CHAFFEY'S LOCK AREA LAKES

Indian, Clear and Benson Lakes

WATER QUALITY MONITORING REPORT

2004

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INTRODUCTION

This report presents the findings of water quality monitoring conducted at 4 sites in the Chaffey Lock's Area Lakes for the 2004 sampling season.

BACKGROUND

Water quality is an excellent diagnostic tool for evaluating the health of a lake. Nutrients and pathogens can enter our waterways from a number of sources. Monitoring water quality indicators can help identify these sources and also evaluate whether things are improving or not.

Lake Dynamics

Deeper lakes tend to stratify during the summer months based on temperature differences (Figure 1). As the 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 below is known as the hypolimnion.

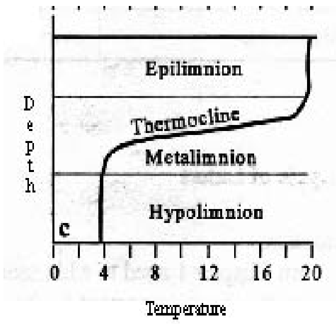


Figure 1: Thermal stratification (Mackie 1999)

Mixing only occurs twice a year in these lakes 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 is at its most dense form at 4°C, so as the surface temperature drops to 4°C, it will sink. Surface water will continue sinking until the whole lake is uniform in density and temperature (4°C). The lake turns over again in the spring as the ice melts and the surface warms to 4°C, 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 can also be used to determine trophic status, as it provides a measure of the impact of plant growth associated with eutrophication. When the plants and algae die, they sink to the bottom and are decomposed by microorganisms, depleting the dissolved oxygen content of the hypolimnion.

Phosphorus

Phosphorus is generally recognized as the limiting nutrient in freshwater ecosystems, and the major contributing nutrient to eutrophication in these environments. Limiting nutrient means that all the other components necessary for growth are available, but a lack of a specific 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. Generally, the concentration of Total Phosphorus (TP) is taken to account for all chemical forms of phosphorus present. Oligotrophic lakes are characterized by an average TP level less than 10 µg/L, mesotrophic lakes have between 10 and 20 µg/L and eutrophic lakes have an average TP level greater than 20 µg/L. (1 mg/L = 1000 µg/L). Provincial water quality objectives are less than 20 µg/L.

The location of sampling is important. Samples taken close to shore are more likely to reflect processes that are happening on land (run-off from fertilizers, storm water runoff, erosion, agriculture). Samples taken in open water (mid lake) better represent the concentrations of phosphorus in the lake on a whole. Samples are taken at secchi depth to reflect the TP concentration just below the biologically productive area of the lake.

Algae Growth

Algae growth is natural in lakes but with excessive nutrient concentrations, it can become a nuisance. Because algae thrive on nutrients in the water, measures of 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 water body.

Chlorophyll can be measured chemically in the lab or its activity can be measured *in situ* (in the lake) by fluorescence meters (chlorophyll becomes activated as it obtains energy from the sun). *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. Readings are subject to human interpretation and weather, such as sun and wind. 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 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.

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

More stringent objectives may be required for waters with sensitive biological communities, lake trout for example, or in situations where additional stressors occur. Ontario Ministry of the Environment and Ministry of Natural Resources suggest that optimal habitat for lake trout occurs at temperatures less than 10°C with greater than 6 mg/L DO (MNR, 1986). The optimal habitat for splake requires temperatures between 10 to 16°C with a minimum dissolved oxygen concentration of 5 mg/L (Kerr, S.J. and R.E. Grant 2000).

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 and increase capacity 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.

CHAFFEY'S LOCK AREA LAKES SAMPLING SCHEME

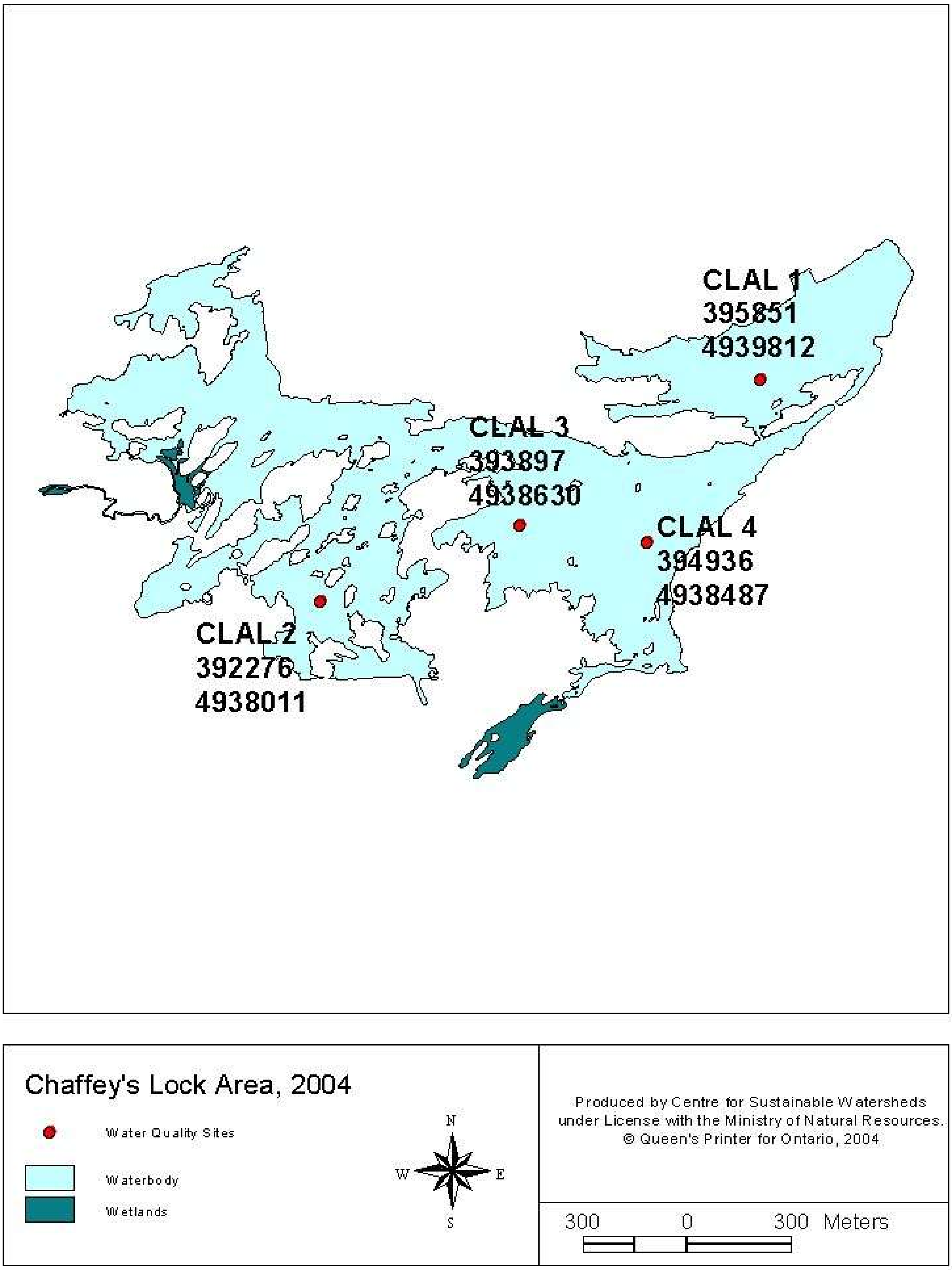
Sampling was carried out at four basin sites during the 2004 field season. The sampling dates were July 12th , August 12th , September 14th, and October 5th, 2004. Table 2 outlines the sampling detail for each site.

