Lake of Bays – 2006 Water Quality Monitoring Program

Prepared for
Lake of Bays Association

Submitted by
Gartner Lee Limited

April 2007

Gartner Lee

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In association with
Gartner Lee Limited

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April 30th, 2007

Ms. Deborah Cumming
Lake of Bays Association
P.O. Box 8
Baysville ON P0B 1A0

Dear Ms. Cumming:

Re: GLL 60609 – Lake of Bays Association 2006 Water Quality Monitoring Report

It has been a pleasure to work with you over the year through the implementation of the water quality monitoring program and the formation of the annual report. We are pleased to provide you with the final version of the Lake of Bays Association 2006 Water Quality Monitoring Report.

We are excited for some of the initiatives which have been discussed for the 2007 season and look forward to any opportunities to support the Association's strong commitment to environmental stewardship.

Please do not hesitate to contact Mr. Miller at extension 5503 if you wish to discuss the report or any other environmental matters.

Yours very truly,
GARTNER LEE LIMITED

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1. Introduction

Since 2000, the Lake of Bays Association has monitored key water quality parameters in Lake of Bays under the direction of Gartner Lee Limited (GLL), an environmental consulting firm with an office in Bracebridge, Ontario. The monitoring program has focussed on the determination of bacteria and phosphorus concentrations in near shore and open water areas of the lake as an indication of water and watershed health. Each year, the environment committee of the LOBA coordinates volunteers to collect samples during the summer season from predetermined sites in the lake. Site selection has changed over as the program has progressed reflecting changes in focus with an ever-increasing understanding of water quality conditions in Lake of Bays. General testing, however, has been repeated at various sites around the lake to maintain the data record for background levels and to consider variations in water by land use. The complete list of sampling sites for the Lake of Bays water quality monitoring program (2000-2006) is provided in Table 1.

The Lake of Bays Association's longest ongoing project is water quality monitoring. Until the summer of 2000, monitoring was limited to tracking water clarity and phosphorus enrichment. In 2000 a pilot study to determine the levels of bacteria present in the lake was undertaken. This pilot project was successful and LOBA made a commitment to expand the area of study in the summer of 2001. From 2000 to 2004, bacterial sampling was conducted at various sites included nearshore areas adjacent to developed and undeveloped properties, and areas influenced by wetlands and rivers. In 2004, LOBA's environment committee expanded the sampling of nearshore sites for analysis of phosphorus concentrations. Over the course of the program, numerous "reactive" sites were sampled in response to a specific concern.

The focus of the 2006 monitoring program shifted from investigation of nearshore impacted zones to assessment of general lake health in nearshore and openwater areas of the lake. This report summarizes results of the 2006 monitoring program for bacteria and phosphorus levels.

2. Methods

Volunteers collected samples for analysis of bacteria and total phosphorus concentrations on five occasions during the summer of 2006 (July 3, 17, August 7, 21, and September 1) at 14 sites in Lake of Bays. These included 9 open water sites, 4 nearshore sites, and one developed site in Little Trading Bay (Table 1). The two Little Trading Bay sites (E 20 P/B and E 17 P/B) were not sampled for bacteria on August 21st, and Dwight Bay was not sampled on August 7th. Total phosphorus was not analyzed for Dwight, Gull Rock and Fairview on August 8th, Fairview on July 17th, or Boothby's on September 1st.

The sampling and analytical methods in 2006 are consistent with those used in previous monitoring years and so only a brief description is provided below. More detailed methodology is provided in the 2001 GLL report.

Table 1. Lake of Bays Monitoring Sites from 2006 that have been sampled in the past

