and trophic status on the whole. Samples are taken at 2X the secchi depth to reflect the TP concentration below the biologically productive area of the lake.

The phosphorus cycle is complex. And while phosphorus is rapidly used by organisms in growth, it remains in the system (carbon and nitrogen are removed as gases by biological means). When plants and algae (and other organisms) die, they settle to the bottom of a water body. As they decompose, the phosphorus that was incorporated into their biomass is released. In addition, sediments that have phosphorus adsorbed will settle, increasing phosphorus loading at the bottom. Sediments have a high capacity to store phosphorus, however phosphorus in the sediments is not permanently removed. Low dissolved oxygen levels stimulate its release, and as described previously, decay of plant growth decreases dissolved oxygen. This can be a problem, especially in high nutrient lakes. Once the lake becomes stratified, no mixing occurs, and dissolved oxygen available in the hypolimnion is depleted. In addition, phosphorus being stored in the hypolimnion will be mixed into the rest of the lake during spring and fall turnover. Therefore concentrations measured in surface waters can grossly underestimate the total amount of phosphorus that is actually available for plant and algae growth. Water samples taken close to the bottom often contain higher phosphorus concentrations than surface samples, but these alone cannot be used as an indication of phosphorus concentrations in the sediment.

Algae Growth
Algae growth is natural in lakes but with excessive nutrient concentrations, algae can become a nuisance. The monitoring of algae growth is carried out through chlorophyll sampling and secchi disc measurements. Because algae thrive on nutrients in the water, measures of algae growth can indicate nutrient availability in the water.

Chlorophyll
Chlorophyll is a pigment found in all aquatic plants and algae and therefore can be used to evaluate the algae content of a water body. There are three different types of chlorophyll -*a*, *b*, and *c*. There are no federal or provincial guidelines for chlorophyll in freshwater, however, monitoring is useful to document changes in productivity of a waterbody.

Certain chemical compounds fluoresce when exposed to sunlight. Chlorophyll is one such compound. Therefore an in-situ measurement of fluorescence can be used as an indicator of the presence of chlorophyll containing algae. Traditional lab methods of chlorophyll analysis are available but tend to be more costly and cumbersome. *In situ* analysis can provide a cost-effective measure, allowing more sites to be assessed, and can be correlated to lab measures. Usually, most of the fluorescence detected is due to the chlorophyll in the phytoplankton, however aquatic plants and other compounds present may fluoresce and contribute to the readings.

Secchi Depth
Secchi depth is a measure of water clarity, and in the past has been correlated to the amount of algae in the system. Secchi depth is measured by lowering a black and white 20cm radius disc into the water until it is no longer visible and then lifting it up until it reappears. Both depths are recorded and averaged for the overall secchi depth reading, a measure of how far light can penetrate the water column. A secchi depth greater then 5m indicates an oligotrophic lake, a measurement of 3-5 m is characteristic of a mesotrophic lake, and less then 3m signifies a eutrophic lake.

Secchi depth can be affected by a variety of factors including, suspended particles from shoreline erosion, agricultural run-off, or tree pollen. Because this reading is subject to human interpretation, weather, such as sun and wind can also influence readings. For these reasons water clarity should not be used alone when assessing water quality.

The presence of zebra mussels can also affect secchi readings. Because they filter water to feed on algae, the clarity of the water they infest is improved, resulting in an increase in secchi depth reading. This can skew correlations of secchi depth to trophic status.

Dissolved Oxygen
Most aquatic life depends on sufficient quantities of dissolved oxygen (DO) for growth and reproduction. Microorganisms use DO in the process of decay. Lakes (or areas in lakes) with higher levels of nutrients and higher rates of growth are at greater risk for low DO. If levels become too low, aquatic life may be threatened. Because there is no mixing between thermally stratified layers in the summer, dissolved oxygen used up in the hypolimnion will not be replenished until fall turnover. Cold water fisheries therefore are extremely sensitive to high nutrient loading due to the threat of oxygen depletion in the hypolimnion.

The Ontario water quality objectives for dissolved oxygen are shown in Table 1. As the life cycle of many fish and other aquatic organisms is dictated by temperature, the relationship between DO and temperature is important. Also, as temperature affects the ability of water to hold DO, DO and temperature are often measured together.

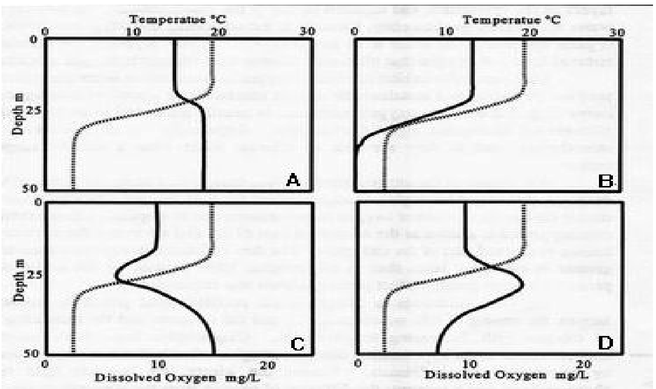
Table 1: Provincial Water Quality Objectives for Dissolved Oxygen

Dissolved oxygen concentrations should not be less than the values specified below for cold and warm water fish communities

Temperature ^{0}C	Cold Water Fish DO mg/l	Warm Water Fish DO mg/l
0	8	7
5	7	6
10	6	5
15	6	5
20	5	4
25	5	4

Figure 2 shows dissolved oxygen profiles that are typical of different types of lakes. Oligotrophic lakes tend to have a dissolved oxygen profile pattern similar to “A” and “C”, with increasing amounts of oxygen in the hypolimnion (bottom). Mesotrophic and eutrophic lakes tend to follow the pattern of “B” and “D”, showing a decrease in oxygen in the hypolimnion.

Figure 2. Examples of Dissolved Oxygen-temperature Profiles



*note** Dissolved Oxygen is represented by the dark lines while temperature is represented by the light lines*

pH

pH is used to determine whether a lake is acidic or alkaline. The pH of lakes is largely dependent on its bedrock composition. In an area that has a lot of granite bedrock, the lakes will tend to be somewhat acidic. Lakes with limestone bedrock or high levels of carbonates in their sediments will tend to have alkaline water chemistry. These elements also help the lake to "buffer" against changes in pH from inputs such as acid rain. In a natural environment, pH of a lake can fluctuate daily and seasonally due to many factors such as plant photosynthesis and respiration. Bacterial decomposition and high nitrogen concentrations can also influence pH. The pH range of a healthy freshwater lake is between 6.5 and 8.5.