Refer to Figure 2 for a complete map of the sampling sites with GPS co-ordinates.

Table 2: Sampling procedure and site depths

Site #	Location	Site Depth	Sampling Details
CLAL1	Clear Lake	33m	-monthly profiling using a YSI multi-parameter unit at 1m intervals measuring pH, dissolved oxygen (mg/L), temperature (°C), and chlorophyll (µg/L) -secchi depth (m) observations
CLAL2	Benson Lake	11m	
CLAL3	Indian Lake West	26m	
CLAL4	Indian Lake East	25m	

Figure 2: Map of Chaffey's Lock Area Lakes sample sites with GPS co-ordinates.



RESULTS

Secchi Depth

Table 3 shows the average secchi depth and associated trophic status throughout the season for the 2004 sampling sites. A reading greater than 5 metres indicates an oligotrophic lake, from 3-5m indicates a mesotrophic lake, and a reading less than 3 m indicates a eutrophic lake.

Table 3: Secchi depth (m) results and associated trophic status for all sites.

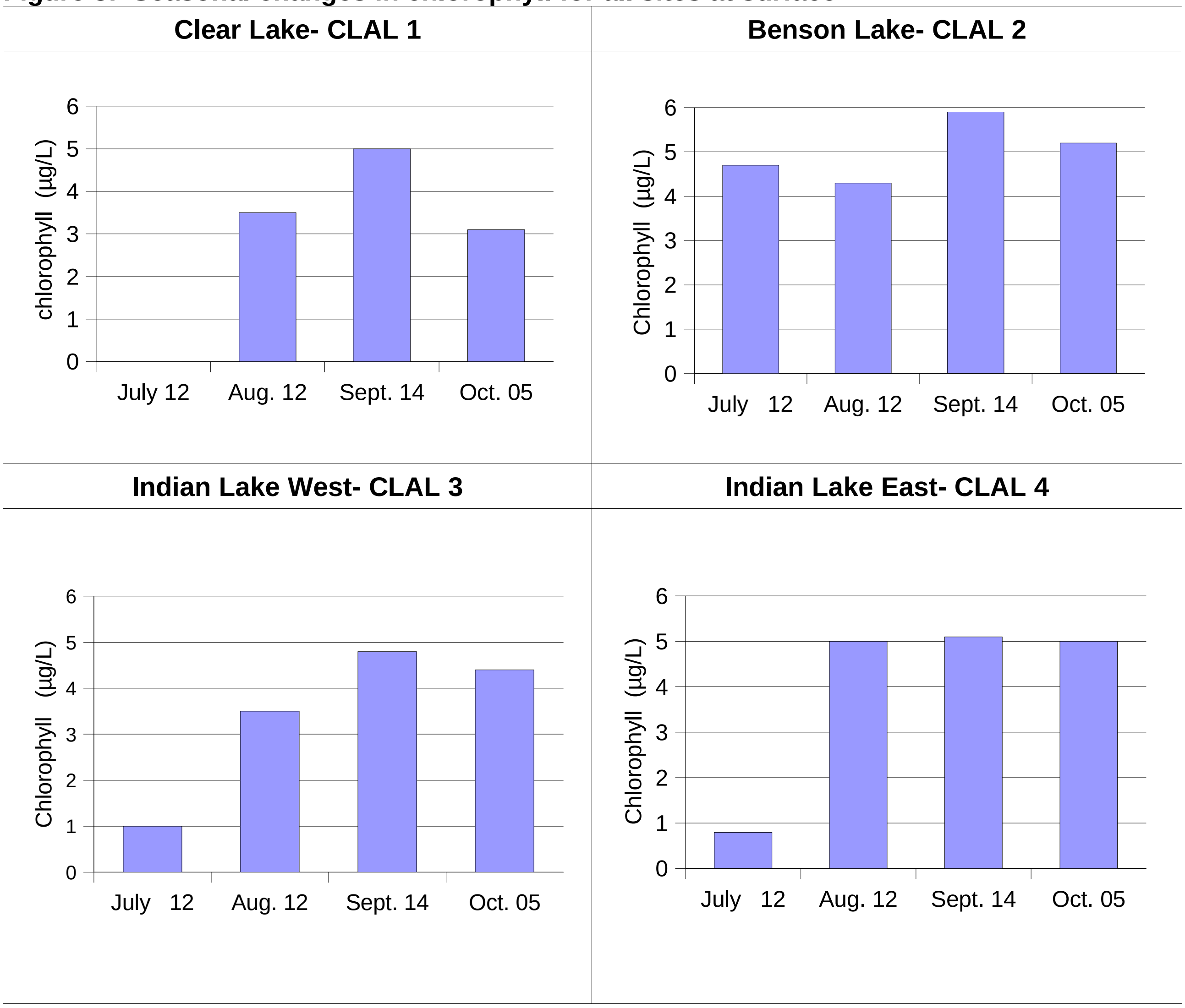
Secchi Depth (m)- Chaffey's Lock Area Lakes, 2004			
Location	**Date**	**Secchi Depth**	**Trophic Status**
Clear Lake CLAL 1	July 12	5.6	Oligotrophic
	August 12	4.3	Mesotrophic
	September 14	6.1	Oligotrophic
	October 05	8.5	Oligotrophic
	Average	**6.1 m**	**Oligotrophic**
Benson Lake CLAL 2	July 12	4.3	Mesotrophic
	August 12	4	Mesotrophic
	September 14	4.8	Mesotrophic
	October 05	5.1	Oligotrophic
	Average	**4.6 m**	**Mesotrophic**
Indian Lake West CLAL 3	July 12	5.2	Oligotrophic
	August 12	4.1	Mesotrophic
	September 14	5.7	Oligotrophic
	October 05	6.2	Oligotrophic
	Average	**5.3 m**	**Oligotrophic**
Indian Lake East CLAL 4	July 12	5.4	Oligotrophic
	August 12	4.4	Mesotrophic
	September 14	5.4	Oligotrophic
	October 05	5.7	Oligotrophic
	Average	**5.2 m**	**Oligotrophic**

2004 secchi readings indicate oligotrophic status at all sites except for Benson Lake (Site CLAL2). The average seasonal secchi depth at Benson Lake was 4.6m, indicating moderate nutrient conditions. These results are consistent with secchi averages from 2003. The higher readings at all sites in October may be related to the possible die off of algae as the water temperatures cooled. As mentioned earlier, there are many factors that can affect secchi depth readings and for that reason it is important not to rely on secchi depth data alone when evaluating water quality.

Chlorophyll

Figure 3 provides the chlorophyll (µg/L) values obtained with the YSI multi-parameter field unit at all four sites. Each of these readings were taken at one metre below the surface.