ID	Site	Classification	'01	'02	'03	'04	'05	'06
E 1 P/B	Trading Bay	Deep/Open Water		X	X	X	X	X
N 10 P/B	Gull Rocks	Deep/Open Water		X	X	X	X	X
E 13 P/B	Haystack Bay	Deep/Open Water	X	X	X	X		X
N 1 P	Dwight Bay	Deep/Open Water		X	X	X	X	X
B 2 P	Fairview	Deep/Open Water	X	X	X	X	X	X
B 1 P	Bigwin East	Deep/Open Water	X	X	X	X	X	X
B 4 P	Bigwin Bay	Deep/Open Water		X	X	X	X	
E 20 P/B	Little Trading Bay	Deep/Open Water					X	X
E 30 P/B	Ten Mile Bay	Deep/Open Water						X
S 3 P/B	Price's Point	Deep/Open Water					X	X
E 7 P/B	Dorset Community	Disturbed	X	X	X	X	X	
E 15 P/B	Haystack New	Disturbed		X	X	X		
E 17 P/B	Little Trading Bay	Disturbed		X		X	X	X
N 3 P/B	Dwight Beach	Disturbed	X	X	X	X	X	
N 15 B	Beaver Dam	Disturbed	X	X	X	X		
B 3 P/B	Bigwin north	Disturbed		X	X	X	X	
E 16 P	Haystack Old	Disturbed		X	X	X		
E 8 P	Trading Bay West	Disturbed		X	X	X	X	
N 4 P	Boyne East	Disturbed		X	X	X	X	
N 8 P	Rat Bay Lawn	Disturbed		X	X	X		
N 12 P	McDonald Bay	Disturbed		X	X	X	X	
B 5 P	Bigwin West	Disturbed		X	X	X	X	
N 13 P/B	Main	Nearshore Undisturbed	X	X	X	X	X	X
N 24 P/B	Boothby's	Nearshore Undisturbed					X	X
S 1 P/B	Adamson's Island	Nearshore Undisturbed					X	X
S 2 P/B	Menominee Bay	Nearshore Undisturbed					X	X
E 9 P	Trading Bay North	Undisturbed		X	X	X	X	
N 11P	Britannia	Undisturbed		X	X	X	X	
N 6 P/B	Rat Bay Wetland	Wetland	X	X	X	X		
E 18 P/B	Hollow Mouth	River				X	X	
N 2 P/B	Oxtongue	River	X	X		X	X	
N 5 P/B	Dwight Bay South	Reactive				X	X	
N 23 P	Regeneration Site	Reactive			X	X	X	
M1	Bigwin Emergency Site 1	Reactive				X		
M2	Bigwin Emergency Site 2	Reactive				X		
M3	Bigwin Emergency Site 3	Reactive				X		

2.1 Bacteria

The bacterial enumeration methodology is based on the use of "Coliplates" (EBPI). Coliplates are a manufactured product in which 96 cells are inoculated with sampled water, incubated for a 24 hour period and then interpreted for both coliform and *Escherichia coli* (*E. coli)* concentration based on comparison of the colorimetric response of each cell against a Most Probable Numbers chart. The detection limit for the Coliplate methodology is 3 cfu in 100 mL of water. For example, if zero coliplate cells turn colour after incubation, the lowest number of bacteria that can be reported is <3 cfu/100 mL. Gartner Lee Limited has advised that a value of 1 cfu/100 mL was an acceptable entry for coliplate observations with zero coloured cells.

Bacteria levels are assessed relative to the 1994 Ontario Ministry of the Environment's (MOE) Provincial Water Quality Objectives (PWQO) for recreational water use. For total coliform, the PWQO is 1000 counts per 100 ml (based on a geometric mean density for a series of water samples). It should be noted that the MOE recommends that this objective be used as a guideline only, and that bacterial assessments of water quality should be based on more specific fecal bacteria indicators such as *E. coli*. The PWQO for *E. coli* is 100 counts per 100 ml, based on a geometric mean of at least five samples taken from one site within one month. This objective is intended to protect swimming and bathing beaches for recreational use. Where testing indicates sewage or fecal contamination, a site–specific judgment must be made as to the severity of the problem and the appropriate course of action.

2.2 Phosphorus

The method for collection of phosphorus samples is widely used across Muskoka and is supported by GLL, the District Municipality of Muskoka, the Ontario Ministry of Environment (MOE,) and the Muskoka Lakes Association. Surface water samples were filtered onsite using nytex mesh provided by the MOE, then delivered in glass tubes on ice in the dark to the Ministry of Environment Centre in Dorset, Ontario, for analysis of total phosphorus concentration.

Phosphorus concentrations in Lake of Bays are compared to the MOE's Interim PWQO (1994) guidelines, which state that:

1. Average total phosphorus concentrations for the ice-free period should not exceed 20 µg/L to avoid nuisance concentrations of algae in lakes.
2. A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration for the ice-free period of 10 µg/L or less. This should apply to all lakes naturally below this value.
3. Excessive plant growth in rivers and streams should be eliminated at a total phosphorus concentration below 30 µg/L.

2.3 Quality Control (QC)

Three quality control measures were repeated in 2006:

1. The inclusion of a sample of distilled water by one volunteer sampler at one selected site for each sample date for bacterial analysis as a field blank;
2. The inclusion of a field duplicate on at least one sampling date for each site for analysis of bacteria and phosphorus; and
3. Submission of water samples to the Central Ontario Analytical Laboratory (COAL), an accredited laboratory in Orillia, Ontario, for membrane filtration analysis of total coliform and *E. coli* for comparison with the volunteer/Coliplate method. COAL has a reportable range from 0 - >80 cfu/100 mL for potable water samples and <4 – >8 million cfu/100 mL for recreational water samples.

