Hutchinson
Environmental Sciences Ltd.

Lake of Bays Water Quality Report 2023

Prepared for: Lake of Bays Association
Job #: J100013

January 2024

Final Report

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January, 2024 HESL Job #: J100013

Susanne Gossage
Environment Chair
Lake of Bays Association
PO Box 8
Baysville, ON P0B 1A0

Dear Ms. Gossage:

Re: Lake of Bays Water Quality Report 2023

I am pleased to submit this final report for the Lake of Bays Water Quality Monitoring Program presenting the results of total phosphorus and bacteria sampling from the summer of 2023.

As in previous years, total phosphorus and bacteria levels were well below applicable Provincial guidelines indicating excellent water quality in 2023. Statistically significant increases in total phosphorus that have been noted in the past were absent with the addition of the 2023 data. An unprecedented number of bad splits and outliers were recorded in the 2023 data, which may be directly the result of a change in sampling methodology. We recommend the continued training refreshers for volunteers and diligence in the field to reduce sample contamination and that any deviations from the prescribed methodology be discussed with HESL and the Environmental Committee before sampling begins.

I thank you and the Lake of Bays Association for the continued opportunity to assist with this project.

Sincerely,
per: Hutchinson Environmental Sciences Ltd.

Kris Hadley

Kristopher Hadley, Ph.D.
kris.hadley@environmentalsciences.ca

Signatures

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Table of Contents

List of Figures

List of Tables

Appendices

1. Introduction

The Lake of Bays Association (LOBA) has championed a volunteer-based water quality monitoring program in Lake of Bays since the 1970s. The aim of the program is to characterize phosphorus and bacteria levels as an indication of general lake and watershed health and to compare different sites across the lake, while fostering community involvement and education.

LOBA has been monitoring spring turnover phosphorus levels as part of the Ministry of Environment, Conservation and Park's Lake Partner Program but the independent monitoring program began in 1970 to monitor bacteria levels in the lake during the ice-free season. In 1972, LOBA became a MoE Self-Help Program participant collecting Secchi depth measurements and water samples for Chlorophyll *a* analysis. In 1978 the program transitioned to analysing Total Phosphorus. This project was successful, deemed valuable and LOBA expanded the area of study in the summer of 2001 to include near-shore sites adjacent to developed and undeveloped properties, and areas influenced by wetlands and rivers. In 2002, the program was again expanded to include monitoring of total phosphorus concentrations in near-shore areas and in the Hollow and Oxtongue rivers and river deltas (deep water sites were already being monitored). Site selection has changed as our understanding of water quality conditions in Lake of Bays has increased and, since 2009, sampling has focused on deep water sites, nearshore disturbed and undisturbed locations, and inflowing rivers. In 2020, the Covid-19 pandemic suspended the data collection program, however the program was able to return to operation in 2021.

In July 2020 an algae bloom was reported and confirmed by the MECP on Ten Mile Bay. Water quality in Ten Mile Bay does not suggest changes in phosphorus concentrations have occurred in Ten Mile Bay, however we are lacking data from 2020 to confirm the conditions during or prior to the bloom. Following the report of the blooms, HESL and LOBA coordinated to gather additional information beyond the MECP sampling, however the bloom could not be located by LOBA residents and therefore may have been a small-scale localized bloom that quickly dissipated. To our knowledge no blooms on Lake of Bays were reported in 2023.

The LOBA monitoring program continues to focus on total phosphorus concentrations. For recreational lakes on the Precambrian Shield like Lake of Bays, water quality concerns are most often associated with nutrient enrichment due to increased human phosphorus sources. Phosphorus is a natural element in the environment and enters lakes from the atmosphere through precipitation, from streams and overland flow, and to a lesser degree through groundwater. Human sources to recreational lakes include storm water runoff and erosion from altered land uses, fertilizers on manicured lawns and faulty septic systems. Increases in phosphorus loads to lakes from human sources can result in increased growth of aquatic plants and algae, which in turn can lead to a deterioration of water clarity and coldwater fish habitat through a decrease in deep-water oxygen concentrations.

Previous monitoring reports have suggested that a reduction in bacteria sampling frequency was warranted; beginning in 2016, it was recommended that bacteria sampling be conducted only in the mid-summer each year at the nearshore sites. Every five years the collection of bacteria samples on all sampling dates was recommended. The reduced sampling frequency will continue to allow for the assessment of long-term trends while maintaining familiarity with bacteria sampling techniques. In 2023, bacteria were sampled on

August 7th; 2018 was the last time bacteria was sampled at all sites and therefore the next occasion is tentatively scheduled for 2024.

The program continues to demonstrate that Lake of Bays is a clear water lake with low phosphorus and bacteria levels with no obvious impact of development on water quality. In this report we present the results of the summer phosphorus monitoring completed by the LOBA in 2023 and discuss them in the context of long-term water quality data collected by the LOBA and local precipitation records.

2. Methods

Volunteers, coordinated by the LOBA Environment Committee, collected samples for analysis of total phosphorus on three occasions during the summer of 2023 (July 3, August 7 and 27) and on August 7 for bacteria (*E. coli* and total coliforms). The sampling and analytical methods in 2023 were consistent with those used in previous monitoring years and are summarized below. Detailed sampling instructions that are provided to the volunteers are presented in Appendix A.

2.1 Sample Collection

Water samples for bacteria and total phosphorus were collected at 23 sites in Lake of Bays to include deep, open water locations ('Deep Water' sites, n=9), nearshore sites adjacent to developed areas ('Disturbed' sites, n=5),undeveloped shorelines ('Nearshore Undisturbed' sites, n=5), and both river (Oxtongue and Hollow rivers) and river-influenced (Oxtongue Delta) sites ('River' sites, n=4) (Table 1, Figure 1).

At each Deep Water site, a composite water sample was collected from the euphotic zone, at approximately two times the Secchi depth. At all other sites, the water sample was collected at a depth of ~30 cm. Three field duplicate samples for bacteria were collected in 2023. Seventeen field duplicate samples for total phosphorus were collected to assess the variability of results related to sampling and analytical procedures (Table 1).

Phosphorus samples were coarse-filtered using a filtered syringe in order to remove zooplankton (microscopic animals living in the water, such as water fleas) or other large debris that can contaminate the sample and result in non-representative, high phosphorus values (Clark et al., 2010). Samples were then directly poured into sampling containers with acid preservative, stored in a cool place and submitted for analysis to ALS Environmental Laboratory.

Table 1. 2023 Sampling Sites and Dates

Site Name	Total Phosphorus Sampling			Bacteria Sampling
	03-Jul	07-Aug	27-Aug	07-Aug
Deep Water Sites				
Bigwin East	2	1	1	1
Dwight Bay	1	1	1	1
Fairview	2	1	1	1
Gull Rock	1	1	1	1
Haystack Bay	1	1	2	1
Portage Bay	1	2	2	1
Price Point	1	1	1	1
Ten Mile Bay	1	2	1	1
Trading Bay	1	2	1	2
Disturbed Sites				
Bigwin Bay	1	1	1	1
Bigwin North	1	1	1	1
Britannia	2	1	2	1
Dwight Beach	1	1	2	1
Portage Bay Docks	1	1	2	1
Nearshore Undisturbed				
Langmaid Island	1	1	1	1
Boothby's	1	1	2	1
Menominee Bay	1	1	2	1
Hemlock Ridge Road	1	1	1	1
Narrows West	1	2	1	2
River Sites				
Hollow River Lagoon	1	1	2	2
Hollow River mouth	2	1	1	1
Oxtongue Delta	1	1	1	1
Oxtongue River mouth*	1	2	1	1

Notes: 1 = single sample collected, 2 = field duplicate samples collected, - = No Sample *Sampled in the mouth of the rivers just upstream of their discharge to the lake.

Sampling Stations
Watercourses
Waterbodies

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0 1 2 4 km

Scale = 1:125,000

N

Project #:	100013	Projection:	UTM Zone 17N
Drafted:	K. Hadley	Datum:	NAD 1983
Reviewed:	K. Hadley	Date:	Jan 9, 2023

Figure 1

Lake of Bays Sampling Stations

2.2 Quality Control

2.2.1 Bacteria

Three field duplicate bacteria concentrations were collected and compared to assess variability in the results due to sampling and analysis by the Coliplate method.

2.2.2 Total Phosphorus

2.2.2.1 Field Duplicates

Duplicate samples were collected for 17 of the 78 samples. Bad splits in the LOBA dataset were identified for duplicate samples that were >35% different or had an absolute difference of >5 μg/L (Hyatt et al., 2012). If a bad split was identified, the higher of the two values was discarded.