Figure 3: Seasonal changes in chlorophyll for all sites at surface

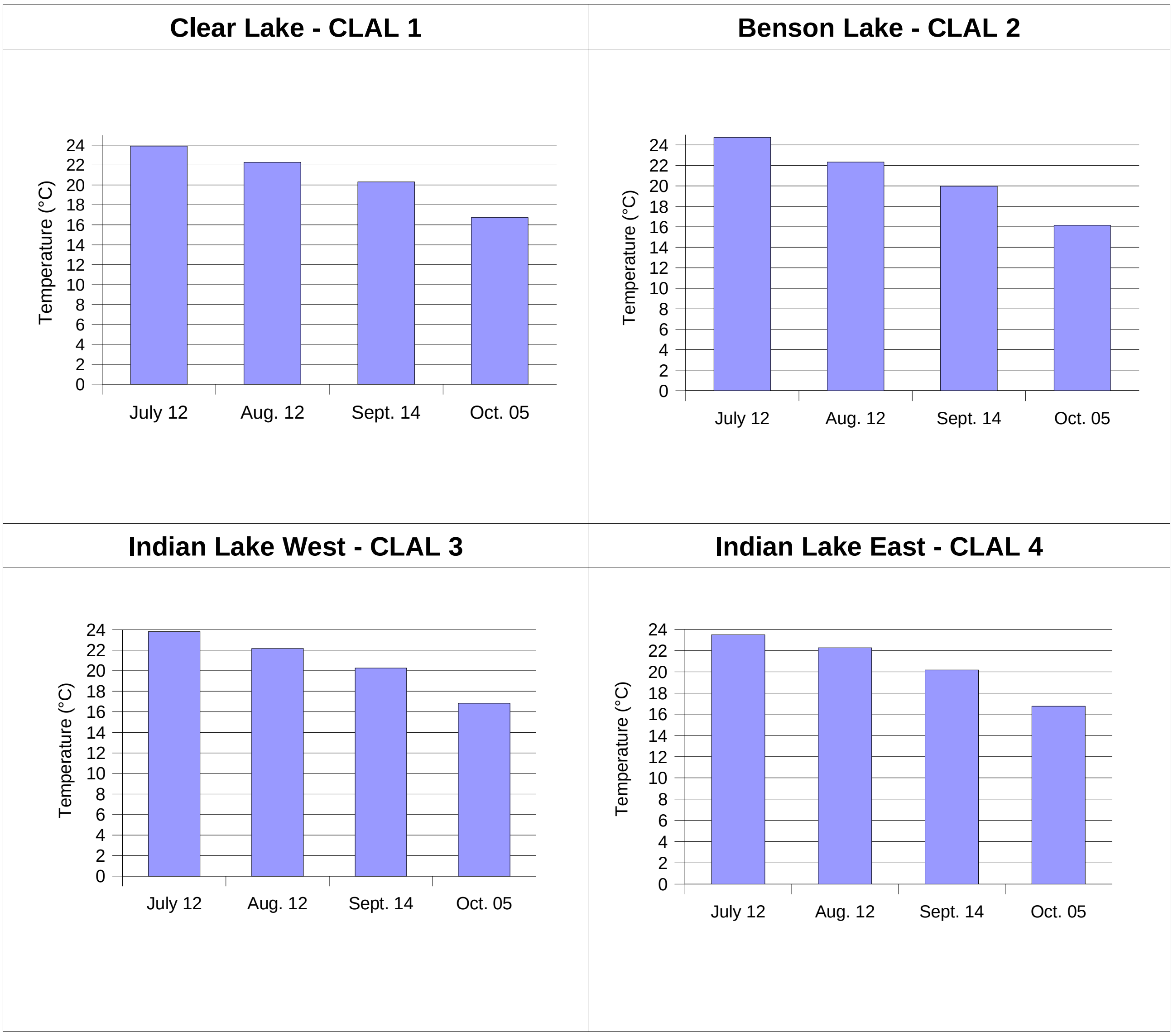


These values represent a total value for all three types of chlorophyll pigment. Readings at all sites in 2004 were low. Elevated readings may be a result of increased levels of nutrient enrichment from fertilization, erosion, or agricultural processes and could be used to identify areas of concern that should perhaps be studied further. For chlorophyll data, refer to Appendix B.

Temperature

Temperature readings taken at one metre below the surface are shown in Figure 4.

Figure 4: Seasonal changes in temperature levels for all sites at surface



The surface temperature for all sites followed seasonal changes peaking in July. While the temperatures peaked in August in 2003, the 2004 sampling season saw heavy rainfall and high winds which may have contributed to this change. Stratification was observed at all sites and for all sampling dates. Refer to Appendix A for temperature data.

Dissolved Oxygen at Surface

Table 4 shows the dissolved oxygen and temperature levels taken at one metre below the surface for all sites.

Table 4: Seasonal changes in dissolved oxygen and temperature for all sites at one metre below the surface.

Location	DO and Temp. - Chaffey's Lock and Area Lakes, 2004				
	Parameter	**July**	**August**	**September**	**October**
Clear Lake CLAL 1	DO (mg/L)	8.72	8.95	10.17	7.93
	Temp (^{0}C)	23.89	22.27	20.08	16.73
Benson Lake CLAL 2	DO (mg/L)	8.37	8.90	9.80	6.70
	Temp (^{0}C)	24.73	22.32	19.97	16.15
Indian Lake West CLAL 3	DO (mg/L)	8.34	8.89	10.07	8.01
	Temp (^{0}C)	23.83	22.17	20.27	16.83
Indian Lake East CLAL 4	DO (mg/L)	8.64	8.15	9.80	7.88
	Temp (^{0}C)	23.51	22.26	20.17	16.77

The DO conditions observed in the surface waters are sufficient to support warm water fish populations such as smallmouth and largemouth bass, which for normal activity, require a minimum of 4 mg/L dissolved oxygen when surface temperatures are above 20^{O}C (refer to Table 1).

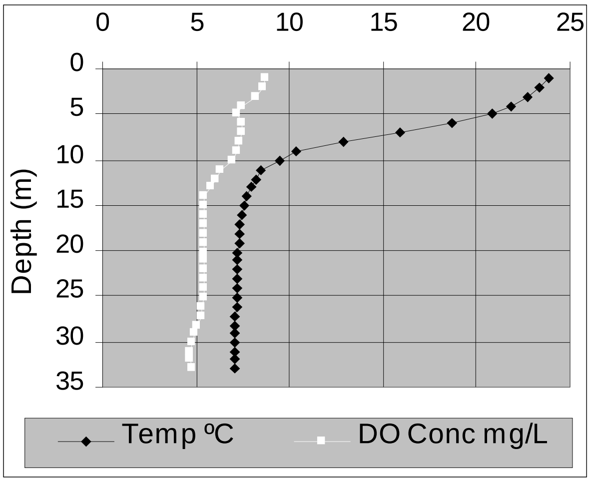
Dissolved Oxygen - Temperature Profiles

Figure 5 shows the dissolved oxygen - temperature profiles taken at all sites. Profiles were taken at each site for each sampling date and can be used to evaluate habitat availability for cold water fish species. Raw data is provided in Appendix A.

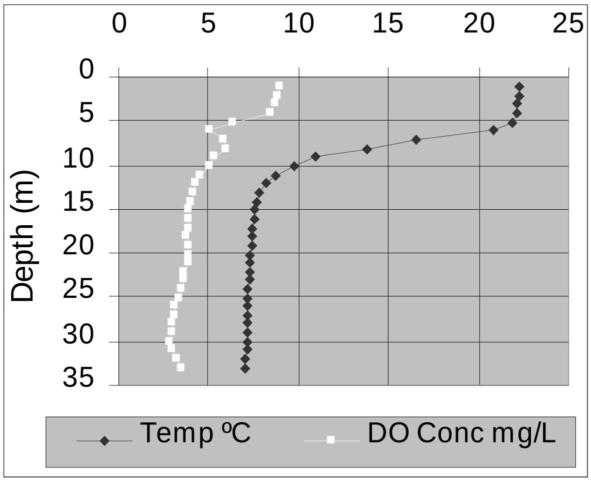
Figure 5: Dissolved oxygen (mg/L) - temperature (°C) profiles