3. Results and Discussion

3.1 Bacteria

Coliform is a group of naturally occurring bacteria that are found in the intestines of warm-blooded animals. The presence of coliform in water potentially indicates the presence of disease-causing (pathogenic) micro-organisms. *E. coli* (*Escherichia coli*) is one of several types of coliform bacteria and is a more specific indicator of fecal contamination. Some strains of *E. coli* are capable of causing disease under certain conditions when the immune system is compromised, or disease may result from environmental exposure. Most strains of *E.coli* will not cause disease symptoms, and live with us as part of our normal microbial population.

There is great variability in total coliform and *E. coli* concentrations that naturally occur in surface waters. Natural sources include waterfowl and wildlife and these bacteria are therefore often concentrated in wetlands and along the shorelines of lakes and rivers. Human waste also contains coliform bacteria that are found in the intestinal tract. Bacterial concentrations that are elevated above natural levels in areas of high human activity may represent the discharge of untreated sewage or grey water to the lake. If not treated properly these bacteria can remain active for a short period of time in surface water, before they are degraded by ultraviolet light and temperature gradients.

On the earliest sampling date (July 3), total coliform concentrations were below 5 cfu/100 mL at all sites with the exception of the two sites located in Little Trading Bay and the nearshore site at Adamson's Island (Figure 1, top). Concentrations generally increased over the summer season, but were maintained

at low levels below 33 cfu/100 mL. The 'developed' site in Little Trading Bay had the highest total coliform concentrations, with a peak concentration of 46 cfu/100 mL on July 3rd. Concentrations declined at this site as well as the 'open water' site in the same bay over the summer season to 11 cfu/100 mL on August 31st.

Unlike previous years, distinct seasonal patterns in *E. coli* concentrations were not apparent in 2006. All values were well below the MOE's Provincial Water Quality Objective (PWQO). The 'developed' Little Trading Bay site had the highest concentration of *E. coli* of all the sites reaching 16 cpu on July 17th. However, this value is still well below the upper limit of 25 cfu/100 mL for locally acceptable water quality that was agreed upon by the Lake of Bays Association.

Discharge from the Hollow Mouth River is a suspected source of bacteria contributing to the relatively higher concentrations of total coliform and *E. coli* observed in Little Trading Bay. This is supported by previous monitoring results from 2004 when total coliforms reached 1,038 cfu/100 mL in early August, exceeding the 1992 PWQO of 1,000 cfu/100 mL[1]. In that same year, *E. coli* concentrations were also elevated with a geometric mean of 62 cfu/100 mL. Additional sampling along the Hollow Mouth River would be required to identify potential bacterial sources to the river, and/or to discriminate human from naturally occurring bacteria sources.

Overall, the geometric mean concentrations of total coliform and *E. coli* were below the PWQO for the summer 2006 season at all of the sampling locations (Figure 2). The bacteria results from 2006 suggest that contamination by bacteria did not pose a significant human health risk with respect to exposure from recreational activity in Lake of Bays.

[1] *PWQO for total coliform (1,000 counts per 100 mL) was established in 1992, but since 1994, the MOE bases compliance and monitoring objectives on E. coli.*

Figure 1. 2006 Trends in Summer Total Coliform (top) and *E. coli* (bottom) Concentration