UPPER RIDEAU LAKE SAMPLING SCHEME

Sampling was carried out at at two basin (deep) sites and 10 near-shore sites monthly from July to October 2003 (July 2, August 20, September 13, October 8). Table 2 outlines the sampling detail for the nearshore and basin sites respectively.

Table 2: Sampling procedures and site depths

<table>
<tr><th colspan="4">Near Shore Sites – Upper Rideau Lake, 2003</th></tr>
<tr><th>Site #</th><th>Location</th><th>Average Depth (m</th><th>Sampling detail</th></tr>
<tr><td>URLA 1</td><td>Duck Bay</td><td>2.5</td><td rowspan="10">Monthly: •Testing for dissolved oxygen (mg/L), pH, temperature (ºC) and chlorophyll (µg/L) using a YSI multi-parameter field unit

•Testing of total phosphorus (TP), measured at one metre below the surface at each site.

•Secchi depth readings and water colour observations.

Sampling Dates: July 2, August 20, September 13 and October 8, 2003</td></tr>
<tr><td>URLA 2</td><td>Golf Course</td><td>2.1</td></tr>
<tr><td>URLA 3</td><td>Kane's Bay</td><td>2.1</td></tr>
<tr><td>URLA 4</td><td>McNally's Bay</td><td>2.0</td></tr>
<tr><td>URLA 5</td><td>Mooney's Bay</td><td>2.1</td></tr>
<tr><td>URLA 6</td><td>Westport</td><td>1.3</td></tr>
<tr><td>URLA 9</td><td>Little Bay</td><td>3.6</td></tr>
<tr><td>URLA 10</td><td>Big Bay</td><td>3.3</td></tr>
<tr><td>URLA 11</td><td>Roes Bay</td><td>1.5</td></tr>
<tr><td>URLA 12</td><td>Adrians Creek</td><td>2.3</td></tr>
<tr><th colspan="4">Basin Sites</th></tr>
<tr><th>Site #</th><th>Location</th><th>Average Depth (m</th><th>Sampling detail</th></tr>
<tr><td>URLA 7</td><td>Narrows Lock</td><td>13.0</td><td rowspan="2">Monthly • Testing for dissolved oxygen (mg/L), pH, temperature (°C) and chlorophyll (µg/L) at one metre intervals.

• Testing for Total Phosphorus (TP) at one metre below the surface and at 2x the secchi depth at each site.

• Secchi depth readings and colour observations.

Sampling Dates: July 2, August 20, September 13 and October 8, 2003</td></tr>
<tr><td>URLA 8</td><td>Three Sisters</td><td>20.0</td></tr>
</table>

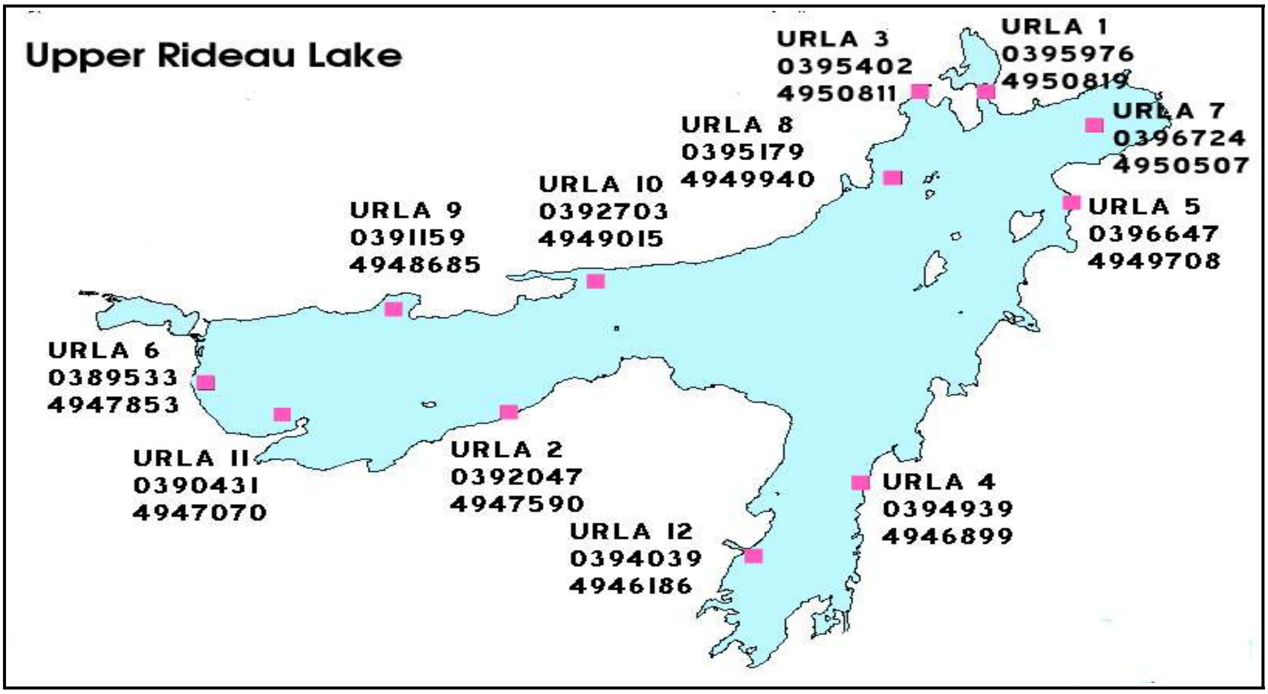
Changes to sampling sites from 2002

This year, 4 sites were added to the sampling protocol bringing the number of sampling sites up to twelve (Figure 3). The added sites were: Little Bay - URLA 9, Big Bay – URLA 10, Roes Bay – URLA 11 and Adrians Creek – URLA 12.

Changes to Sampling Details

The water samples were passed through an 80 X 80 micron Nitex mesh filter to remove zooplankton from the samples taken. This change was made in accordance with the change in the Ministry of Environment's Lake Partner Program sampling protocol. Some species of zooplankton (i.e. large species of Daphnia) can contain up to 25 micrograms of total phosphorus per litre (Schulz and Sterner, 2000). CSW will continue to liaise with the Ministry of the Environment as well as the Rideau Valley Conservation Authority to ensure that sampling protocols remain current.