Clear Lake - CLAL 1

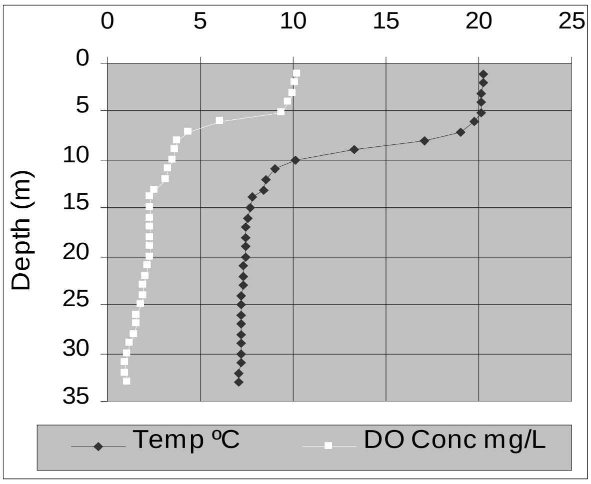
July 12, 2004



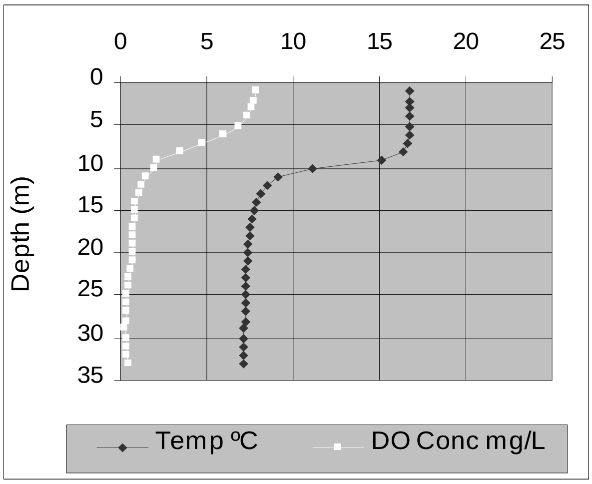
August 12, 2004



September 14, 2004



October 5, 2004



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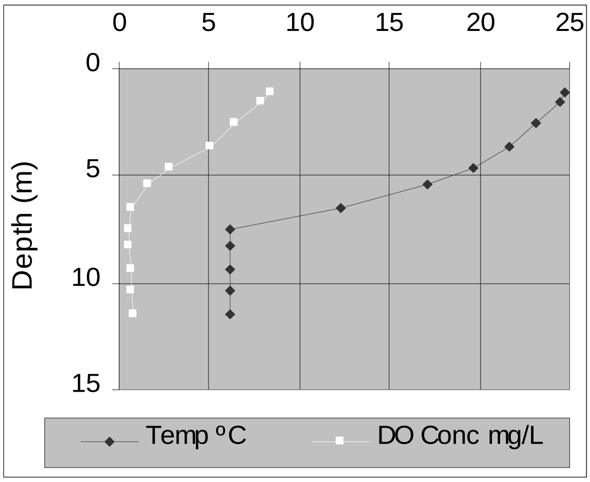
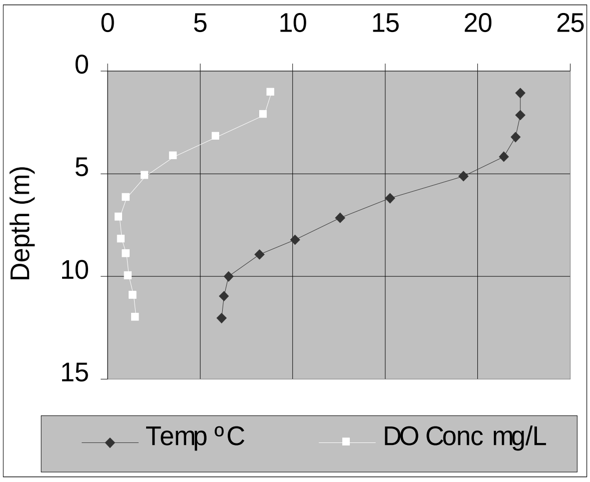
Benson Lake - CLAL 2