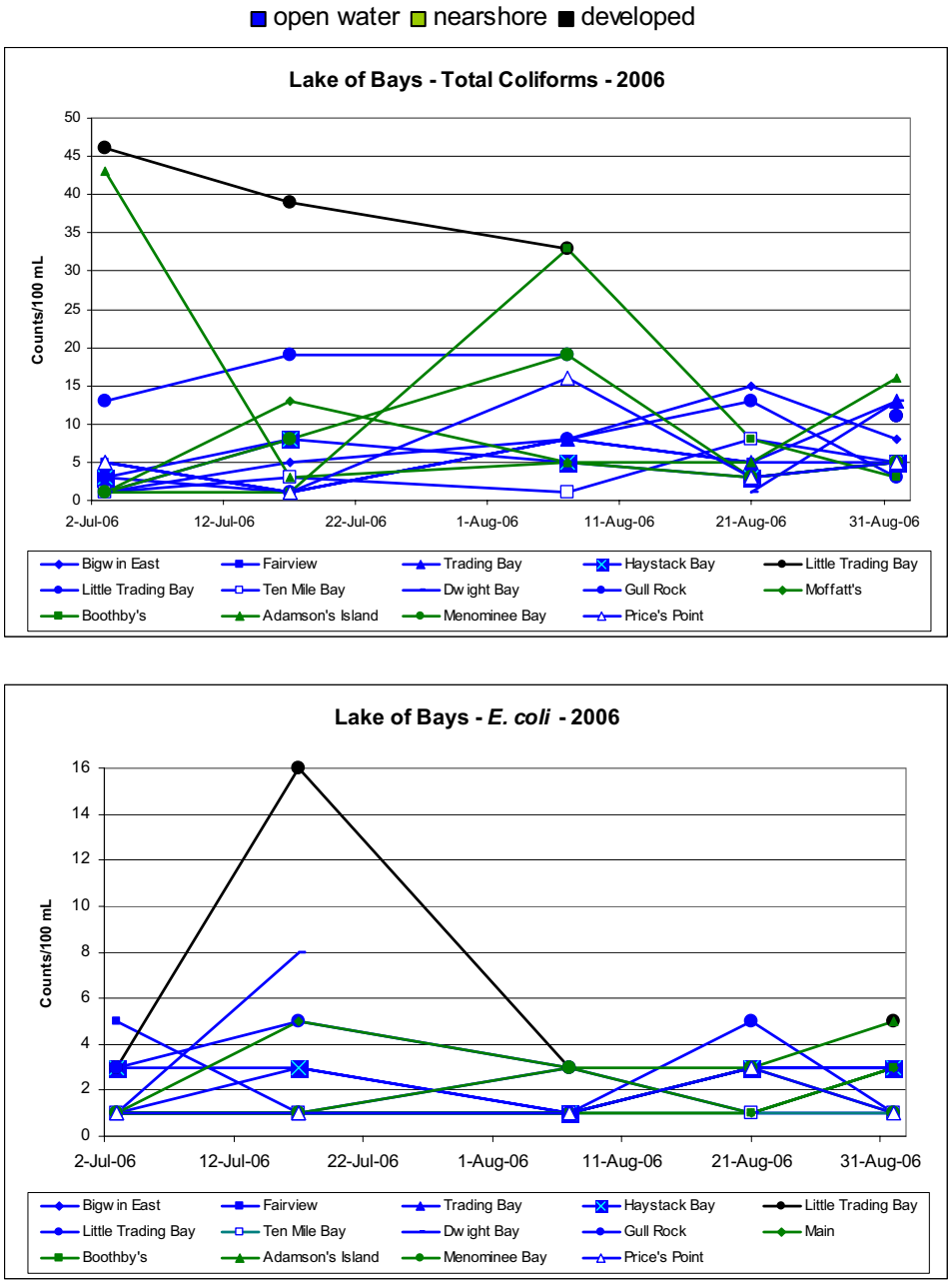
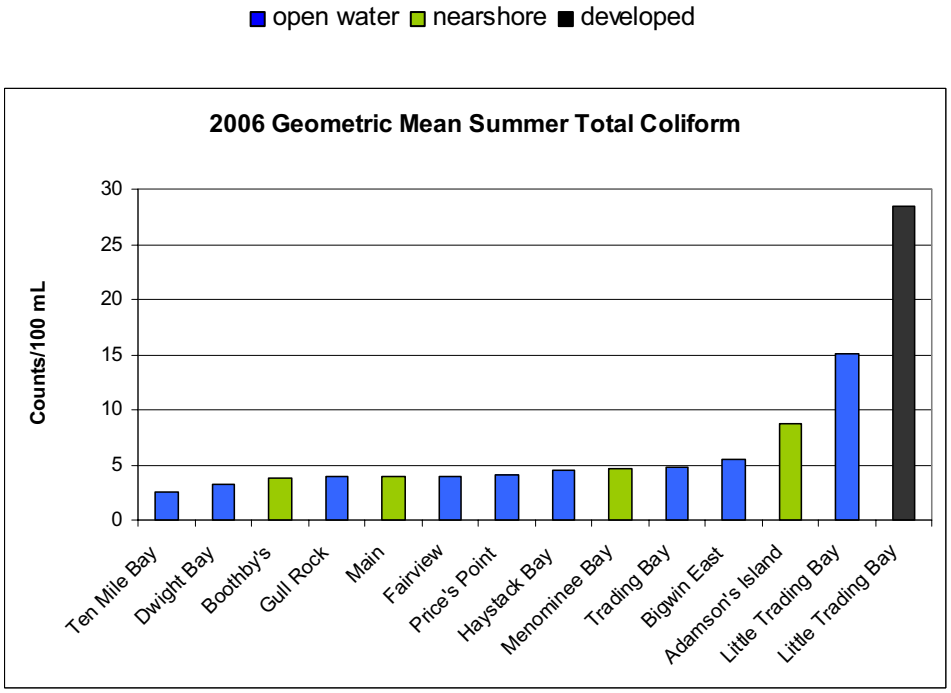
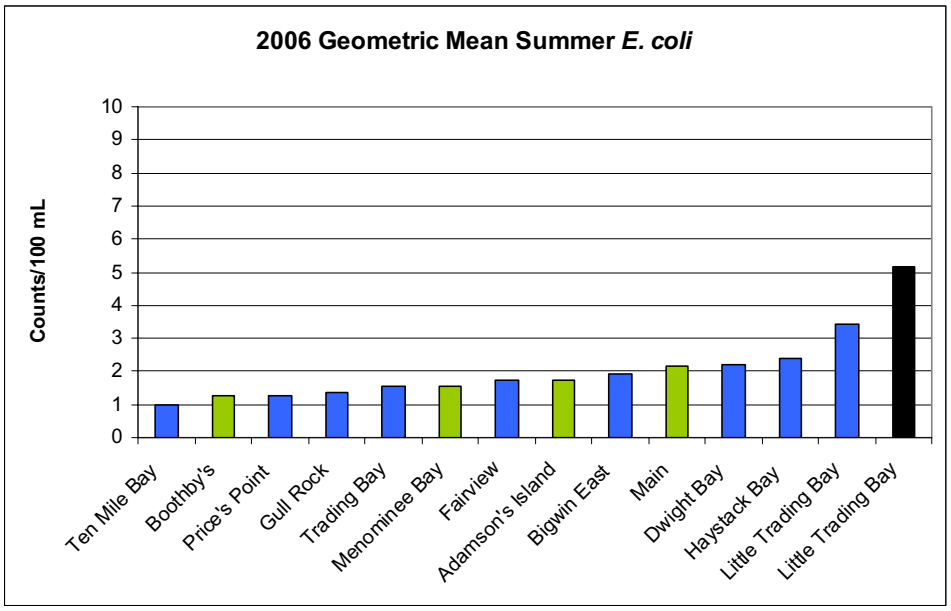