Figure 3: Map of Upper Rideau Lake indicating sample sites and GPS coordinates for the 2003 sampling season



RESULTS

Total Phosphorus

Table 3 shows the TP results obtained at the basin sites throughout the sampling season

Table 3: TP results for basin sites at surface and 2 X secchi depth

Location	Total Phosphorus (ug/L) – Upper Rideau Lake, 2003					
	Depth	July	August	September	October	Average
Narrows Lock	Surface	25	23	16	17	20
	2 X secchi	29	23	15	18	21
Three Sisters	Surface	22	22	17	20	20
	2 X secchi	15	21	17	25	20

The average seasonal TP concentrations at the surface and at 2 X secchi depth for both of the basin sites were approximately 20ug/L. These results are indicative of eutrophic conditions. Fluctuations in TP concentrations can result from numerous factors, compounded by the complex nature and geography of Upper Rideau Lake. This highlights the importance of maintaining a monthly sampling scheme. If a sample was only taken at one point in the season, it would not provide as accurate a representation of its overall status.

TP measurements obtained at the nearshore sites can be found in Table 4 below.

Table 4: TP results for nearshore sites at surface

Location	Total Phosphorus (ug/L) Upper Rideau Lake, 2003				
	July	August	September	October	Average
Duck Bay	36	24	23	25	**27**
Golf Course	30	25	18	24	**24**
Kane's Bay	24	20	16	28	**22**
McNally's Bay	30	28	23	17	**25**
Mooney's Bay	27	23	20	17	**22**
Westport	82*	28	25	19	**24**
Little Bay	20	27	19	24	**23**
Big Bay	29	21	17	28	**24**
Roes Bay	57*	22	18	23	**21**
Adrians Creek	27	29	20	35	**28**

** value not used in calculation of seasonal average*

The average seasonal TP levels for all of the nearshore sites were above 20ug/L indicating high nutrient levels. The fact that the nearshore sites have higher nutrient levels than the lake as a whole (basin sites) suggests that these areas could be potential sources of nutrient loading. However, it is also possible for nearshore areas of a lake to act as TP sinks, when the current continually directs water to the area. Continual monitoring is necessary to fully understand TP dynamics in Upper Rideau Lake.

Higher TP levels in July may be a result of heavy rainfall that occurred in the area on June 29th, 2003. The very high values at the Westport and Roe's Bay sites in July may indicate these sites to be subject to high amounts of nutrient loading however, they are perceived to be outliers (abnormal values) and were not used in calculation of the seasonal average.

Secchi Depth

Table 5 shows the average secchi depth and associated trophic status throughout the season for the basin sites. A reading greater than 5 metres indicates an oligotrophic lake, from 3-5 metres indicates a mesotrophic lake, and a reading less than 3 metres indicates a eutrophic lake.

Most readings for both sites indicated mesotrophic status. However, a decrease in the water clarity was observed during the month of August for both sites, resulting in secchi depth readings more characteristic of a eutrophic lake. As mentioned, earlier, there are many factors that can affect secchi depth readings. The recent presence of zebra mussels may have an affect on secchi readings, and for that reason it is important not to rely on secchi depth data alone when evaluating water quality.

Table 5: Secchi depth data for basin sites – Upper Rideau Lake, 2003

Narrows Lock		
Date	**Secchi Depth (m)**	**Trophic Status**
July 2	3.7	**Mesotrophic**
August 20	2.7	**Eutrophic**
September 13	3.4	**Mesotrophic**
October 8	4.4	**Mesotrophic**
Site Average	**3.6**	**Mesotrophic**
Three Sisters		
Date	**Secchi Depth (m)**	**Trophic Status**
July 2	4.3	**Mesotrophic**
August 20	2.3	**Eutrophic**
September 13	4.8	**Mesotrophic**
October 8	4.5	**Mesotrophic**
Site Average	**4.0**	**Mesotrophic**

Chlorophyll

Figure 4 provides the chlorophyll values (µg/L) obtained with the YSI multi-parameter field unit at the twelve sites at one metre below the surface. Refer to Appendix B for chlorophyll surface data for all sites.