2.2.2.2 Outliers

In relatively small datasets like the LOBA dataset, the calculation of average total phosphorus concentration is sensitive to outliers, that is, extreme values that are not representative of the site condition. Rosner's ESD Many-Outlier Procedure (Rosner's Test; Rosner, 1983) was performed in the R statistical Software Environment V. 3.3.3, using the "rosnerTest" function of the "EnvStats" package (Millard, 2013), to identify outliers in total phosphorus concentrations collected since 2002 for each LOBA monitoring site. This procedure detects high and low extreme values and is not limited for multiple outliers.

Statistically significant outliers (at $p<0.05$) were removed from the dataset for further analyses (as detailed in Section 3.1.3) but will be re-evaluated each year as additional data are collected, as outliers may, over time, indicate a change to representative conditions.

2.2.2.3 Detection Limits

Laboratory detection limits changed in 2018 (0.1 to 3 μg/L) as the result of an unavoidable laboratory change from Trent University at the Dorset Environmental Science Centre to ALS Environmental. In 2022 detection limits were 3.0 μg/L in July but improved to 2.0 μg/L during sampling in August. A detection limit of 2.0 μg/L was maintained during the 2023 sampling season. Values below detection were substituted with the full detection limit to make the most conservative estimate of total phosphorus concentrations in the samples collected. In 2022, 36 of the 85 (42%) samples collected were below the detection limit.

2.3 Data Analysis

2.3.1 Bacteria

Bacteria (*E. coli* and total coliform) levels were compared to the Provincial Water Quality Objectives (PWQO) for recreational water use (MOEE, 1994). The former benchmark for total coliform was 1,000 colony forming units (cfu) per 100 mL, based on a geometric mean for a series of water samples and is intended as a general guideline. Bacterial assessment of water quality should be based on more specific fecal bacteria indicators such as *E. coli*. The PWQO for *E. coli* is 100 cfu per 100 mL, based on a geometric mean of at least five samples taken from one site within one month. 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. This type of assessment is not possible under the current program design.

2.3.2 Total Phosphorus

Mean total phosphorus concentrations were calculated for each site and site type for the 2023 monitoring period following the assessment of bad splits between duplicate samples and outliers.

Total phosphorus (TP) results were evaluated against the interim PWQO for phosphorus, which suggests average ice-free period TP concentrations should not exceed 20 μg/L in order to avoid nuisance algal growth and that maintaining TP concentrations at or below 10 μg/L provides protection against aesthetic deterioration (MOE 1994). Furthermore, excessive macrophyte growth in rivers and streams should be reduced below 30 μg/L of TP (MOEE, 1994).

Mann Kendall Trend analysis was performed using the “mk.test” and “sens.slope” functions of the “Trend” package in R (Pohlert, 2017) to assess any long-term changes in total phosphorus concentrations over time (2002-2023) for each site.

3. 2023 Monitoring Results

3.1 Quality Control

3.1.1 Bacteria

The quality control program of the Coliplate samples in 2023 provided a high degree of confidence in the sampling protocols and analyses for bacteria (Figure 2). The maximum differences between bacteria duplicates using the Coliplate method was 5 cfu/100 mL for *E. coli* and 10 cfu/100 mL for total coliforms. Pairwise testing of the Coliplate duplicate samples showed no significant difference ($p<0.05$).

3.1.2 Total Phosphorus

3.1.2.1 Field Duplicates

In 2023, 9 of the 17 field duplicates (53%) collected were bad splits (i.e., >5 μg/L difference or >35% difference between sample pairs) (Figure 3; Table 2). By contrast, the average annual proportion of bad splits in samples since 2005, when duplicate sampling began, is 18%. The increased occurrence of bad splits in 2022 and 2023 may be the result of sample contamination during collection or changes in methodology made prior to sampling. Two additional field duplicates were detected as bad splits however as they were near the detection limit (2 μg/L) where measurement error at the lab would be expected to increase, they were retained in the dataset. Continued diligent compliance to and review of sampling protocols are necessary to ensure the integrity of the data.

Figure 2. Comparison of field duplicate results for total coliform and *E. coli*, 2023

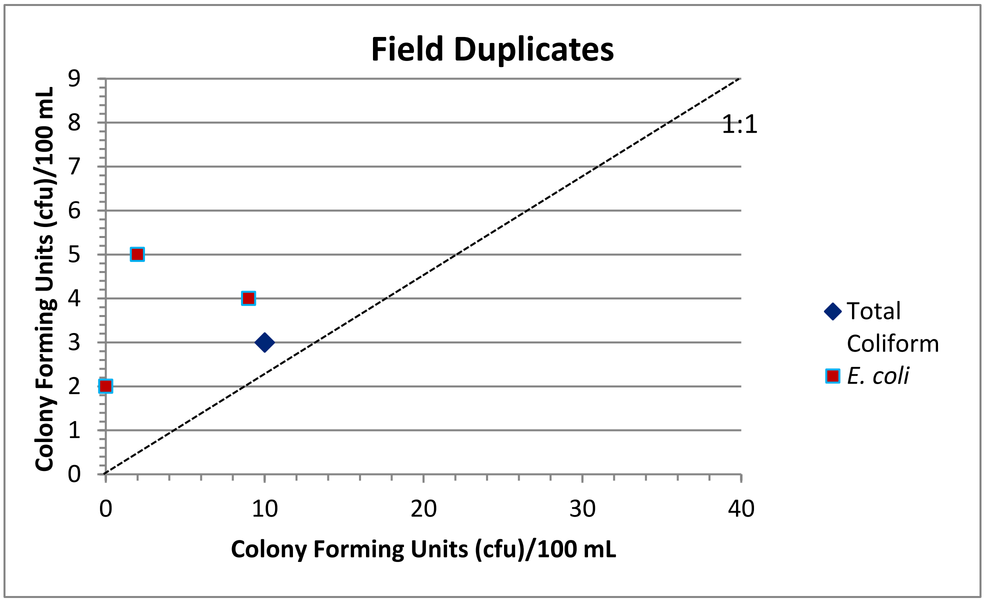


Figure 3. Total phosphorus field duplicates in Lake of Bays, 2023.

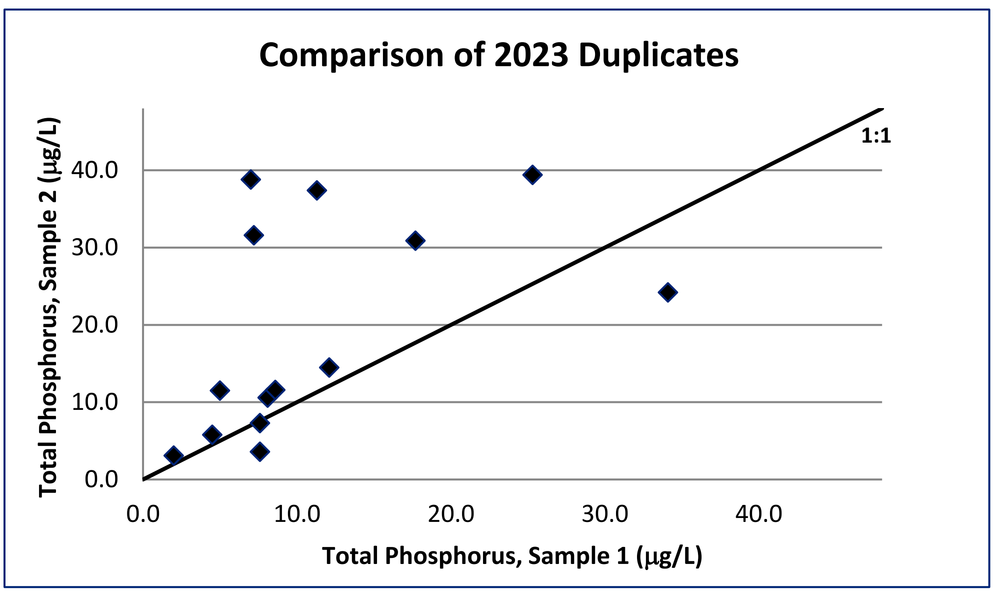


Table 2. Summary of Bad Splits between Total Phosphorus Field Duplicates in Lake of Bays, 2005-2023.