Figure 2. 2006 Geometric Mean Summer Total Coliform and *E. coli* Concentrations



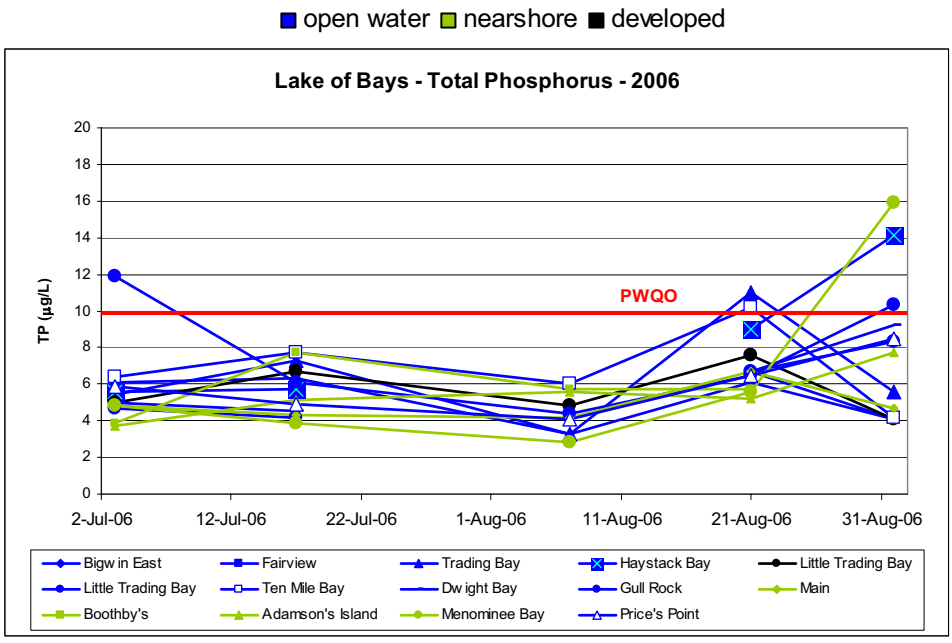


3.2 Total Phosphorus

Phosphorus is a nutrient that limits growth of aquatic plants in most freshwater environments, such that additional phosphorus inputs can lead to increased primary productivity in a process called eutrophication. The total phosphorus (TP) concentration in Lake of Bays, as in most lakes in Muskoka, is considered low. Lakes with low nutrient levels and low productivity are characterized as oligotrophic (i.e., TP concentration <10 µg/L). To date, the primary objective of the Lake of Bays monitoring program has been to determine if phosphorus concentrations are elevated above the "whole lake" levels in the nearshore areas due to land use activities.