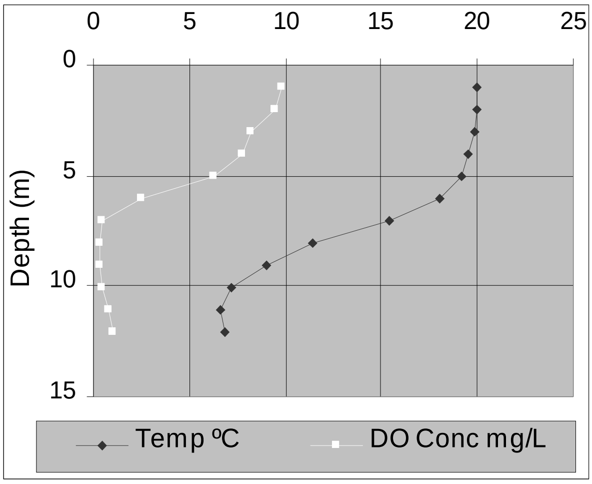
July 12, 2004



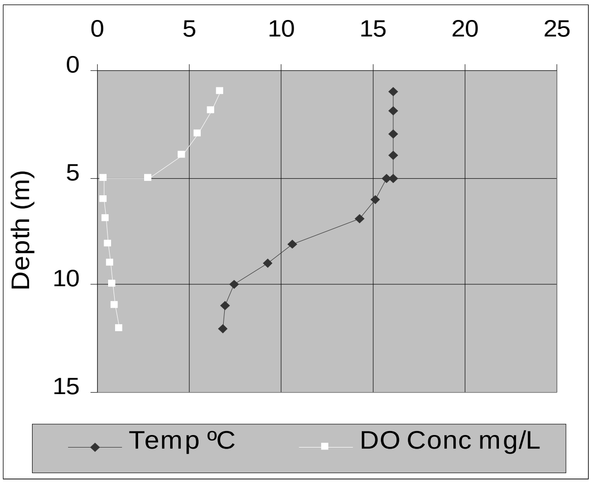
August 12, 2004



September 14, 2004

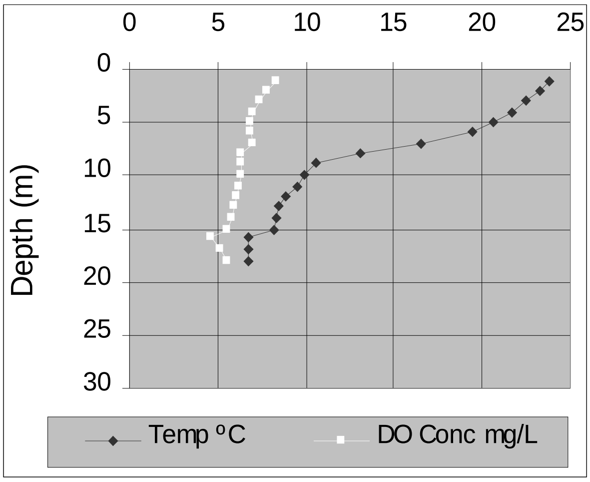


October 5, 2004

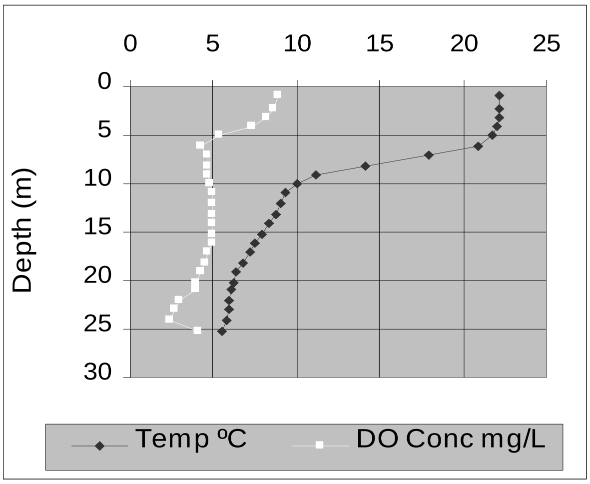


Indian Lake West - CLAL 3

July 12, 2004



August 12, 2004



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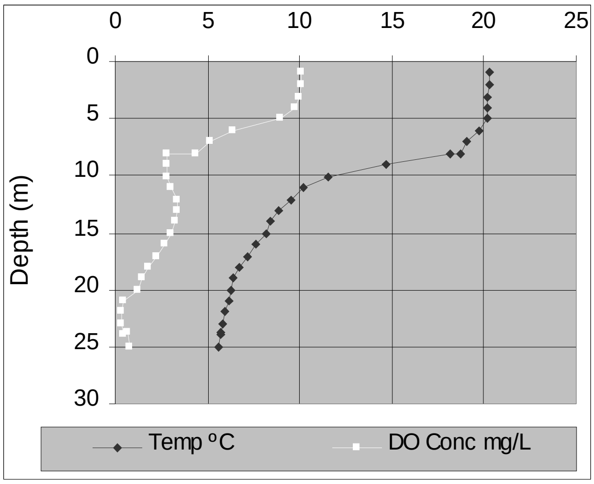

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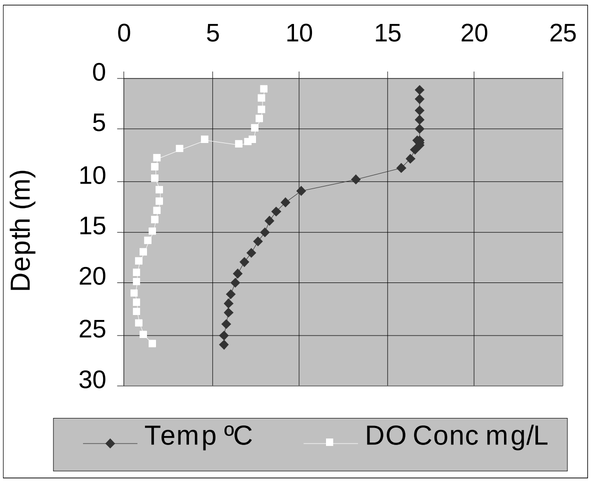
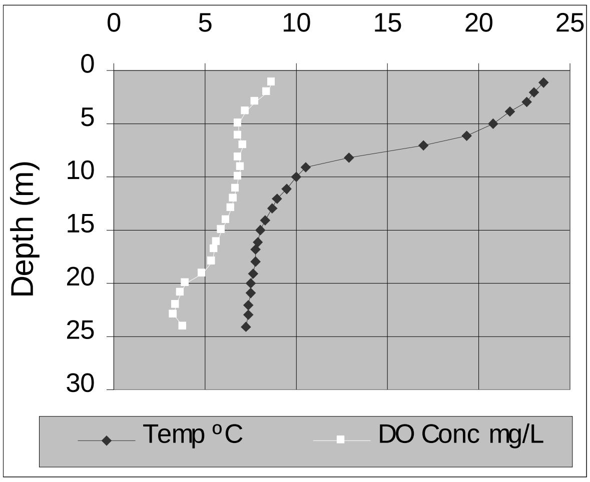
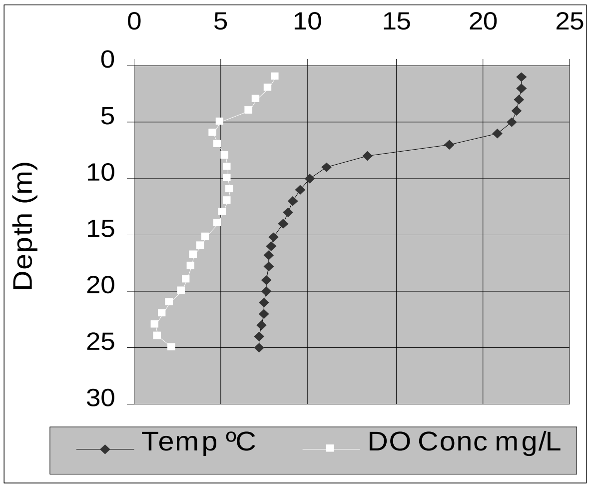


Indian Lake East - CLAL 4

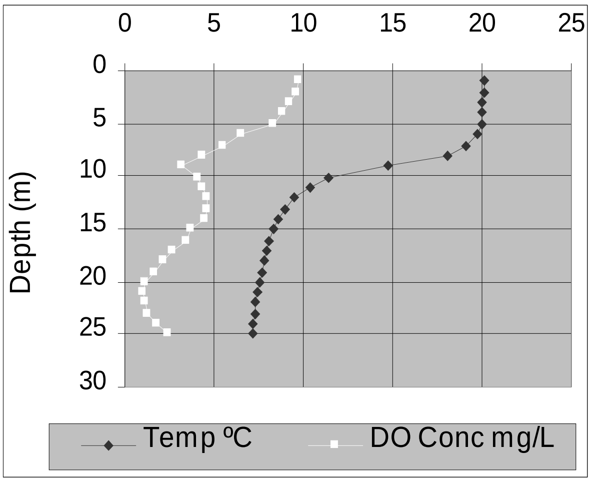
July 12, 2004



August 12, 2004



September 14, 2004



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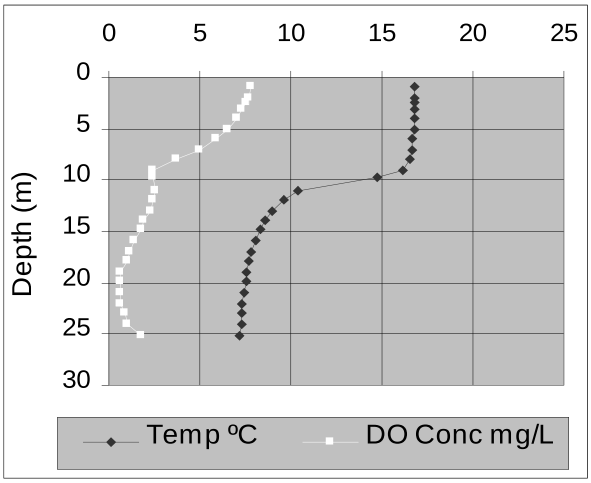

Testing near the end of summer, before fall turn-over provides an indication of the worst case scenario as demand for dissolved oxygen is at its highest. It is evident at all sites that dissolved oxygen in the hypolimnion is gradually getting used up as the season progresses. Anoxic DO readings (less than 1mg/L of dissolved oxygen) occurred below the thermocline for Benson Lake in July, August, September and October. Indian Lake West demonstrated some anoxic readings in both September and October, while at Clear and Indian Lake East anoxic readings were observed below the themocline only in October.

Tables 5 and 6 show the amount of available habitat at each lake for lake trout and splake respectively. Optimal conditions for lake trout are 6mg/L of DO at temperatures less then 10^{O}C. Splake (30,000 stocked in Indian Lake by the Ministry of Natural Resources in 2004) are commonly used by fisheries managers to provide angling opportunities in waters that may be marginal for brook trout or lake trout populations. Although optimal splake temperatures are between 10 and 16^{O}C some populations can tolerate temperatures up to 20^{O}C. (Kerr, S.J. 2000).