Site Name	Date	TP 1 (µg/L)	TP2 (µg/L)
Langmaid Island	1-Sep-06	7.7	4.1
	1-Sep-17	11.2	4.6
	4-Jul-22	3	19.6
Bigwin Bay	5-Jul-21	4.4	3
Bigwin East	20-Jul-14	6	9.5
	1-Aug-22	2	6.1
Bigwin North	2-Sep-11	5.9	3.7
	4-Sep-15	4.5	8.7
	4-Aug-15	19.3	4
	14-Aug-16	5.9	3.5
	5-Jul-21	10.1	6.5
	4-Jul-22	3	21.4
Boothby's	20-Jul-15	4.1	7.4
	1-Jul-16	8.7	3.3
	26-Aug-22	2	3.7
	27-Aug-23	7	38.8
Britannia	1-Aug-16	3.9	5.9
	4-Jul-22	13.8	5.6
	3-Jul-23	5	11.5
	27-Aug-23	25.3	39.4
Dwight Bay	1-Sep-06	9.2	31.9
	4-Sep-15	7	4.4
	20-Jul-15	4.3	8.3
	14-Aug-16	11.2	7.3
	26-Aug-22	31.4	15.5
Dwight Beach	1-Aug-22	3.1	2
Fairview	7-Aug-06	4.3	7.5
	14-Aug-16	3.7	10.2
Gull Rock	29-Jun-14	5.5	9
	5-Aug-19	4.1	11.1

Haystack Bay	26-Aug-22	3	2
Hollow River Lagoon	27-Aug-23	7.2	31.6
Menominee Bay	1-Sep-06	15.9	8.1
	1-Jul-16	4.8	3.1
	26-Aug-22	2	3.8
Hemlock Ridge Road	4-Jul-05	5.7	4
	7-Sep-10	5.1	3.3
	18-Aug-13	4.1	6.1
	28-Aug-14	4.4	6.9
	23-Aug-15	3.9	1.8
	5-Aug-19	7.6	3.4
	5-Jul-21	5.8	3
	1-Aug-22	4.3	6.7
Narrows West	23-Jul-07	8.2	4.1
	18-Jul-16	12.3	5.9
	21-Aug-17	6.1	29.5
	3-Jul-17	6.2	12.7
	30-Aug-19	4.5	3
	7-Aug-23	34.1	24.2
Oxtongue Delta	30-Aug-19	16	3.8
	1-Aug-22	5.3	15.8
Oxtongue mouth	7-Aug-23	17.7	30.9
Portage Bay	27-Aug-23	2	3.1
	7-Aug-23	7.6	3.6
Portage Bay docks	30-Aug-19	20.7	3
	26-Aug-22	4.9	2
Price's Point	1-Aug-16	6.2	3.9
	23-Jul-17	5.4	8.5
Ten Mile Bay	14-Jul-08	4.7	6.9
	7-Sep-10	6.1	12.9
Trading Bay	17-Jul-06	7.3	4.5
	21-Aug-17	11.1	6.1
	1-Aug-22	4.9	2

Note: Values in grey shaded cells were considered to be contaminated and were excluded from further analyses.

3.1.3 Outliers

A total of 67 samples were identified as outliers in the LOBA dataset (excluding River sites) using the Rosner's Test, 27 of which occurred in the 2023 monitoring year (Table 3). Bad splits (Section 3.1.2) were frequent in 2023 suggesting potential contamination issues when sampling. Ongoing training of sample volunteers and diligence in the field to ensure sample integrity is recommended. We also recommend returning to the ALS sampling equipment provided with the sampling bottles as this method appear to significantly reduce potential for contamination in phosphorus samples. Precipitation was also relatively high in 2023 compared to the past 5 years which may account for some of the elevated concentrations of phosphorus in 2023, however we were informed that the sampling methodology was altered in 2023, specifically changing the equipment setup used for filtering. Given the extreme results observed in 2023 it is likely that altering the methods of sampling contributed to the unusual results. Future sampling in 2024 and beyond will be needed to determine if the 2023 results should be retained in the dataset or removed entirely. Outliers were removed from all analyses in this report but will be reassessed each year as additional data are added to the dataset.

Table 3. Outliers in the LOBA Dataset (2002-2023), Rosner's Test (*p* <0.01)

Lake	Date	Total Phosphorus (µg/L)
Langmaid Island	18-Jul-11	15.1
	31-Aug-12	7.9
	18-Aug-13	9.9
	18-Jul-16	8.9
	7-Aug-23	28.2
Bigwin Bay	15-Jul-02	9.6
	20-Jul-14	10.1
	4-Aug-15	12.0
	27-Aug-23	10.3
Bigwin East	7-Aug-23	10.7
Bigwin North	23-Aug-04	27.7
	6-Aug-07	97.7
	3-Jul-23	64.9
Britannia	1-Sep-03	12.6
	1-Sep-05	9.4
	18-Aug-13	21.6
	28-Aug-13	13.3
	7-Aug-23	22.0
	27-Aug-23	25.3
Dwight Bay	23-Jul-17	15.5
	1-Sep-17	15.4

Fairview	31-Aug-07	12.5
	17-Jul-09	12.3
	23-Jul-17	10.4
	4-Jul-22	33.4
	7-Aug-23	36.3
	27-Aug-23	38.2
Gull Rock	14-Jul-03	16.9
	3-Jul-23	10.9
Haystack Bay	6-Sep-04	74.0
	7-Aug-06	40.3
	1-Sep-06	14.1
	17-Jul-09	57.7
	31-Aug-12	22.4
	28-Jun-15	14.6
	4-Sep-15	15.7
	3-Jul-23	15.5
Menominee Bay	4-Jul-05	11.0
	1-Sep-16	12.0
	3-Jul-23	11.0
Hemlock Ridge Road	5-Aug-02	36.7
	6-Aug-07	15.1
	5-Aug-13	11.4
	18-Jul-16	17.2
	4-Jul-22	13.5
	7-Aug-23	11.6
	27-Aug-23	15.6
Narrows West	4-Jul-11	11.4
	3-Jul-23	45.7
	7-Aug-23	24.2
	27-Aug-23	10.6
Price's Point	2-Aug-10	12.7
	18-Jul-11	12.8
	2-Jul-18	102.0
	6-Aug-18	12.3
	1-Jul-19	12.1
	4-Jul-22	21.6
	3-Jul-23	30.2
	7-Aug-23	11.9

Ten Mile Bay	18-Jul-16	15.0
	3-Jul-23	12.1
Trading Bay	19-Aug-02	17.7
	19-Jul-04	12.3
	1-Sep-16	15.8
	5-Aug-19	19.5
	3-Jul-23	30.2
	27-Aug-23	27.2

3.2 Bacteria

E.coli counts in Lake of Bays on August 7th were low (0-5 cfu/100 mL) at all Deep Water sites (Table 4). Higher total coliform counts have typically been observed in the river-influenced and nearshore sites and have been attributed to increased exposure to bacteria sources from wildlife and human activity, lower dilution and less time for assimilation or attenuation in comparison to the offshore Deep Water sites. The highest bacteria count in 2023 was recorded at Portage Bay docks (10 cfu/100ml). Absolute bacteria counts were below the PWQO of 100 cfu/100 mL for *E. coli* and benchmark value of 1,000 cfu/100 mL for total coliform at all sampling sites (Table 4).

Table 4. Summer E. coli and Total Coliform Concentration in Surface Water Collected by Coliplate Technique, 2023

Site	*E. coli* (cfu/100 mL)	Total Coliform (cfu/100 mL)
Deep water		
Bigwin East	2	13
Dwight Bay	5	14
Fairview	1	15
Gull Rock	2	25
Haystack Bay	0	4
Price Point	0	2
Ten Mile Bay	3	6
Trading Bay	1	7
Portage Bay	2	36
Disturbed		
Bigwin Bay	1	27
Bigwin North	1	8
Britannia	5	11
Dwight Beach	0	16
Portage Bay Docks	10	21
Nearshore Undisturbed		
Langmaid Island	2	6
Boothby's	3	35
Menominee Bay	1	3
Hemlock Ridge Road	0	6
Narrows West	4	34
River		
Hollow River Lagoon	7	31
Hollow River Mouth	3	21
Oxtongue Delta	0	2
Oxtongue River	7	18

3.3 2023 Total Phosphorus Concentrations

Samples collected during the 2023 monitoring campaign were characterized by low phosphorus concentrations typical in oligotrophic, clear-water lakes on the Precambrian Shield. The summer total phosphorus concentrations of the Deep Water, Disturbed, Nearshore Undisturbed and River sites ranged from 2.0 to 22.8 µg/L, with an overall mean concentration of 7.2 µg/L (Table 5). Mean annual phosphorus concentrations for Deep Water (6.2 µg/L), Disturbed (6.8 µg/L), Nearshore Undisturbed (6.2 µg/L) groups were similar. River sampling sites were more phosphorus-enriched (mean TP = 11.0 µg/L), as would be expected given the higher concentrations of particulate matter and dissolved organic carbon typical in rivers.