Figure 4: Chlorophyll results for all sites at surface

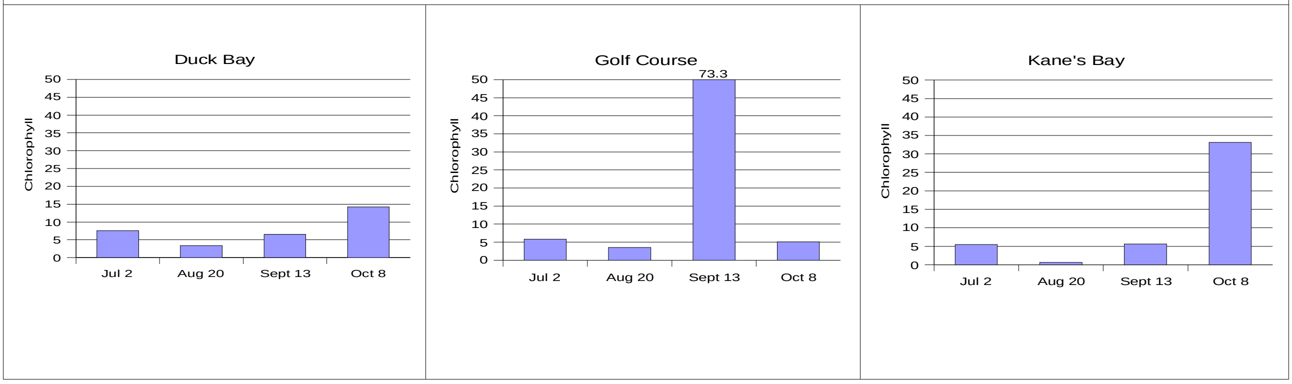
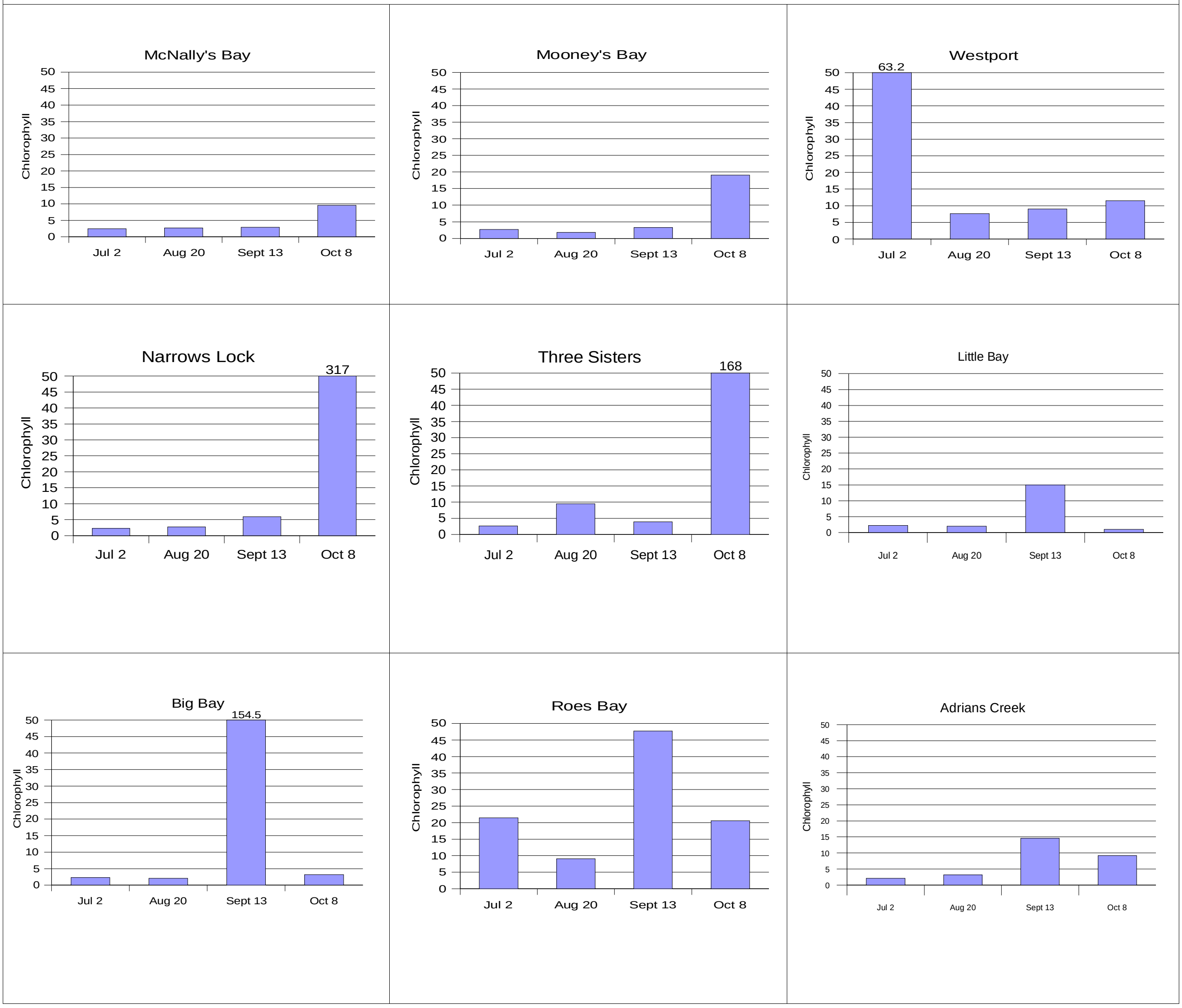