The total phosphorus trends for Lake of Bays in 2006 are shown in Figure 3. Values were very consistent and showed little variability beyond what would be described as natural. With the exception of the Little Trading Bay open water site, concentrations were below 8 µg/L until the end of the summer season (August 21 and September 1). We note that a total phosphorus concentration of 40.3 µg/L was obtained on August 8th for Haystack Bay. This value was considered to be an outlier and is not included in Figure 3.

Figure 3. 2006 Trends in Summer Phosphorus Concentrations



3.3 Quality Control (QC)

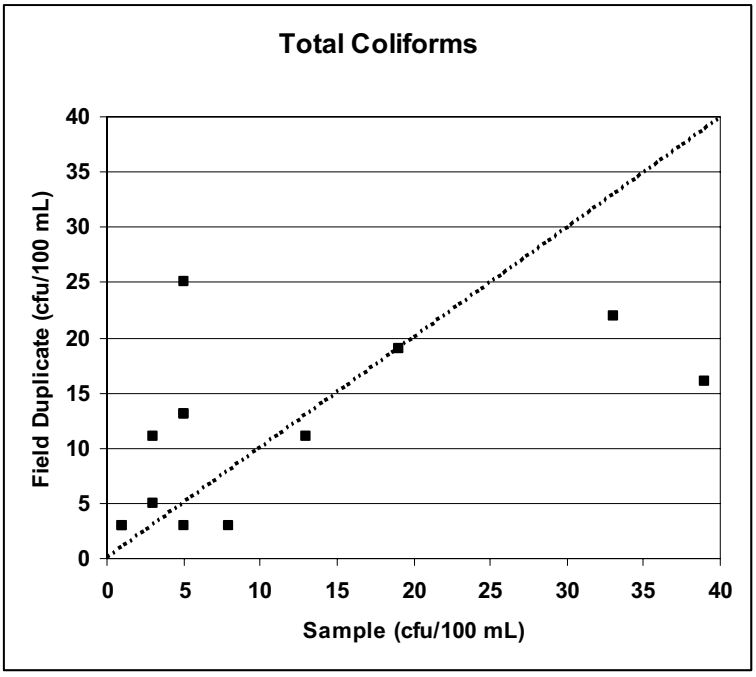
The quality control program in 2006 yielded positive results. As described in the methods section, it included field duplicate samples for bacteria and phosphorus and laboratory duplicate samples of bacteria counts for comparison with Coliplate results.

It is important to recognize that bacteria are organisms and can be present in samples as clumps (groups of organisms). Therefore, the natural variation between samples is expected to be higher for bacteria concentrations compared to concentration of a dissolved component like phosphorus. Despite this expected variability, field duplicates for both total coliform and *E. coli* lie near the 1:1 line thereby providing confidence in the sample results (Figure 4). Similarly, there is a relatively close agreement between Coliplate data with results from Central Ontario Analytical Laboratories (Figure 5). Because most values lie above the 1:1 line, this suggests that the Coliplate method may be consistently underestimating bacterial levels. However, it should be noted that the reported bacterial levels by both the Coliplate and COAL methods are very low.

A total of 10 duplicate water samples were collected for analysis of total phosphorus concentrations. All duplicate results compare well with the exception of results from Dwight Bay collected on September 1st, as illustrated in Figure 6. The greater value of 39.1 mg/L from Dwight Bay is likely an outlier resulting from either laboratory error, or organic material contained in the sample that was not removed during filtration.

Overall, the results of the QC program provide a high degree of confidence in the bacteria and phosphorus sampling protocol and analysis, and QC should continue to be assessed as part of any future monitoring programs.