Mean summer total phosphorus concentration was less than the interim PWQO for phosphorus of 10 µg/L for all sites, with the exception of a single measurement at Fairview in early July, suggesting a low risk of aesthetic deterioration due to nuisance aquatic plant growth (MOEE, 1994). These values are similar to mean spring overturn concentrations of 4.6-6.6 µg/L measured in seven locations in Lake of Bays by the District of Muskoka's Program, which targets only deep-water sites, however DMM data are only posted for 2021 but will be updated to include additional data in future reports. (http://www.muskokawaterweb.ca/lake-data/muskoka-data/lake-data-sheets/lake-of-bays).

Total phosphorus concentrations at the Deep Water, and Nearshore Undisturbed sites remained stable at most sampling locations throughout the summer (e.g., Figure 4, Figure 5, Figure 8), phosphorus concentrations at Fairview were elevated in July (13.3 µg/L), however both August samples were identified as outliers in the dataset (36.3 and 38.2 µg/L). Given the Quality Assurance/Quality Control (QA/QC) issues with the data collected in 2023 it is difficult to determine if these concentrations represent a concerning increase in phosphorus concentrations or are the result of contamination due to deviations from the sampling methodology provided by ALS Environmental. Sampling in 2024 will be critical to assess unusual results collected in 2023 and we highly recommend strict adherence to the ALS sampling equipment protocols. We found no consistent pattern in total phosphorus concentrations for Disturbed or River sites (Figure 6, Figure 7, Figure 8). Elevated phosphorus concentrations on August 7th at the River stations (Figure 8) are likely the result on ~36.9 mm of precipitation that fell in the 4 days prior to sampling.

There was no significant difference (Mann-Whitney test; p >0.05) in phosphorus concentration between the Nearshore Undisturbed (mean TP = 6.1 µg/L) and Disturbed (mean TP = 6.5 µg/L) sites suggesting that shoreline disturbance has had little impact on summer phosphorus concentrations.

Table 5. Total Phosphorus Concentrations (µg/L) in Lake of Bays, 2023

Site ID	Site Name	3-Jul	7-Aug	27-Aug	AVG	SD
Deep water (mean)		**7.6**	**5.8**	**5.2**	**6.2**	**1.2**
B1	Bigwin East	5.2		6.3	5.7	0.8
N1	Dwight Bay	6.2	5.9	4.6	5.6	0.9
B2	Fairview	13.3			13.3	
N10	Gull Rock		5.6	2.7	4.2	2.1
E13	Haystack Bay		5.0	9.4	7.2	3.1
N26	Portage Bay	5.8	3.6	2.6	4.0	1.7
S3	Price Point			2.0	2.0	
E30	Ten Mile Bay		7.4	9.2	8.3	1.3
E1	Trading Bay		7.5		7.5	
Disturbed (mean)		**7.3**	**5.5**	**6.8**	**6.5**	**0.9**
B3	Bigwin Bay	6.7	3.3		5.0	2.4
B4	Bigwin North		7.4	6.5	7.0	0.6
N11	Britannia	5.0			5.0	
	Dwight Beach	7.0	8.3	11.3	8.9	2.2
	Portage Bay Docks	10.3	3.1	2.7	5.4	4.3
Nearshore Undisturbed (mean)		**5.7**	**6.6**	**6.2**	**6.1**	**0.4**
S1	Langmaid Island	4.8		4.0	4.4	0.6

N24	Boothby's	6.8	4.7	7.0	6.2	1.3
S2	Menominee Bay		8.4	7.5	7.9	0.7
N13	Hemlock Ridge Road	5.4			5.4	
E26	Narrows West					
River (mean)		**10.1**	**15.9**	**11.0**	**12.3**	**3.1**
E18	Hollow River Lagoon	5.3	22.8	7.2	11.8	9.6
	Hollow River Mouth	10.1	7.3		8.7	2.0
N2	Oxtongue Delta	10.0			10.0	
N30	Oxtongue Mouth	15.0	17.7	14.8	15.8	1.6
				All sites	7.2	2.2
				All sites excluding River sites	6.3	1.1

An additional site at Portage Bay (i.e., N26 – Portage Bay), initially sampled in 2012 to address concerns over potential water quality degradation following construction activities, has been maintained as a part of the LOBA sampling program. Mean total phosphorus concentration in Portage Bay have declined from 8.1 µg/L to 3.0 µg/L from 2013 to 2021 and remained low in 2023 (4.0 µg/L) representing a consistent and sustained decline from elevated concentrations observed in 2012 (mean TP = 9.6 µg/L) that were coincident with construction activities. Based on these results, ongoing sampling at Portage Bay to monitor long-term construction effects appears unnecessary. Ongoing sampling at the Portage Bay site will be discussed with the LOBA to determine if there is an interest or benefit in maintaining the sampling station.

Figure 4. Total phosphorus concentrations in Lake of Bays 2023, Deep Water sites.

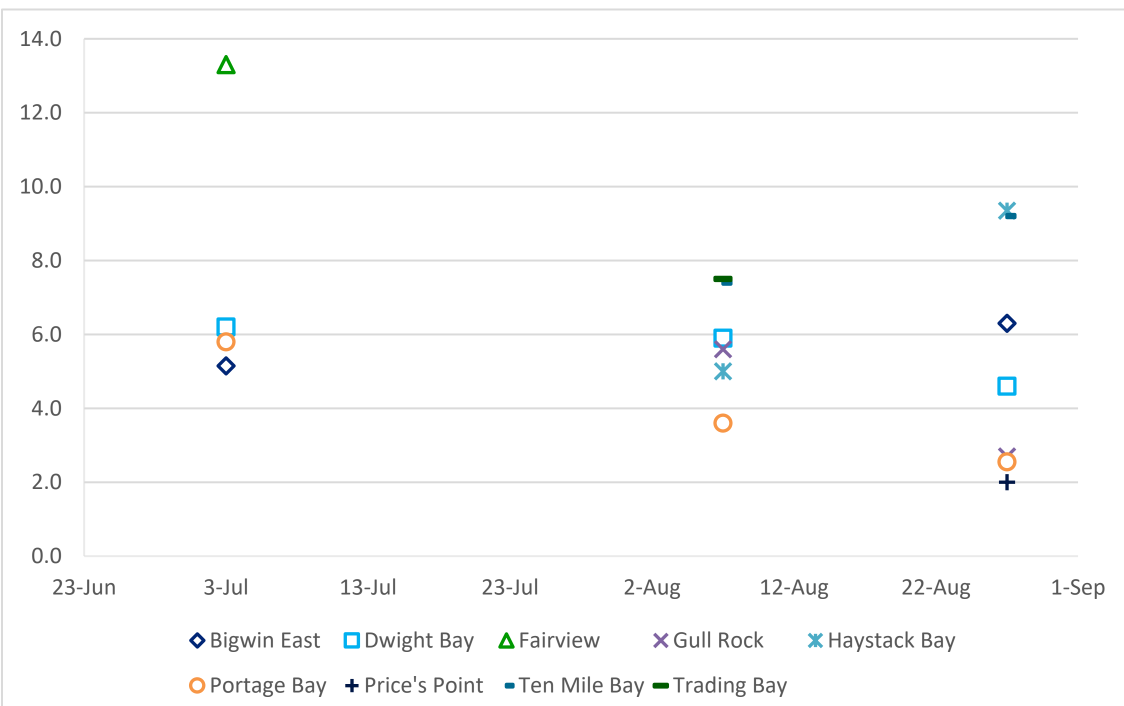


Figure 5. Total phosphorus concentrations in Lake of Bays 2023, Nearshore Undisturbed sites.