Table 5: Available lake trout habitat in metres – 6mg/L DO at temperatures less than 10°C.

Location	Lake Trout Habitat (m)- Chaffey's Lock Area Lakes, 20			
	July	August	September	October
Clear Lake CLAL 1	3	0	0	0
Indian Lake West CLAL 3	3	0	0	0
Indian Lake East CLAL 4	5	0	0	0

Table 6: Available splake habitat in metres – 5mg/L DO at temperatures between 10-16°C.

Location	Splake Habitat (m)- Chaffey's Lock Area Lakes, 2004			
	July	August	September	October
Clear Lake CLAL 1	3	2	0	0
Indian Lake West CLAL 3	2	0	0	0
Indian Lake East CLAL 4	2	3	0	0

As observed in 2003, dissolved oxygen concentrations in the late summer would cause stress to lake trout populations.

Clear and Indian Lake showed sufficient DO at the optimal temperature ranges (10-16°C) for splake in July and August, but in September and October DO at these sites did not meet these requirements. As some populations of splake can tolerate temperatures up to 20°C, it is possible that they could survive in these lakes throughout the entire season, however would likely be stressed to reproduce.

pH

The pH range of a healthy freshwater lake is between 6.5 and 8.5. Table 7 shows the pH levels for all sites one metre below the surface.

Table 7: pH results for all sites at surface

Location	pH – Chaffey's Lock Area Lakes, 2004				
	July	August	September	October	Average
Clear Lake CLAL 1	7.76	7.90	7.77	7.25	**7.67**
Benson Lake CLAL 2	7.87	8.10	7.84	6.98	**7.70**
Indian Lake West CLAL 3	7.63	7.84	7.70	7.13	**7.58**
Indian Lake East CLAL 4	7.66	7.73	7.64	7.11	**7.54**

Results indicate acceptable pH levels for the Chaffey's Lock Area Lakes. The lake is slightly alkaline, common for lakes with limestone bedrock or high levels of carbonates in their sediments. This chemistry will help the lake to “buffer” against changes in pH from inputs such as acid rain.

SUMMARY

- Average secchi depth readings observed at Clear Lake, Indian Lake West, and Indian Lake East suggested oligotrophic conditions. Secchi depth results obtained at the Benson Lake sampling site suggested mesotrophic conditions. All secchi averages this year were similar to 2003 results.

- Average chlorophyll values were low at all sites.

- Dissolved oxygen and temperature levels at the surface for all three lakes were sufficient to support warm water fisheries.

- DO-temperature profiles indicated that cold water fisheries would be stressed by September.

- The pH levels for the Chaffey Lock Area Lakes were within the healthy range for eastern Ontario lakes.

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RECOMMENDATIONS

Annual water quality testing is useful to track changes in water quality over time and identify hot spots (problem areas). It has been estimated that three to five years of data should be recorded at the same sites in order to determine yearly trends.

- Because it is the limiting nutrient for plant and algae growth in an aquatic environment, TP is one of the most important nutrients to monitor. Testing in the open water areas (the basins) helps assess overall status of the lake, while near-shore testing may help identify potential on-shore impacts. The Chaffey's Lock and Area Lakes Association should continue monitoring TP levels through the use of the Ministry of the Environment's Lake Partner Program.
- While more sampling will provide a clearer picture of the nutrient status at a site, frequency of sampling is always dictated by resources available. In any event, sampling events should be evenly spaced – preferably starting as soon after ice out as possible, before the spring turn-over and continuing through to the fall turn-over.
- Dissolved oxygen is critical for fisheries habitat. The levels observed this year indicate that cold water fisheries would experience stress near the end of the summer. While comprehensive profiling is probably not required on a yearly basis, at least one profile per site would be recommended during the period of peak oxygen demand (mid September) to evaluate trends.
- Benthic macroinvertebrates are excellent and inexpensive indicators of long term water quality in lakes and streams. The Ministry of the Environment has developed a program to help volunteers participate in monitoring benthics in their waterways. Contact CSW or the Cataraqui Region Conservation Authority to learn about how to get involved.
- Keep up the good work with your efforts in raising awareness about potential impacts on water quality!

APPENDIX A: Temperature and DO profile data collected, using the YSI multi - parameter sampling unit for Chaffey's Lock Area Lakes.

Clear Lake - CLAL 1								
Depth	July 12, 2004		August 12, 2004		September 14, 2004		October 5, 2004	
(m)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)
1	8.72	23.89	8.95	22.27	10.22	20.30	7.93	16.73
2	8.64	23.31	8.85	22.22	10.14	20.20	7.76	16.72
3	8.21	22.73	8.68	22.18	10.05	20.16	7.58	16.72
4	7.40	21.81	8.45	22.14	9.81	20.11	7.36	16.72
5	7.15	20.81	6.44	21.90	9.39	20.09	6.88	16.71
6	7.46	18.63	5.09	20.86	6.04	19.74	6.06	16.69
7	7.41	15.87	5.83	16.57	4.35	18.98	4.72	16.63
8	7.37	12.86	5.95	13.85	3.74	17.04	3.51	16.35
9	7.16	10.30	5.37	10.93	3.62	13.24	2.13	15.11
10	6.91	9.47	5.07	9.75	3.55	10.07	1.95	11.12
11	6.35	8.45	4.61	8.77	3.30	9.08	1.50	9.09
12	6.04	8.23	4.33	8.16	3.11	8.57	1.27	8.45
13	5.79	8.01	4.18	7.86	2.56	8.39	1.10	8.13
14	5.41	7.69	4.04	7.69	2.28	7.82	0.89	7.90
15	5.47	7.58	3.91	7.55	2.29	7.66	0.84	7.70
16	5.41	7.45	3.87	7.49	2.28	7.56	0.82	7.58
17	5.40	7.34	3.86	7.45	2.27	7.49	0.80	7.52
18	5.38	7.31	3.83	7.42	2.28	7.47	0.77	7.46
19	5.38	7.28	3.89	7.39	2.32	7.43	0.74	7.40
20	5.40	7.24	3.89	7.33	2.30	7.40	0.73	7.37
21	5.42	7.22	3.87	7.30	2.23	7.35	0.69	7.34
22	5.42	7.20	3.71	7.25	2.07	7.31	0.63	7.31
23	5.41	7.18	3.62	7.23	2.00	7.27	0.55	7.28
24	5.39	7.18	3.50	7.22	1.92	7.24	0.48	7.26
25	5.37	7.16	3.36	7.21	1.85	7.22	0.41	7.22
26	5.31	7.15	3.18	7.18	1.63	7.21	0.38	7.21
27	5.24	7.12	3.13	7.15	1.57	7.20	0.35	7.20
28	5.06	7.10	3.05	7.14	1.47	7.19	0.32	7.19
29	4.98	7.10	2.93	7.13	1.27	7.18	0.31	7.18
30	4.83	7.08	2.89	7.12	1.06	7.17	0.32	7.17
31	4.67	7.07	2.98	7.10	0.97	7.16	0.34	7.17
32	4.66	7.05	3.21	7.09	1.00	7.13	0.41	7.16
33	4.86	7.03	3.53	7.08	1.11	7.12	0.46	7.15