Figure 4. Total Coliform and *E. coli* Field Duplicate Sample Results



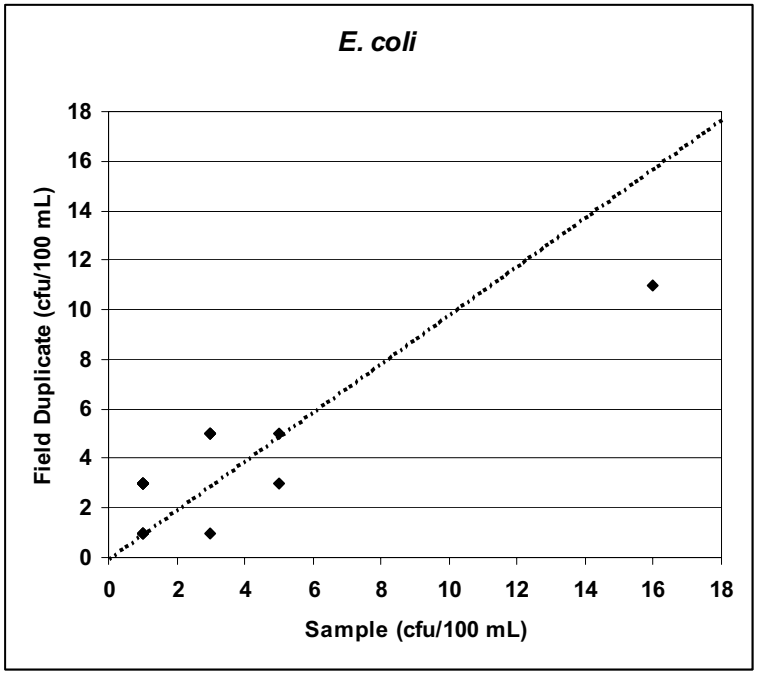
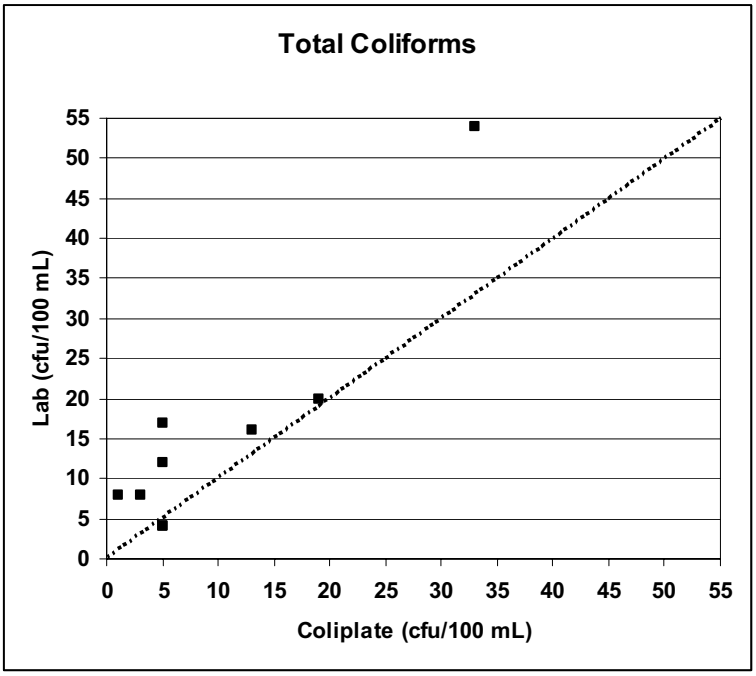