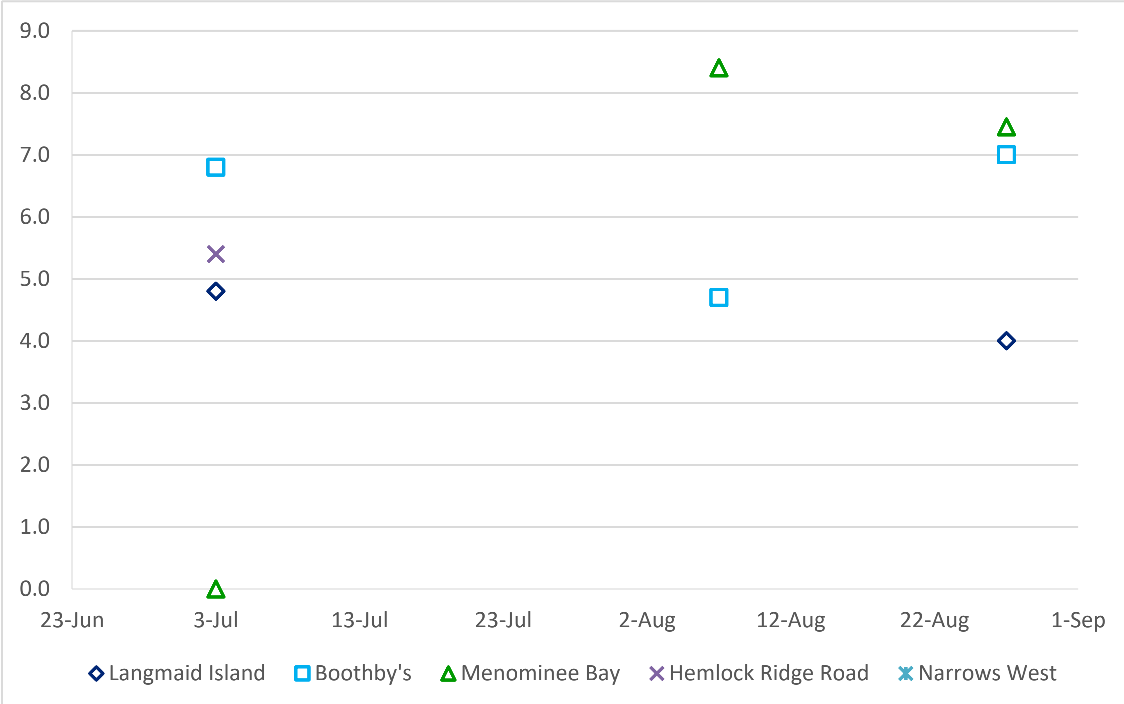


Figure 6. Total phosphorus concentrations in Lake of Bays 2023, Disturbed sites.

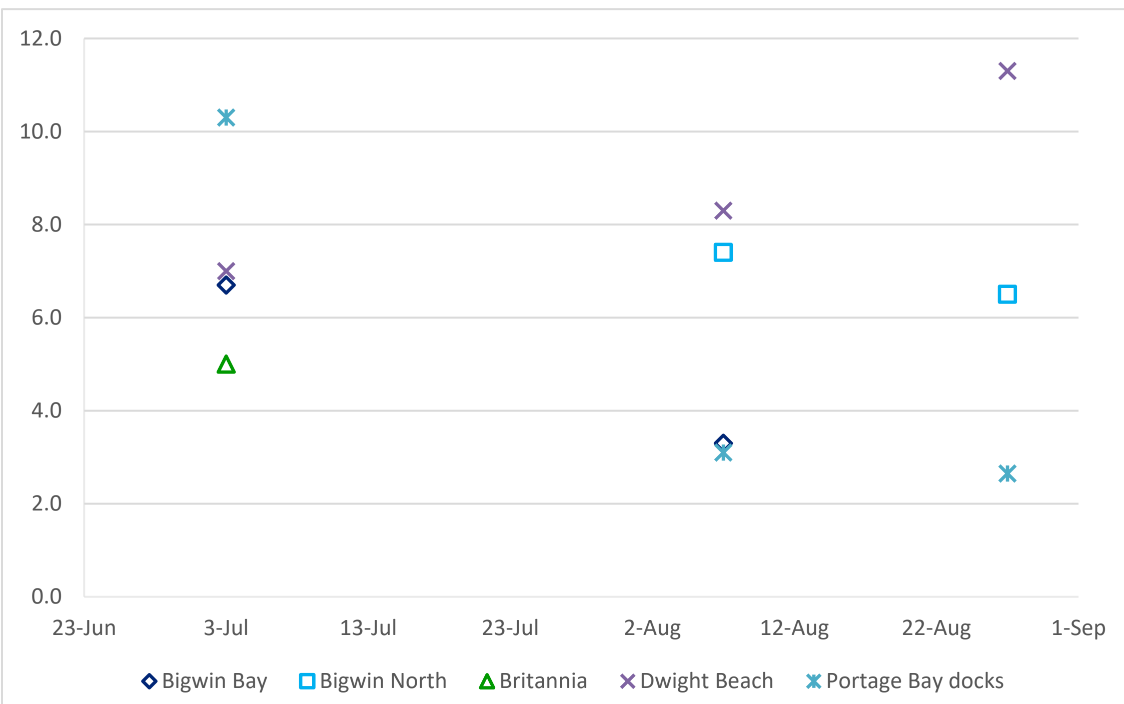


Figure 7. Total phosphorus concentrations in Lake of Bays 2023, River sites.

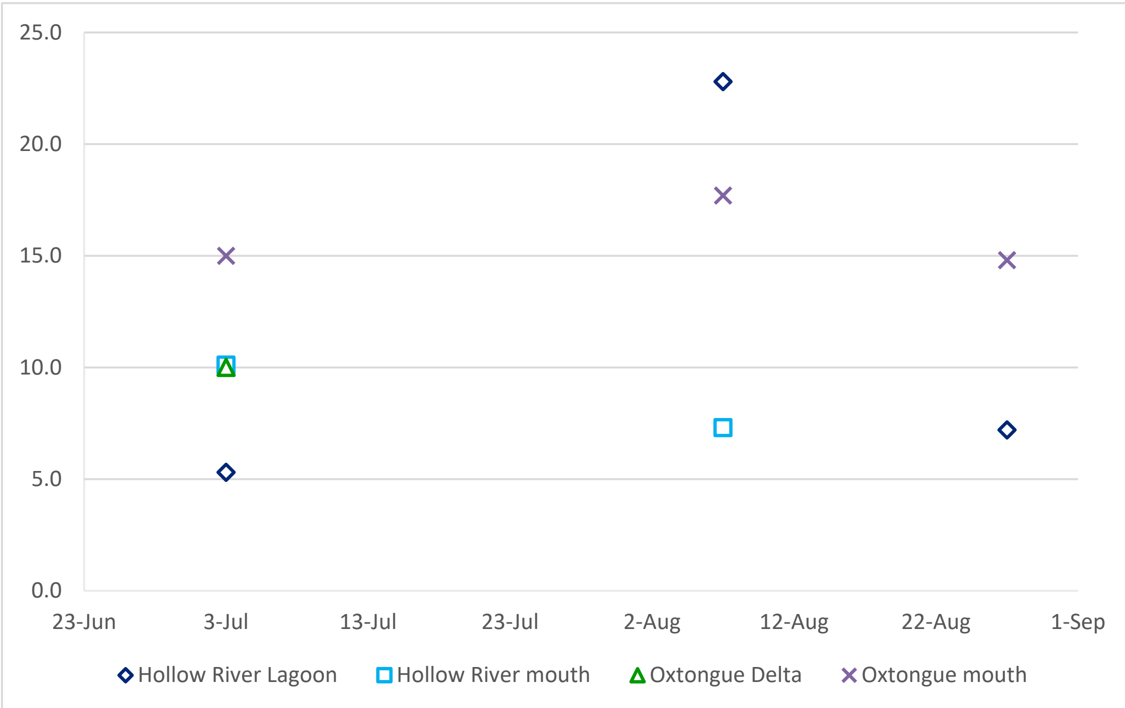
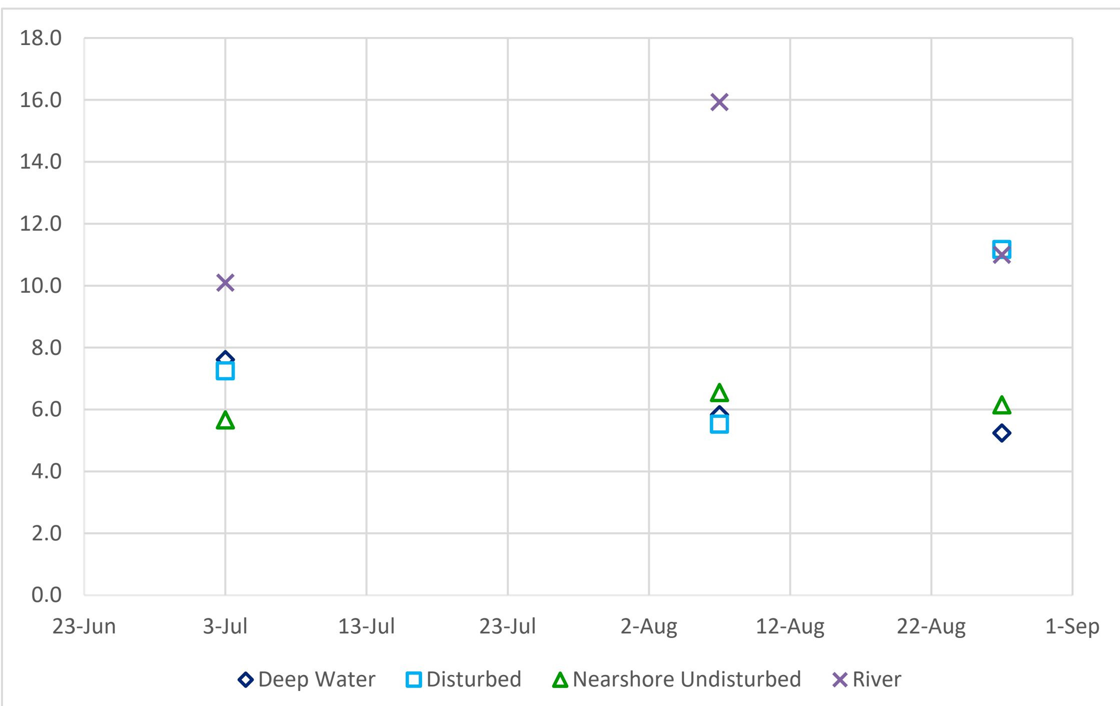


Figure 8. Average total phosphorus concentrations in Lake of Bays 2023 by Site Type.