Thermocline

Benson Lake - CLAL 2								
Depth	July 12, 2004		August 12, 2004		September 14, 2004		October 5, 2004	
(m)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)
1	8.37	24.73	8.90	22.32	9.80	19.97	6.70	16.15
2	7.92	24.43	8.52	22.30	9.45	19.95	6.19	16.14
3	6.44	23.12	5.91	22.10	8.26	19.87	5.51	16.13
4	5.07	21.72	3.56	21.47	7.76	19.57	4.64	16.12
5	2.85	19.69	1.99	19.24	6.29	19.15	2.79	16.07
6	1.65	17.11	1.01	15.27	2.56	18.00	0.37	15.73
7	0.67	12.25	0.70	12.53	0.46	15.37	0.41	15.17
8	0.58	6.15	0.79	10.08	0.29	11.47	0.45	14.31
9	0.59	6.15	0.97	8.17	0.31	9.04	0.58	10.59
10	0.62	6.15	1.21	6.59	0.50	7.16	0.68	9.25
11	0.69	6.15	1.45	6.27	0.75	6.67	0.80	7.42
12	0.80	6.16	1.58	6.19	1.04	6.88	0.96	6.90
13	**	**	**	**	**	**	1.27	6.77

Thermocline

Indian Lake West- CLAL 3								
Depth	**July 12, 2004**		**August 12, 2004**		**September 14, 2004**		**October 5, 2004**	
(m)	**DO (mg/L)**	**Temp (°C)**	**DO (mg/L)**	**Temp (°C)**	**DO (mg/L)**	**Temp (°C)**	**DO (mg/L)**	**Temp (°C)**
1	8.34	23.83	8.89	22.17	10.07	20.27	8.01	16.83
2	7.85	23.26	8.62	22.14	10.04	20.24	7.96	16.82
3	7.41	22.44	8.25	22.12	9.95	20.22	7.84	16.82
4	6.98	21.70	7.30	22.08	9.74	20.22	7.72	16.82
5	6.87	20.61	5.41	21.79	9.01	20.19	7.57	16.82
6	6.87	19.45	4.30	20.90	6.39	19.75	7.38	16.82
7	7.04	16.49	4.63	17.93	5.21	19.09	7.10	16.82
8	6.36	13.13	4.67	14.13	4.32	18.73	6.67	16.81
9	6.39	10.55	4.73	11.10	2.82	14.74	4.67	16.74
10	6.32	9.88	4.84	10.07	2.85	11.50	3.26	16.59
11	6.23	9.53	4.88	9.39	3.08	10.16	1.91	16.28
12	6.06	8.92	4.95	8.98	3.34	9.55	1.80	15.78
13	5.96	8.48	4.99	8.79	3.40	8.87	1.84	13.22
14	5.83	8.27	4.96	8.32	3.21	8.45	2.06	10.04
15	5.52	8.17	4.93	7.88	3.04	8.13	2.05	9.21
16	4.67	6.77	4.89	7.48	2.70	7.65	1.99	8.72
17	5.12	6.77	4.61	7.14	2.28	7.17	1.84	8.29
18	5.49	6.80	4.46	6.84	1.74	6.70	1.63	7.97
19	**	**	4.26	6.42	1.51	6.39	1.38	7.63
20	**	**	3.95	6.20	1.26	6.28	1.15	7.29
21	**	**	3.89	6.11	0.46	6.12	0.96	6.89
22	**	**	2.90	5.98	0.35	5.91	0.80	6.53
23	**	**	2.62	5.89	0.36	5.78	0.74	6.30
24	**	**	2.36	5.80	0.44	5.73	0.67	6.15
25	**	**	4.16	5.55	0.79	5.64	0.73	6.01
26	**	**	**	**	**	**	0.83	5.91
27	**	**	**	**	**	**	0.95	5.78
28	**	**	**	**	**	**	1.20	5.70
29	**	**	**	**	**	**	1.69	5.68

Thermocline

Indian Lake East- CLAL 4								
Depth (m)	**July 12, 2004**		**August 12, 2004**		**September 14, 2004**		**October 5, 2004**	
	DO (mg/L)	**Temp (°C)**	**DO (mg/L)**	**Temp (°C)**	**DO (mg/L)**	**Temp (°C)**	**DO (mg/L)**	**Temp (°C)**
1	8.64	23.51	8.15	22.26	9.80	20.17	7.88	16.77
2	8.37	23.01	7.70	22.19	9.61	20.07	7.69	16.76
3	7.78	22.61	7.07	22.13	9.21	20.03	7.37	16.76
4	7.3	21.75	6.67	22.01	8.87	20.01	7.05	16.75
5	6.78	20.83	4.99	21.63	8.35	19.99	6.60	16.75
6	6.85	19.38	4.49	20.92	6.58	19.72	5.94	16.73
7	7.07	16.93	4.87	18.09	5.53	19.10	5.02	16.68
8	6.79	12.85	5.29	13.44	4.30	18.07	3.73	16.55
9	6.97	10.49	5.34	11.05	3.18	14.74	2.43	16.14
10	6.9	9.97	5.44	10.10	4.10	11.41	2.43	14.71
11	6.76	9.43	5.46	9.56	4.37	10.36	2.61	10.34
12	6.56	8.98	5.33	9.18	4.60	9.53	2.47	9.57
13	6.4	8.63	5.17	8.85	4.62	9.01	2.27	8.93
14	6.23	8.27	4.82	8.53	4.53	8.63	1.95	8.57
15	5.91	8.04	4.17	8.08	3.74	8.27	1.77	8.33
16	5.71	7.88	3.85	7.88	3.42	8.08	1.44	8.08
17	5.54	7.77	3.52	7.76	2.71	7.92	1.14	7.85
18	5.45	7.71	3.35	7.67	2.19	7.76	1.01	7.74
19	4.93	7.66	3.05	7.6	1.70	7.63	0.69	7.60
20	3.89	7.54	2.72	7.55	1.13	7.52	0.60	7.51
21	3.7	7.48	2.11	7.45	1.01	7.42	0.60	7.43
22	3.39	7.41	1.69	7.39	1.11	7.34	0.69	7.35
23	3.32	7.34	1.27	7.32	1.32	7.28	0.87	7.30
24	3.79	7.26	1.36	7.25	1.77	7.23	1.03	7.26
25	**	**	2.21	7.16	2.41	7.2	1.76	7.21

Thermocline

APPENDIX B: Chlorophyll (µg/L) and pH profile data collected, using the YSI multi - parameter sampling unit for Chaffey's Lock Area Lakes