Figure 4: Chlorophyll results for all sites at surface

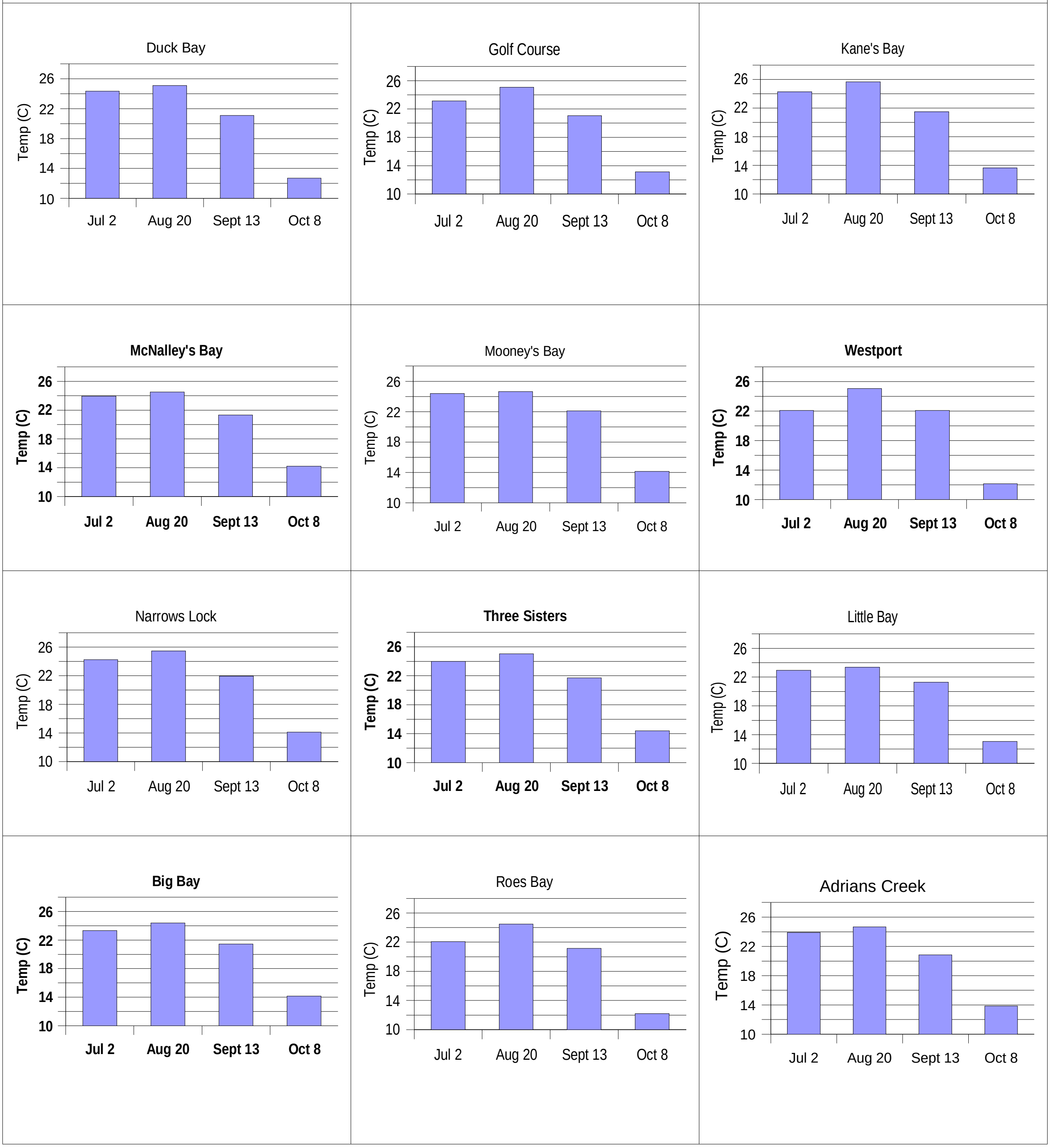


These values represent a total value for all three types of chlorophyll pigment. There are currently no provincial water quality objectives for chlorophyll however, consistently higher values can be used to identify areas of concern that should perhaps be studied further. Sites that did show higher values at times during the sampling season were, Westport, Golf Course, Roe's Bay, Narrows Lock, Three Sisters, and Big Bay. Chlorophyll readings may also be affected by aquatic plants which were apparent at the near shore sites.

Temperature

The surface temperature for all sites followed a normal seasonal change peaking at the end of August. Temperature readings taken at one metre below the surface are shown in Figure 5, found below.

Figure 5: Seasonal changes in temperature (°C) at one metre below the surface



Thermocline

On July 2nd the thermocline at the Narrows Lock site was between 5 to 12 metres in depth. By September the thermocline appeared at a greater depth, with the top at 9m and the bottom at the 12 metre mark. Temperature and density differences were almost nonexistent by October and as a result, the thermocline disappeared.

On July 2nd, the thermocline at the Three Sisters site was situated between the depths of 5 to 12 metres. By October, the properties of the lake slowly became uniform as temperature and density differences decreased at the surface of the water, moving the thermocline towards the bottom depths. At this point the top of the thermocline appeared at 14m and it spanned down to the 16 metre mark. Thermoclines are visible in dissolved oxygen - temperature profiles shown in Figure 6. Refer to Appendix A for temperature profile raw data.

Dissolved Oxygen At Surface

Table 6 shows the dissolved oxygen and temperature levels taken at one metre below the surface for all sites.

Table 6: Surface temperature and dissolved oxygen data for all sites

Location	Upper Rideau Lake, 2003				
		July	August	September	October
Duck Bay	DO (mg/L)	6.39	7.02	6.50	13.52
	Temp (^{0}C)	24.33	25.10	21.11	12.72
Golf Course	DO (mg/L)	9.77	9.48	10.63	13.28
	Temp (^{0}C)	23.14	25.08	21.04	13.14
Kane's Bay	DO (mg/L)	10.18	9.62	4.88	12.27
	Temp (^{0}C)	24.27	25.67	21.49	13.63
McNally's Bay	DO (mg/L)	9.71	8.48	9.56	12.85
	Temp (^{0}C)	23.95	24.51	21.34	14.22
Mooney's Bay	DO (mg/L)	9.82	8.24	8.18	13.52
	Temp (^{0}C)	24.38	24.64	22.10	14.15
Westport	DO (mg/L)	7.39	10.34	10.31	14.36
	Temp (^{0}C)	22.08	25.06	22.11	12.13
Narrows Lock	DO (mg/L)	9.42	8.96	7.15	9.35
	Temp (^{0}C)	24.24	25.46	21.93	14.13
Three Sisters	DO (mg/L)	9.25	7.17	6.94	10.56
	Temp (^{0}C)	23.99	25.04	21.71	14.40
Little Bay	DO (mg/L)	9.79	7.07	4.93	12.95
	Temp (^{0}C)	22.95	23.36	21.29	13.08
Big Bay	DO (mg/L)	9.19	8.52	10.09	12.30
	Temp (^{0}C)	23.33	24.39	21.46	14.14
Roes Bay	DO (mg/L)	9.89	9.52	10.67	14.07
	Temp (^{0}C)	22.07	24.48	21.16	12.19
Adrians Creek	DO (mg/L)	10.56	9.11	9.79	12.96
	Temp (^{0}C)	23.90	24.68	20.83	13.84

The DO conditions observed at surface are sufficient to support warm water fish populations such as smallmouth and largemouth bass, which require a minimum of 5mg/L of dissolved oxygen for normal activity. Smallmouth desire temperatures from 20.3^{0}C to 21.3^{0}C whereas largemouth prefer warmer temperatures from 26.6^{0}C to 27.7^{0}C. Dissolved oxygen levels at these temperatures was consistently above the minimum requirements for these fish.

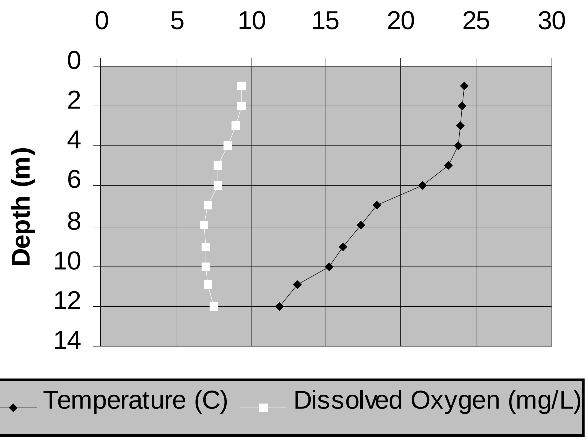
Dissolved Oxygen - Temperature Profiles

Figure 6 shows the dissolved oxygen - temperature profiles taken at the basin sites. Raw data is provided in Appendix A.