Note: Data points for each date represent mean values of all sites of one type.

4. Long-term Phosphorus Patterns

The Lake of Bays Water Quality Monitoring Program has collected data over the summer season for 20 years at 12-23 locations throughout the lake. The yearly number of samples collected including QA/QC samples ranged from 50 in 2002 to 123 in 2012, with a total of 1,920 samples collected by the end of the 2023 program (Table 6). The large number of sites monitored, and samples collected under the program since 2002 provide for a robust data set for assessing long-term trends and inter-annual variability in total phosphorus concentration in Lake of Bays. The complete LOBA monitoring program data set since 2002 is provided in Appendix B.

Mean summer total phosphorus concentrations were elevated in 2023 compared to 2022 in the Disturbed (mean TP = 6.5 μg/L vs 4.5 μg/L), Nearshore Undisturbed sites (mean TP = 6.1 μg/L vs 3.0 μg/L) and Deep Water sites (mean TP = 6.2 μg/L vs 4.3 μg/L) (Table 7, Figure 8). As in the past, River sites were more variable with generally higher concentrations than lake stations with a range of 4.0 to 22.8 μg/L, and mean TP (12.3 μg/L). Elevated TP at the River stations is not uncommon in the dataset and therefore we recommend LOBA consider the addition of total suspended solids sampling at river stations to the program to determine if river total phosphorus is associated with high sediment loads and runoff in the river or if it is the result of sample contamination. The addition of suspended solids sampling to the 2024 program will be discussed with the program administrator and Environment Committee.

A statistically significant increasing trend in mean summer total phosphorus concentration of the Deep Water sites was last identified in 2017. Considering all data collected since 2002, there are no significant trends in total phosphorus concentrations in the Deep Water sites of Lake of Bays between 2002 and 2023 (Figure 9; Mann Kendall Trend Test: $p>0.05$, Sen's Slope = 0).

Assessment of total phosphorus concentrations at each individual monitoring station did not identify any significant increasing trends. Significant increasing trends in TP at Trading Bay were identified in 2019, however, with the addition of the 2021-2023 data, there was no longer a statistically significant increase in TP over time in Trading Bay.

Table 6. Number of Total Phosphorus Samples Collected by the Lake of Bays Monitoring Program (2002-2023)

Year	Deep Water	Disturbed	Nearshore Undisturbed	River	Total # of Samples
2002	30	15	5		50
2003	39	22	7	16	84
2004	28	13	5	7	53
2005	29	8	14	8	59
2006	53		21		74
2007	54	10	36	10	110
2008	48	13	32	15	108
2009	47	15	21	10	93
2010	46	15	29	16	106
2011	44	28	28	13	113
2012	51	26	31	15	123
2013	57	19	25	15	116
2014	53	16	32	18	119
2015	52	19	32	19	122
2016	52	19	30	16	117
2017	54	16	29	19	118
2018	29	10	15	8	62
2019	33	13	19	10	75
2021	27	14	16	9	66
2022	33	13	16	12	74
2023	34	11	18	15	78
Total # of Samples	893	315	461	251	1920

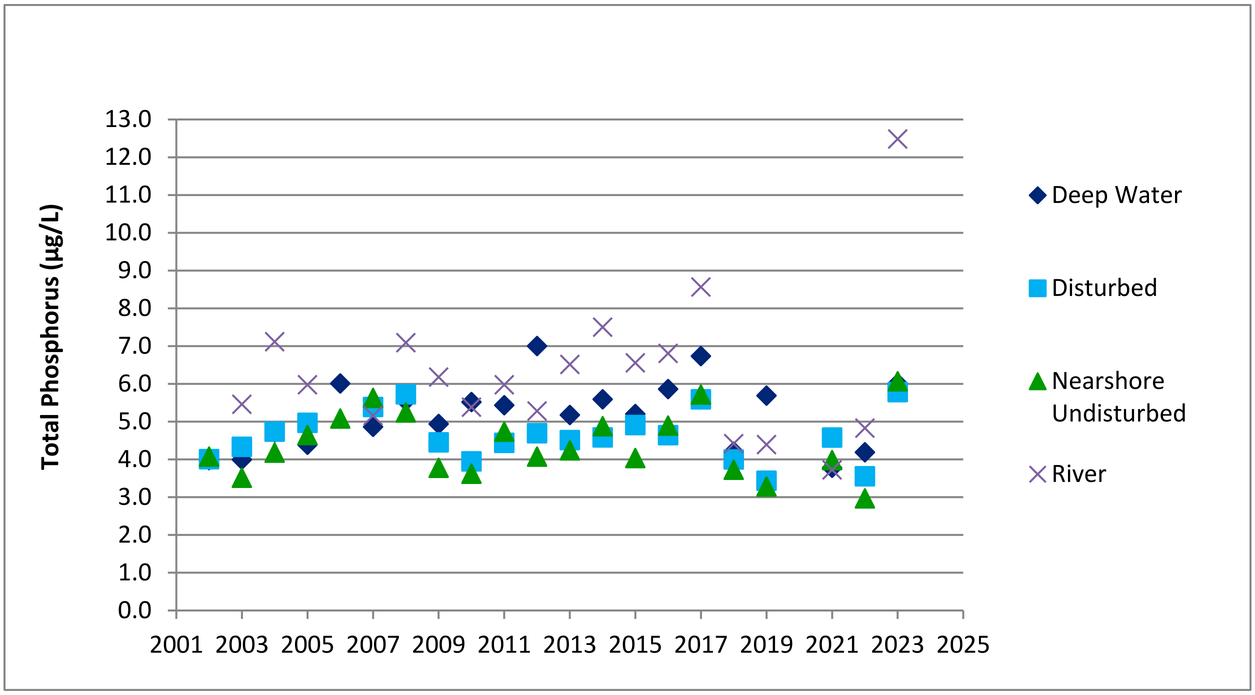
Table 7. Mean Summer Total Phosphorus Concentrations in Lake of Bays (2002-2023)