Clear Lake- CLAL 1								
Depth	July 12, 2004		August 12, 2004		September 14, 2004		October 5, 2004	
(m)	Chlorophyll	pH	Chlorophyll	pH	Chlorophyll	pH	Chlorophyll	pH
1	0.00	7.76	3.50	7.90	5.00	7.77	3.10	7.25
2	2.90	7.76	3.80	7.87	5.00	7.77	3.50	7.23
3	5.00	7.73	4.20	7.85	5.40	7.77	3.20	7.21
4	5.80	7.45	3.90	7.82	5.80	7.72	3.60	7.19
5	6.30	7.19	3.60	7.67	6.10	7.70	3.60	7.15
6	6.70	6.93	3.30	7.00	4.80	7.39	3.90	7.08
7	6.80	6.79	3.30	6.71	4.40	6.89	3.50	6.99
8	7.10	6.74	3.40	6.72	5.00	6.67	3.50	6.85
9	6.90	6.71	3.70	6.70	5.00	6.59	3.20	6.60
10	5.80	6.65	3.30	6.67	4.60	6.59	3.50	6.49
11	4.00	6.59	3.50	6.64	4.60	6.61	3.90	6.48
12	3.90	6.57	3.20	6.64	4.10	6.61	3.20	6.48
13	3.90	6.56	2.90	6.63	4.00	6.59	2.50	6.48
14	3.30	6.53	3.10	6.63	3.70	6.59	2.50	6.47
15	3.00	6.52	2.80	6.62	3.80	6.59	2.80	6.47
16	2.70	6.51	2.80	6.64	3.90	6.57	3.00	6.45
17	2.70	6.51	2.70	6.64	4.00	6.59	3.10	6.47
18	2.90	6.52	2.50	6.66	4.10	6.58	2.90	6.46
19	2.70	6.51	2.80	6.64	3.50	6.59	2.90	6.47
20	2.60	6.50	2.40	6.68	3.50	6.60	3.10	6.48
21	2.80	6.52	2.30	6.69	3.60	6.63	3.10	6.48
22	2.90	6.51	2.70	6.70	3.90	6.63	2.90	6.48
23	2.70	6.51	2.70	6.74	3.70	6.64	3.10	6.46
24	2.70	6.51	2.50	6.73	3.90	6.64	2.90	6.47
25	2.70	6.53	2.80	6.76	3.60	6.67	2.90	6.49
26	2.70	6.51	2.60	6.77	3.60	6.67	2.50	6.48
27	2.60	6.53	2.40	6.78	3.70	6.69	2.70	6.51
28	2.60	6.53	2.70	6.79	3.50	6.68	3.00	6.51
29	2.50	6.52	3.50	6.80	3.00	6.71	3.00	6.52
30	3.00	6.55	4.20	6.81	3.20	6.73	2.80	6.54
31	4.50	6.33	5.80	6.83	4.20	6.73	3.80	6.55
32	6.20	6.29	8.40	6.86	4.70	6.76	0.70	6.61
33	7.80	6.57	10.30	6.89	5.70	6.81	0.70	6.61

Benson Lake- CLAL 2								
Depth	July 12, 2004		August 12, 2004		September 14, 2004		October 5, 2004	
(m)	Chlorophyll	pH	Chlorophyll	pH	Chlorophyll	pH	Chlorophyll	pH
1	4.70	7.87	4.30	8.10	5.90	7.84	5.20	6.98
2	5.00	7.86	6.90	8.10	5.60	7.80	6.60	6.95
3	7.30	7.62	7.40	7.98	6.00	7.69	8.90	6.91
4	10.40	7.05	8.50	7.58	6.70	7.42	12.80	6.86
5	14.60	6.60	11.40	6.82	5.80	7.15	26.50	6.75
6	10.90	6.41	14.50	6.69	6.30	6.87	1.00	6.19
7	**	6.28	34.50	6.66	9.80	6.64	1.00	6.19
8	**	6.12	**	6.70	29.20	6.65	1.10	6.17
9	1.90	6.01	**	6.67	**	6.73	1.00	6.19
10	2.00	6.02	50.30	6.53	**	6.64	0.60	6.20
11	2.40	6.04	22.30	6.42	2.10	6.53	0.80	6.20
12	2.20	6.06	2.50	6.32	1.20	6.39	1.10	6.21
13	**	**	**	**	**	**	0.80	6.23

Indian Lake West- CLAL 3								
Depth	July 12, 2004		August 12, 2004		September 14, 2004		October 5, 2004	
(m)	Chlorophyll	pH	Chlorophyll	pH	Chlorophyll	pH	Chlorophyll	pH
1	1.00	7.63	3.50	7.84	4.60	7.70	4.40	7.13
2	3.70	7.58	3.60	7.81	4.80	7.69	3.90	7.12
3	4.50	7.49	4.60	7.75	4.70	7.65	4.30	7.10
4	4.80	7.25	4.70	7.67	4.20	7.64	4.20	7.09
5	4.90	6.95	5.10	7.51	4.60	7.58	4.40	7.07
6	5.80	6.79	4.70	7.31	4.10	7.13	4.30	7.05
7	5.70	6.74	4.80	6.62	3.80	6.95	4.30	6.86
8	5.60	6.68	4.40	6.63	3.30	6.84	4.20	6.75
9	6.00	6.63	4.40	6.61	3.60	6.61	4.60	6.66
10	5.30	6.62	4.30	6.61	3.10	6.57	5.00	6.48
11	4.30	6.64	4.30	6.60	3.70	6.57	4.80	6.48
12	3.50	6.64	4.40	6.61	3.30	6.58	4.80	6.50
13	3.30	6.65	4.40	6.62	3.00	6.58	5.00	6.51
14	3.30	6.64	4.00	6.61	3.30	6.58	5.30	6.51
15	2.60	6.65	3.90	6.62	3.30	6.58	5.30	6.50
16	13.40	6.52	3.70	6.61	3.00	6.58	5.40	6.51
17	2.50	6.56	3.40	6.64	3.50	6.57	5.80	6.51
18	1.60	6.61	3.70	6.64	3.00	6.55	6.00	6.53
19	**	**	3.50	6.65	2.70	6.56	6.00	6.54
20	**	**	3.40	6.69	2.60	6.56	7.10	6.56
21	**	**	2.60	6.72	2.80	6.55	7.00	6.55
22	**	**	88.90	6.78	2.90	6.56	7.80	6.56
23	**	**	87.90	6.82	2.90	6.56	8.30	6.59
24	**	**	80.90	6.89	3.10	6.54	8.00	6.61
25	**	**	38.60	6.92	2.70	6.55	9.50	6.61

Indian Lake East- CLAL 4								
Depth	**July 12, 2004**		**August 12, 2004**		**September 14, 2004**		**October 5, 2004**	
(m)	**Chlorophyll**	**pH**	**Chlorophyll**	**pH**	**Chlorophyll**	**pH**	**Chlorophyll**	**pH**
1	0.80	7.66	5.00	7.73	5.10	7.64	5.00	7.11
2	2.30	7.67	4.40	7.69	5.30	7.59	5.60	7.08
3	4.30	7.55	4.30	7.67	5.60	7.59	6.70	7.04
4	3.50	7.34	4.60	7.60	5.40	7.54	6.50	7.01
5	4.70	7.00	4.60	7.37	5.40	7.49	7.80	7.00
6	5.00	6.80	4.80	6.91	5.60	7.21	9.80	6.96
7	5.00	6.70	5.00	6.65	5.00	6.91	9.70	6.90
8	6.10	6.65	4.80	6.64	5.60	6.82	10.60	6.82
9	5.90	6.63	4.70	6.62	5.30	6.61	10.60	6.65
10	4.60	6.63	4.30	6.63	5.40	6.62	10.90	6.54
11	4.00	6.61	3.70	6.65	4.80	6.65	11.10	6.46
12	3.10	6.62	3.90	6.67	4.00	6.67	12.10	6.47
13	3.00	6.63	3.80	6.68	4.00	6.67	14.20	6.48
14	2.80	6.64	3.40	6.68	3.90	6.69	17.30	6.49
15	2.80	6.64	3.00	6.65	3.50	6.69	13.20	6.49
16	2.60	6.64	3.00	6.65	3.60	6.71	13.20	6.49
17	2.20	6.66	2.80	6.67	3.70	6.71	13.90	6.47
18	2.30	6.67	2.70	6.68	3.60	6.73	13.30	6.50
19	2.80	6.69	3.20	6.67	3.30	6.74	14.00	6.50
20	55.30	6.72	3.20	6.70	4.00	6.75	15.70	6.51
21	54.00	6.74	49.20	6.72	3.60	6.76	15.80	6.50
22	45.10	6.74	49.20	6.78	3.50	6.78	17.80	6.53
23	36.50	6.84	49.00	6.83	3.30	6.79	19.00	6.54
24	21.10	6.90	47.70	6.87	3.50	6.81	21.70	6.53
25	**	**	28.90	7.01	4.40	6.82	13.30	6.56