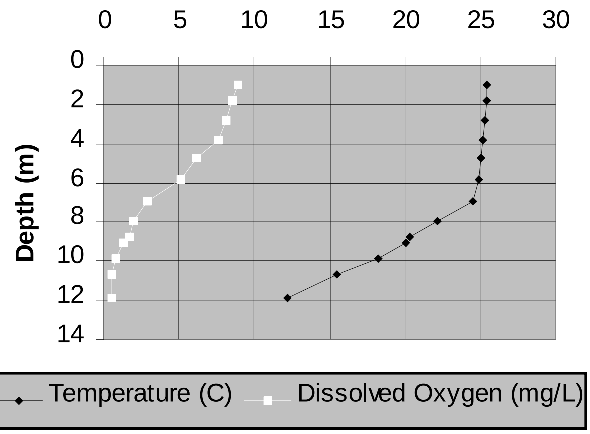
Figure 6: Dissolved oxygen and temperature profiles at one metre intervals for the Narrows Lock and Three Sisters sites

Narrows Lock

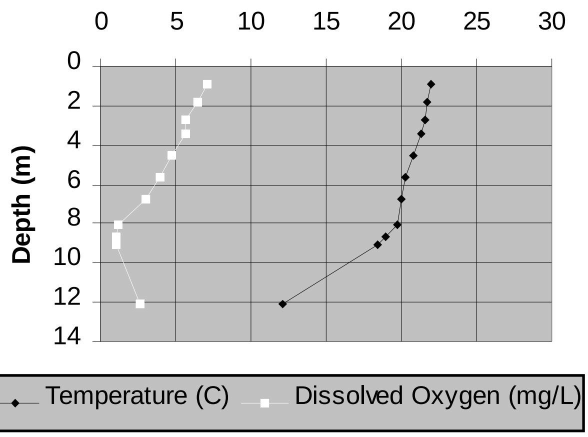
July 2nd, 2003



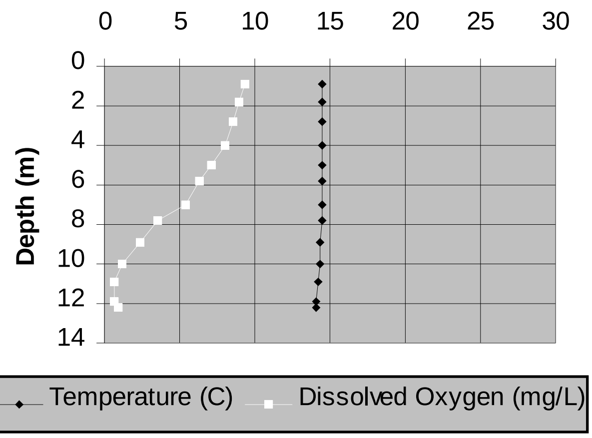
August 20th, 2003



September 13th, 2003

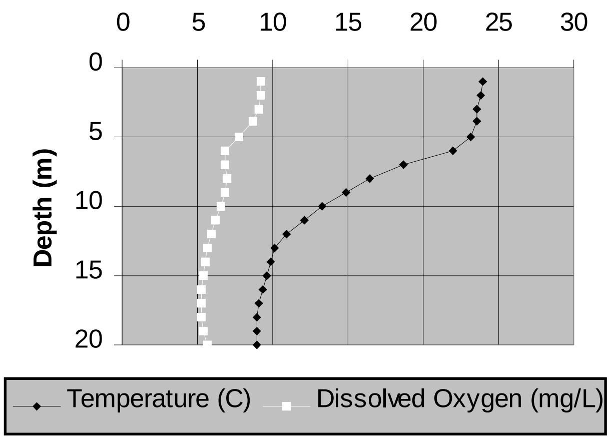


October 8th, 2003

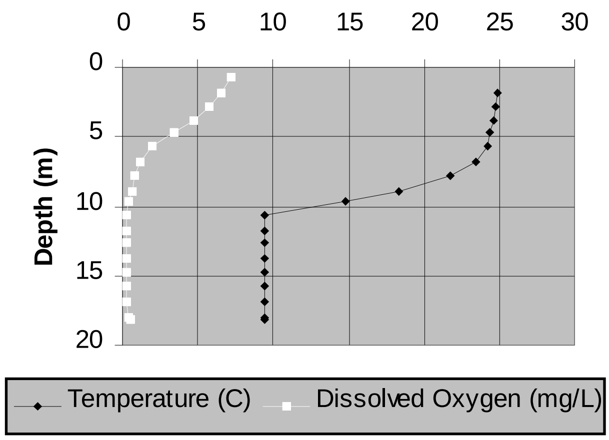


Three Sisters

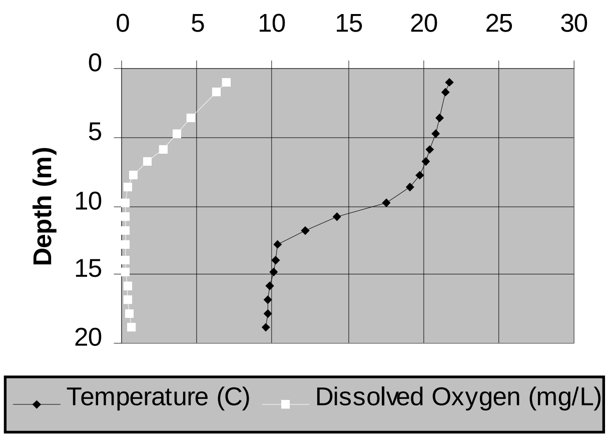
July 2nd, 2003



August 20th, 2003



September 13th, 2003



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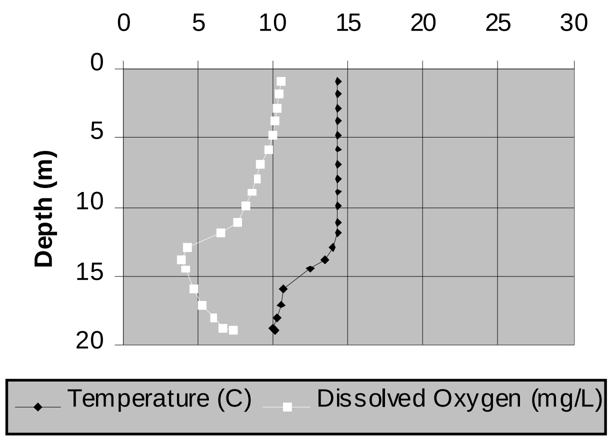

Testing near the end of summer, before fall turn-over provides an indication of the worst case scenario as demand for dissolved oxygen is at its highest. After stratification occurs, dissolved oxygen in the hypolimnion, gradually gets used up and is generally not replenished until fall turnover.