Site	Total Phosphorus (µg/L)																					
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021	2022	2023	AVG.
Deep Water	**4.0**	**4.0**	**4.7**	**4.4**	**6.0**	**4.9**	**5.6**	**4.9**	**5.5**	**5.4**	**5.7**	**5.2**	**5.6**	**4.9**	**5.9**	**6.7**	**4.2**	**3.9**	**3.8**	**4.2**	**6.0**	**5.1**
Bigwin East	4.2	4.2	4.2	4.0	5.5	4.5	6.4	4.1	5.7	4.9	5.0	4.9	6.2	4.5	4.4	6.6	4.1	3.1	3.2	2.8	5.7	4.7
Dwight Bay	4.6	3.6	6.1	4.7	6.4	5.9	6.1	4.9	6.2	5.3	6.5	5.3	6.1	5.0	8.9	8.3	3.7	3.4	3.0	10.1	5.6	5.5
Fairview	2.8	3.6	4.0	4.7	5.3	3.9	6.1	4.6	5.2	4.9	4.7	4.5	4.8	4.4	4.1	5.7	3.6	3.3	4.7	2.0	13.3	4.5
Gull Rock	4.0	4.2	5.1	4.4	5.6	4.7	5.0	4.4	5.5	5.8	5.1	3.9	5.0	4.1	5.2	5.7	3.9	3.7	4.3	2.9	4.2	4.7
Haystack Bay	4.2	4.4	4.6		6.8	5.5	5.3	6.4	5.9	6.2	4.7	7.3	6.2	4.1	5.7	8.2	3.5	4.4	4.4	3.6	7.2	5.4
Portage Bay											9.6	5.7	6.3	4.7	5.3	8.1	7.3	3.9	3.0	3.4	4.0	6.0
Price Point				3.4	6.0	4.5	4.7	5.7	5.2	5.5	4.5	5.8	4.5	4.0	5.7	5.3	3.9	4.2	4.7	2.6	2.0	5.5
Ten Mile Bay					6.9	5.0	5.5	4.8	5.2	5.1	6.8	5.7	7.3	5.1	7.3	6.4	3.8	3.5	3.3	4.6	8.3	5.4
Trading Bay	4.1	4.0	4.9	5.1	6.0	4.7	5.4	4.9	5.2	5.8	5.1	2.5	4.2	7.6	6.9	6.3	4.9	6.7	3.4	3.9	7.5	5.1
Disturbed	**4.0**	**4.3**	**4.7**	**5.0**		**5.4**	**5.7**	**4.5**	**3.9**	**4.4**	**4.7**	**4.5**	**4.6**	**4.9**	**4.6**	**5.6**	**4.0**	**3.4**	**4.6**	**3.6**	**6.5**	**4.6**
Bigwin Bay	3.6	4.7	4.9				5.5	4.2	3.6	4.5	4.5	4.5	4.3	4.8	4.3	5.4	3.4	3.9	3.7	3.6	5.0	4.4
Bigwin North	5.0	3.9	5.3	5.2		6.3	6.1	5.6	4.5	4.6	4.8	4.8	4.6	5.1	5.1	6.0	3.7	3.4	5.3	2.5	7.0	5.0
Britannia	3.3	4.4	4.0	4.6		4.7	5.5	3.6	3.8	4.2	4.8	4.1	4.8	4.9	4.5	5.5	4.7	3.1	4.7	4.5	5.0	4.4
Dwight Beach										6.3	4.5	6.8							4.3	8.8	8.9	5.5
Portage Bay docks																		3.3	3.1	3.2	5.4	3.2
Nearshore Undisturbed	**4.1**	**3.5**	**4.2**	**4.6**	**5.1**	**4.3**	**5.2**	**3.8**	**3.6**	**4.6**	**4.1**	**4.2**	**4.9**	**3.8**	**4.9**	**5.6**	**3.7**	**3.3**	**4.0**	**3.0**	**6.1**	**4.3**
Langmaid Island				4.8	4.7	3.3	4.5	2.9	2.8	4.2	3.9	4.0	4.2	3.5	4.3	4.8	3.7	3.0	4.5	2.3	4.4	4.0
Boothby's				8.3	5.8	5.2	5.4	4.3	4.6	4.8	3.9	4.3	5.0	3.7	5.3	6.0	4.0	3.3	4.1	2.6	6.2	4.9
Menominee Bay				3.1	5.0	3.9	6.0	3.1	2.9	4.9	3.7	4.3	4.8	3.7	5.7	5.7	3.7	3.5	3.8	2.6	7.9	4.2

Site	Total Phosphorus (µg/L)																				
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2021**	**2022**	**2023**	**AVG.**
Hemlock Ridge Road	4.1	3.5	4.2	3.9	4.9	3.8	5.2	4.8	3.6	4.6	4.5	4.2	5.5	4.1	3.8	5.5	3.6	3.1	3.6	4.0	5.4	4.2
Narrows West						5.1	4.7		4.3	4.0	4.5	4.5	4.9	4.4	5.4	6.0	3.6	3.5	4.0	3.6		4.7
River		**5.5**	**7.1**	**5.3**		**5.2**	**6.7**	**6.2**	**5.4**	**6.0**	**5.3**	**6.5**	**7.5**	**6.6**	**6.8**	**9.1**	**4.4**	**4.4**	**3.7**	**4.3**	**12.2**	**6.0**
Hollow River Lagoon		7.2				5.3	6.3												3.9	2.5	11.8	5.7
Hollow River mouth		5.5	6.6	4.4		5.2	5.7		4.5	5.3	5.1	4.1	5.5	7.3	7.3	9.4	4.7	4.4	3.9		8.7	5.5
Oxtongue Delta							6.9	4.8	4.0	4.9	4.4	6.3	8.5	6.0	6.2	8.9	3.0	3.5	3.0		10.0	5.4
Oxtongue mouth			7.4	5.9			7.3	7.6	8.3	7.8	6.4	8.1	8.7	6.6	7.2	8.9	6.3	5.7	4.3		15.8	7.1

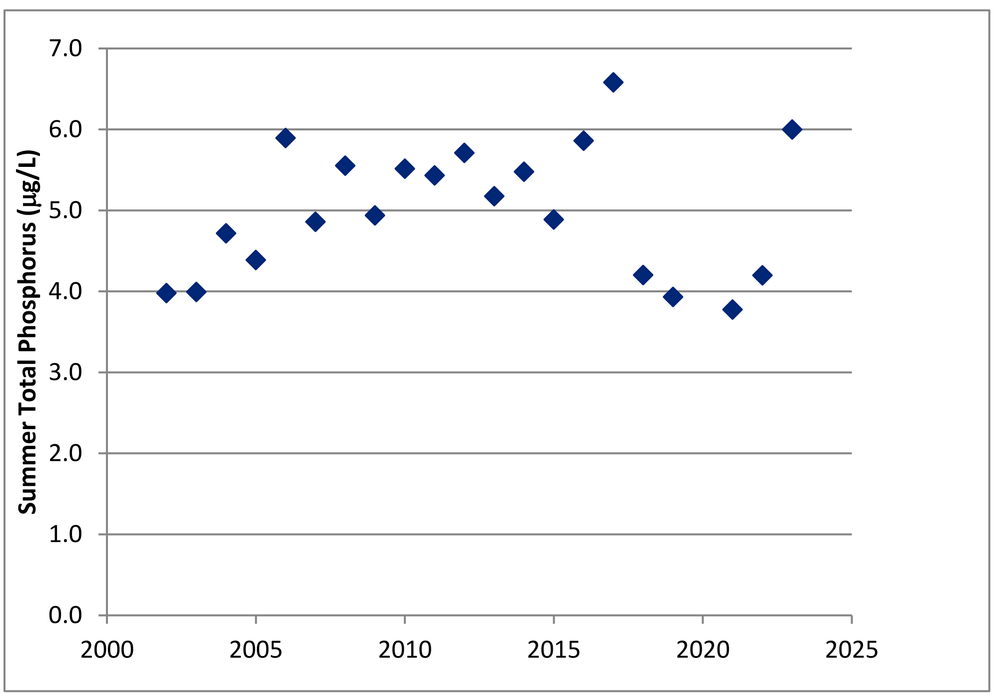
Note: Includes only those sites with at least two years of data collected within the last five years

Figure 9. Long-term (2002-2023) Mean Summer Euphotic Zone Total Phosphorus (TP) by Site Type.



Note: Only includes sites with at least five years of data.

Figure 10. Long-term Mean Summer Total Phosphorus in Deep Water areas of Lake of Bays.