Figure 5. Total Coliform and *E.coli* Laboratory Versus Coliplate Results



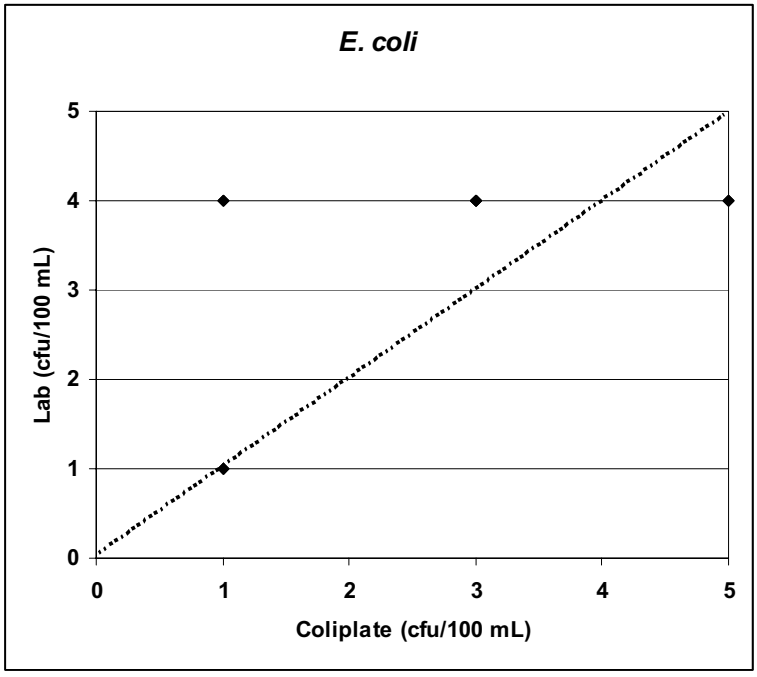
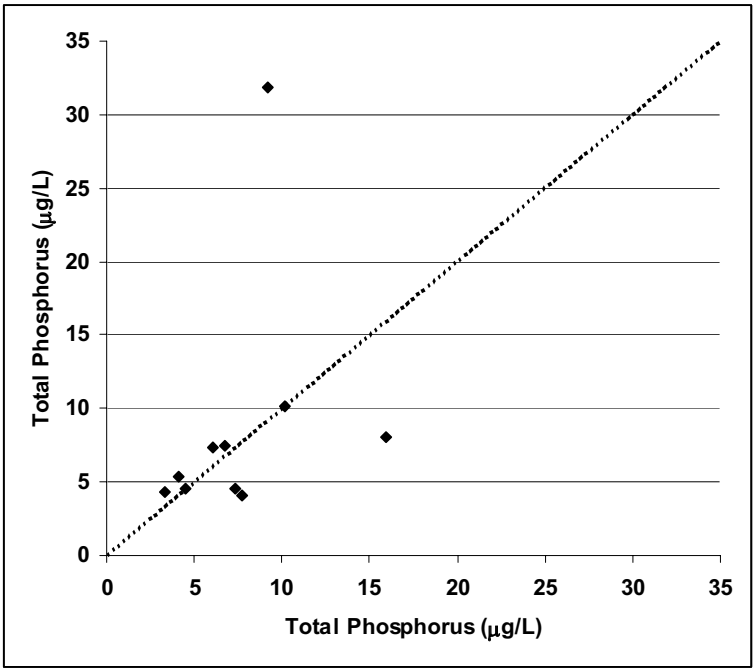


Figure 6. Comparison of Total Phosphorus Duplicate Samples



4. Summary and Recommendations

The volunteers of the Lake of Bays Association water quality program sampled 14 sites in 2006 for bacteria (total coliform and E. coli) and total phosphorus concentration. The sampling occurred on 5 dates between July and September and included deep water (9 sites), developed (1 site), and nearshore undisturbed (4 sites) areas in the lake.

Overall, results showed favourable water quality conditions that are within the Provincial Water Qality Objectives to protect aquatic life and recreational water use.

The nutrient monitoring program (total phosphorus) demonstrated consistent results again in 2006. With the exception of one outlier, the phosphorus values ranged from 2.8 µg/L to 15.9 µg/L with a mean concentration of 6.21 µg/L. Very little difference in phosphorus concentration was observed between the open water and nearshore sites.

The analysis of the data from the quality control program demonstrates that the program is producing repeatable, reliable results. The bacterial analyses yielded excellent comparison between duplicate

samples. Laboratory results were generally higher than Coliplate results for total coliforms, but values for the bacterial parameter were very low, regardless of the analytical method employed.

We make the following recommendations for the 2006 program:

- Given that the Hollow Mouth River is a potential source of elevated bacterial levels in Little Trading By, a more detailed analysis of bacterial levels near the mouth of the Hollow Mouth River is warranted to confirm this potential source and to determine whether bacteria are from fecal or natural river sources.
- An undisturbed nearshore site in the east arm of Lake of Bays should be created and sampled for bacteria and total phosphorus.
- Where possible, sampling for total phosphorus should begin in May to determine concentrations when the lake is fully mixed.
- The Lake of Bays Association should review the historical data and plot the results for each year for any sites that have been sampled continuously. This will provide a good reference for any trends over time and would be useful input to the "Watershed Report Card" of the Muskoka Watershed Council.
- The sampling program should continue to monitor all sites that have been consistently monitored by the program in past years.
- The sampling program should be expanded to include analysis of dissolved oxygen profiles from deep, open water areas that have been routinely monitored in past years. This analysis would provide an evaluation of existing coldwater fish habitat as well as a broader indication of lake health. These data are important to establish 'benchmark' conditions for future studies.
- South Portage Bay could be considered for sampling in 2007 as it has been sampled in the past, has resort and marina development and is relatively isolated from the rest of the north arm of the lake.
- A paleolimnological study that reconstructs past water quality for Lake of Bays would be beneficial to provide an historical context for observed patterns in water quality that have been determined by the LOBA monitoring program. Paleolimnology is a technique that determines past water quality conditions from information contained in lake sediments. This method can be used to determine background and natural variability in lake conditions as well as identify the timing and magnitude of past changes in water quality that predate monitoring data.

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