Anoxic conditions (less than 1mg/L of dissolved oxygen) occurred at depth for The Narrows Lock site in August and October. These conditions are common to shallow lakes such as Upper Rideau Lake. By October, fall mixing was occurring at the Narrows Lock site.

At the Three Sisters site, anoxic conditions were noted in August and September ranging in depth from 8 to 20 metres. In October, DO concentrations in the hypolimnion at this site are increasing, indicating that the hypolimnion may have begun mixing with upper layers thus replenishing DO concentrations. At both sites, DO levels above the thermocline were sufficient to support warm water fisheries.

pH

Table 7 shows the pH levels obtained at all sites taken at one metre below the surface. Although results vary from site to site, most of them remained within the normal lake levels of 6.5 – 8.5. As the summer progressed, pH levels increased at most sites, followed by a decrease in early fall. This could be due to high decay rates after the vegetation died off. In a natural environment, the pH of a lake can vary on a daily basis due to many factors including plant photosynthesis and high precipitation. It should be noted that the high pH levels found at Westport and Roes Bay remain well below alkali levels of 9.5 and above which are lethal pH levels for perch and trout (Kentucky Water Watch, 2001).

Table 7: pH data for all sites at surface

Location	pH – Upper Rideau Lake, 2003				
	July 2	August 20	September 13	October 8	Average
Duck Bay	8.25	8.27	8.15	8.25	8.23
Golf Course	8.34	8.79	8.91	8.46	8.63
Kane's Bay	8.48	8.76	8.32	8.04	8.40
McNally's Bay	8.38	8.70	8.58	8.36	8.51
Mooney's Bay	8.48	8.58	8.64	8.69	8.60
Westport	7.79	8.42	8.42	8.75	8.35
Narrows Lock	8.44	8.76	8.30	7.97	8.37
Three Sisters	8.40	8.60	8.34	8.07	8.35
Little Bay	8.20	8.20	8.23	8.35	8.25
Big Bay	8.22	8.34	8.77	8.12	8.36
Roes Bay	8.27	8.79	9.13	8.87	8.77
Adrians Creek	8.43	8.69	8.53	8.32	8.49

SUMMARY

- TP values in the Narrows Lock and the Three Sisters basin sites indicated that these parts of the lake exhibited eutrophic conditions during the 2003 sampling season. The secchi depth readings obtained at both the Narrows Lock and the Three Sisters sites suggested mesotrophic conditions, however it should be noted that secchi readings can be affected by zebra mussels and should not be used alone when determining trophic status.

- Average TP values in the nearshore sites were higher in comparison to the basin sites suggesting there may be unknown nutrient sources contributing to the measured phosphorus content. It is also possible that these areas act as TP sinks if the current continually directs water into the area.

- Chlorophyll levels at Westport, Golf Course, Roe's Bay, Narrows Lock, Three Sisters, and Big Bay did show higher values at points during the sampling season. Higher chlorophyll readings could be a result of increased growth of aquatic plants and algae, indicating that these areas may be subject to greater levels of nutrient loading.

- The dissolved oxygen profiles for the Narrows Lock and Three Sisters sites showed oxygen in the hypolimnion decrease throughout the summer which is normal for shallow lakes. For both basin sites, DO above the thermocline was sufficient to support warm water fisheries.

- At all sites, dissolved oxygen levels at the surface were sufficient to support warm water fisheries.

RECOMMENDATIONS

The data gathered during the 2003 sampling season suggests that Upper Rideau Lake is meso-eutrophic to eutrophic (moderate to high nutrient enrichment). The continued monitoring of key factors, such as phosphorus and algae growth, will help in establishing trends in the health of the lake. Information gathered will aid in determining the impact of development pressures on the lake environment.

After profiling the Narrows Lock and Three Sisters basin sites in 2002 and 2003 a good understanding of the dynamics of each site has been determined. CSW feels that taking one profile during late August to September should be sufficient. Sampling DO after fall turnover (before spring turnover) may also be considered. Nearshore 'profiles' could be used to map available fisheries habitat based on water quality.

Nearshore sites are used to track pressures from the land, and the nearshore sites tested this year showed higher levels of nutrients than observed in the open water. More work might be considered in these areas. As well, more nearshore sites might be considered, and in fact, the Rideau Valley Conservation Authority is planning a comprehensive testing of nearshore sites on Upper Rideau Lake in 2005. To supplement future studies, the Upper Rideau Lake Association will make existing data available to government agencies and other related agencies such as conservation authorities and academic institutions.

Upper Rideau exhibits high nutrient levels and low dissolved oxygen, which is in part due to the shallow nature of this lake. Higher nearshore phosphorus and chlorophyll levels may represent other regions of the lake in need of stewardship and rehabilitation. Shoreline stewardship efforts should be ongoing in order to reduce nutrient loading into the lake. Educating the public is a primary component of watershed protection and conservation. Positive communication with landowners can be achieved through shoreline home visits and workshops, newsletter articles, and healthy shoreline demonstration sites.

Complimenting water quality monitoring with other monitoring programs such as shoreline inventories, stream assessments, and bathymetry will help provide a more detailed picture of the Upper Rideau Lake aquatic ecosystem. Assessing all potential nutrient sources in the watershed including aging or malfunctioning septic systems, lawn care, stormwater run-off, agriculture, and boating can also provide a more comprehensive understanding of lake status. Stream assessments at all inflows would also compliment water quality data. Benthic invertebrates are useful indicators of water quality and environmental health. Incorporated into a volunteer monitoring program, benthic assessment can be a cost-effective method for evaluating several sites, including streams.

Another area that might be considered for monitoring are zones of high boat traffic, especially 'overnight' areas. Other environmental groups such as the Georgian Bay Association have been very successful in identifying areas that have experienced pressure from gray water discharge (nutrients as well as *E.coli*). A program such as this may apply to the area close to the town of Westport. Historically, nutrient loading in this area has been higher than other areas of the lake.

Because there does not currently exist any detailed information on the bathymetry of Upper Rideau Lake, the volume of the basins cannot be calculated. Centre for Sustainable Watersheds has recently acquired sophisticated bathymetry equipment that will provide a detailed georeferenced description of the lake bottom. CSW also has the printing capabilities to produce maps from the bathymetric work, which could be produced and sold to lake residents for fundraising purposes of both organizations.

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APPENDIX A: Profile data collected, using the YSI multi-parameter sampling unit

URLA 7: Narrows Lock								
Depth	July 2nd, 2003		August 20, 2003		September 13, 2003		October 8, 2003	
(m)	DO (mg/L)	Temp (ºC)	DO (mg/L)	Temp (ºC)	DO (mg/L)	Temp (ºC)	DO (mg/L)	Temp (ºC)
1	9.42	24.24	8.96	25.46	7.15	21.93	9.35	14.45
2	9.32	24.06	8.46	*25.35*	*6.44*	21.77	8.99	14.45
3	8.99	23.97	8.09	25.27	5.6	21.53	8.56	14.45
4	8.42	23.76	7.59	25.18	5.64	21.29	8.06	14.44
5	7.76	23.14	6.12	25.05	4.78	20.83	7.14	14.43
6	7.74	21.43	5.15	24.83	3.91	20.32	6.36	14.42
7	7.08	18.41	2.85	24.45	3.01	20.01	5.41	14.42
8	6.86	17.33	1.96	22.2	1.21	19.71	3.57	14.42
9	6.97	16.17	1.28	20.08	1.10	18.45	2.39	14.40
10	7.03	15.26	0.78	18.21	-	-	1.20	14.30
11	7.12	13.05	0.51	15.52	-	-	0.65	14.16
12	7.56	11.95	0.56	12.22	2.68	12.08	0.62	14.13

URLA 8: Three Sisters								
Depth	July 2nd, 2003		August 20, 2003		September 13, 2003		October 8, 2003	
(m)	DO (mg/L)	Temp (ºC)	DO (mg/L)	Temp (ºC)	DO (mg/L)	Temp (ºC)	DO (mg/L)	Temp (ºC)
1	9.25	23.99	7.17	25.04	6.94	21.71	10.56	14.4
2	9.20	23.78	6.51	24.85	6.28	21.52	10.43	14.38
3	9.02	23.61	5.70	24.73	-	-	10.29	14.37
4	8.72	23.56	4.66	24.59	4.59	21.15	10.14	14.36
5	7.71	23.10	3.39	24.41	3.66	20.87	9.96	14.35
6	6.85	21.91	2.00	24.21	2.69	20.43	9.76	14.34
7	6.87	18.68	1.15	23.42	1.67	20.15	9.26	14.34
8	6.98	16.41	0.84	21.74	0.79	19.84	8.94	14.33
9	6.86	14.84	0.60	18.39	0.38	19.11	8.57	14.33
10	6.61	13.32	0.37	14.83	0.27	17.56	8.13	14.32
11	6.24	12.04	0.32	9.49	0.20	14.28	7.61	14.31
12	5.86	10.91	0.28	9.47	0.22	12.16	6.61	14.3
13	5.71	10.09	0.28	9.47	0.25	10.39	4.35	13.98
14	5.47	9.81	0.28	9.47	0.28	10.24	3.99	13.41
15	5.33	9.56	0.29	9.47	0.31	10.05	4.19	12.44
16	5.25	9.33	0.3	9.47	0.35	9.84	4.77	10.61
17	5.25	9.07	0.31	9.47	0.40	9.72	5.24	10.47
18	5.31	9.00	0.41	9.47	0.49	9.63	6.03	10.23
19	5.39	8.99	-	-	0.61	9.59	6.74	10.02
20	5.65	9.00	-	-	-	-	7.41	10.16

APPENDIX B: Profile data including temperature, dissolved oxygen, pH and chlorophyll results for all sites measured at surface

Location	Date	Temperature (ºC)	DO (mg/L)	pH	Chlorophyll (ug/L)
Duck Bay	July 2	24.33	6.39	8.25	7.6
	August 20	25.10	7.02	8.27	3.4
	September 13	21.11	6.50	8.15	6.5
	October 8	12.72	13.52	8.25	14.2
Golf Course	July 2	23.14	9.77	8.34	5.8
	August 20	25.08	9.48	8.79	3.5
	September 13	21.04	10.63	8.91	73.3
	October 8	13.14	13.28	8.46	5.1
Kane's Bay	July 2	24.27	10.18	8.48	5.5
	August 20	25.67	9.62	8.76	0.6
	September 13	21.49	4.88	8.32	5.6
	October 8	13.63	12.27	8.04	33.1
McNally's Bay	July 2	23.95	9.71	8.38	2.5
	August 20	24.51	8.48	8.70	2.7
	September 13	21.34	9.56	8.58	2.9
	October 8	14.22	12.85	8.36	9.6
Mooney's Bay	July 2	24.38	9.82	8.48	2.7
	August 20	24.64	8.24	8.58	1.8
	September 13	22.10	8.18	8.64	3.25
	October 8	14.15	13.52	8.69	19.1
Westport	July 2	22.08	7.39	7.79	63.2
	August 20	25.06	10.34	8.42	7.6
	September 13	22.11	10.31	8.42	9
	October 8	12.13	14.36	8.75	11.5
Narrows Lock	July 2	24.24	9.42	8.44	2.3
	August 20	25.46	8.96	8.76	2.7
	September 13	21.93	7.15	8.30	5.9
	October 8	14.13	9.35	7.97	316.8
Three Sisters	July 2	23.99	9.25	8.40	2.6
	August 20	25.04	7.17	8.60	9.5
	September 13	21.71	6.94	8.34	3.9
	October 8	14.4	10.56	8.07	167.6
Little Bay	July 2	22.95	9.79	8.20	2.2
	August 20	23.36	7.07	8.20	8.2
	September 13	21.29	4.93	8.23	15
	October 8	13.08	12.95	8.35	1
Big Bay	July 2	23.33	9.19	8.22	2.3
	August 20	24.39	8.52	8.34	2.1
	September 13	21.46	10.09	8.77	154.5
	October 8	14.14	12.30	8.12	3.2
Roes Bay	July 2	22.07	9.89	8.27	21.5
	August 20	24.48	9.52	8.79	9.09
	September 13	21.16	10.67	9.13	47.7
	October 8	12.19	14.07	8.87	20.6
Adrians Creek	July 2	23.90	10.56	8.43	2.1
	August 20	24.68	9.11	8.69	3.2
	September 13	20.83	9.79	8.53	14.6
	October 8	13.84	12.96	8.32	9.2