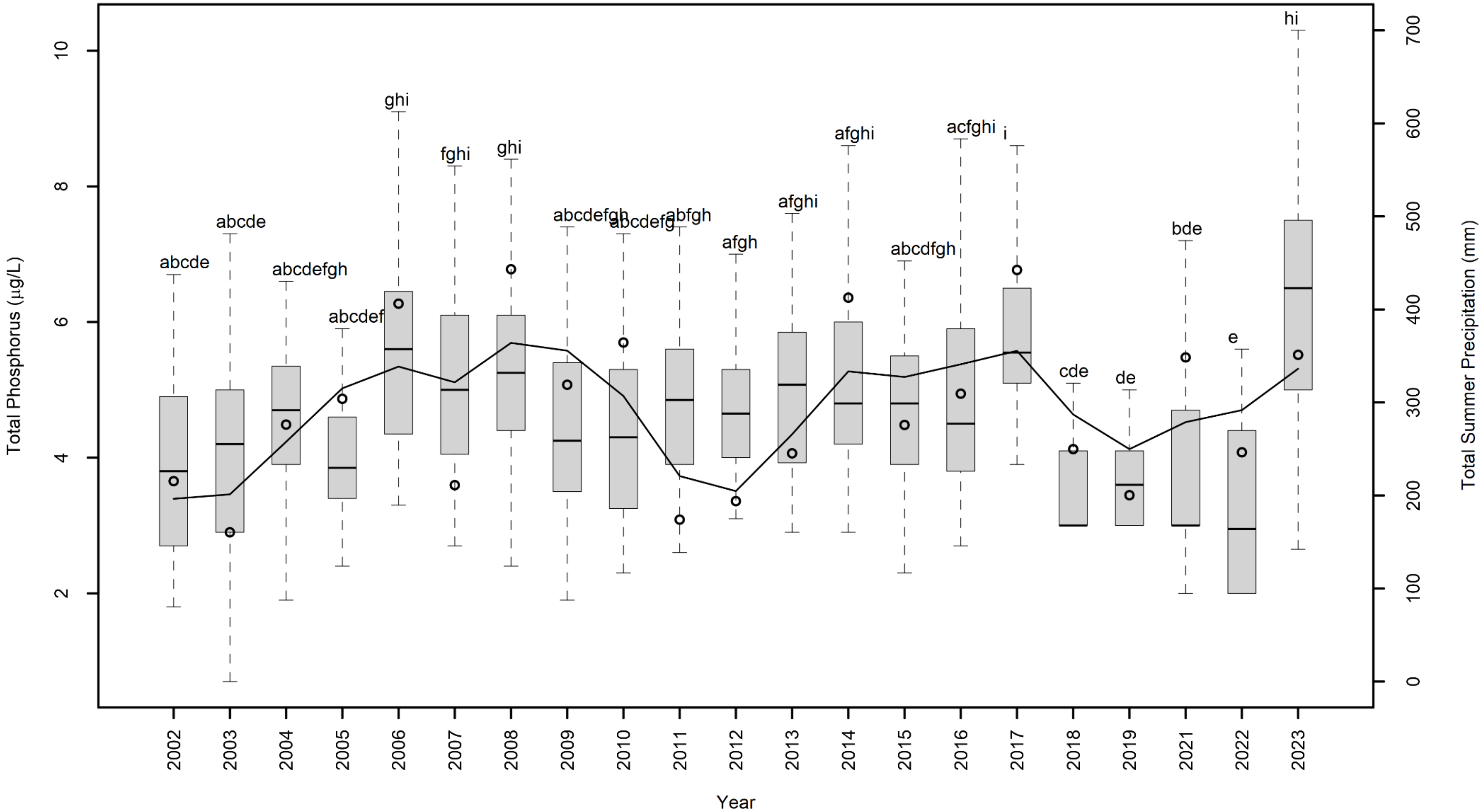
Note: LOBA sites exclude Little Trading Bay (2005-2008) and Portage Bay (Special Study).

Long-term monitoring has shown that increasing trends in total phosphorus have occurred in some Muskoka lakes monitored by the Dorset Environmental Science Centre (DESC), while other lakes exhibited decreasing or no trends (Andrew Paterson, MOECC lake scientist, pers. comm.). These lakes had little to no development in their watersheds and so regional (e.g., climate change, long range atmospheric deposition) and local factors other than development may be influencing lakes in the Muskoka area, including Lake of Bays. The District of Muskoka (DMM) has monitored spring total phosphorus at deep water sites in Lake of Bays since 2001 and has observed no increase which substantiates the findings presented herein.

Changes in annual precipitation patterns (amount of precipitation, frequency and duration of storm events) can strongly influence phosphorus loads from atmospheric deposition and also the mobilization and transport of phosphorus from the watershed. Long-term data collected in Lake of Bays, coupled with climate data from Beatrice Climate Station, suggests that inter-annual variability in precipitation may exert a significant influence on the total phosphorus concentration in the lake (Figure 11). In general, total phosphorus concentrations tended to decrease in drier years over the period of record. Total phosphorus concentrations in 2022 decreased slightly at nearshore stations, likely as a result of lower precipitation. Total phosphorus concentration across all sites excluding River stations were statistically similar to those recorded in most years since the program began (i.e., 2002-2007, 2009-2013, 2015, 2018, 2019 and 2021) and significantly lower than concentrations recorded during high precipitation years (i.e., 2008, 2014, 2016, and 2017; Figure 11, similarity indicated by the letters “a” “b”, “c”).

In summary, summer total phosphorus concentration in Lake of Bays exhibits inter-annual variability, which based on long-term TP and precipitation data appears to be driven by natural processes related to precipitation. The Lake of Bays Association water quality monitoring program experienced QA/QC issues in 2023 which resulted in a marked increase in the frequency of bad splits and outliers in the data set. We highly recommend sampling be conducted in a manner consistent with the program recommendations and that any changes to sampling equipment be discussed prior to the sampling season to avoid future issues. The result of the 2023 program was elevated phosphorus concentrations which may be the result of increased precipitation but may also be the result of non-conformity with sampling methods. The future of the program and its ability to monitor long-term changes in phosphorus in Lake of Bays is contingent upon consistent sampling.

Figure 11. Annual Summary of Summer Total Phosphorus Concentrations at All Nearshore Disturbed, Undisturbed and Deep Water Sites and Precipitation (Beatrice Climate Station; 6110607) in Lake of Bays



Open Circles = Sum of Total Summer Precipitation; Line = Spline Smoothed Precipitation; Boxplots = Total Phosphorus Concentrations. Letters indicate years which are statistically similar

5. Summary

The total phosphorus and bacteria data collected by the LOBA in 2023 indicated increased nutrients, however data have been tainted by QA/QC issues. The main results of data analyses from 2023 are as follows:

1. The quantity of QA/QC sampling in 2023 was good. Ongoing QA/QC sampling for total phosphorus in 2024 is recommended.
2. No changes to sampling methodology should be made without discussion with HESL and the Environmental Committee. Results in 2023 may have been compromised as a result of sample contamination which based on our information may be the result of sampling equipment changes. Approximately 33% of the data collected in 2023 was either bad splits, outliers or both.
3. Data collected in 2023 will need to be revisited in 2024 and beyond to determine if it should be removed entirely from future analyses and reporting.
4. Deep Water sites did not exhibit a significant increasing trend in total phosphorus concentration.
5. Significant long-term trends in total phosphorus previously detected in the lake at Trading Bay, no longer exhibited a positive trend with the addition of 2021-2023 data. As a result, no significant trends in phosphorus concentration were noted in the individual site data on Lake of Bays.
6. Bacteria levels collected by the Coliplate technique were below the PWQO for recreational use at all sites.
7. Total phosphorus concentrations (excluding River sites; mean TP = 6.3 μg/L) continue to be characteristic of lakes with low primary productivity and meet the highest Provincial standards for protection of nuisance aquatic plant growth due to phosphorus of <10 μg/L at all sites.
8. Mean summer total phosphorus concentration in Portage Bay has been consistently low since 2013, representing a decline from elevated concentrations observed in 2012 that coincided with construction activities. This remains true in 2023.
9. As in previous monitoring, no significant difference in phosphorus concentration between the Deep Water, Disturbed and Nearshore Undisturbed sites were found, suggesting that shoreline disturbance is having little impact on summer phosphorus concentrations.
10. Our analysis continues to demonstrate a correlation between changes in total phosphorus concentrations in the lake and regional precipitation with no evidence of increased nutrient concentrations due to development pressure.
11. We recommend LOBA consider the addition of total suspended solids sampling at River stations to help us better understand the influence of suspended solids on total phosphorus concentrations.

6. References

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Appendix A. Monitoring Protocols for the LOBA Water Quality Monitoring Program

WATER QUALITY SAMPLING PROCEDURES

General:

1. Check for equipment, including:
-metre depth pole (if required)
-thermometer
-cooler and ice packs
-sterilized jars, phosphorus tubes, duplicates
-secchi depth disc and jar (if required)
-data sheets and pen
2. verify that you have the appropriate boating safety equipment on board and that the weather is safe for sampling
3. record air temperature on data sheet as you leave the dock. Then attach thermometer to a rope in preparation for taking water temperature at sampling sites.
4. at each site, complete the data sheet, recording any factors or conditions that may make the sampling trip unusual or that may have an influence on sample results (eg. cloudy water, unusual activity in the area, presence of waterfowl)

Coliform and E coli testing

Near shore sample collected 22 – 30 cm. below the surface in water that is 1 m. in depth
Deep water samples also collected 22 – 30 cm. below the surface of the water.
1. Carefully and correctly assemble the jars required for the specific site (all should be named and number coded)
2. Remove the cap/lid from the jar/bottle **without touching the inside of the lid or jar**, and place carefully, upside down on a flat stable surface
3. Grip the bottle at the base and plunge it into the water in a downward motion to the a depth of 22 – 30 cm. (9 – 15 in). The bottle goes in **upside down** (open end to lake bottom) and the appropriate depth is roughly around your elbow.
4. Adjust the bottle position in your hand so that the bottle is now parallel to lake surface and lake bottom, facing forward and **collect sample by sweeping the bottle forward** (forward, not up). This directional motion is important so that the water being collected in the bottle/jar does not pass over your hand. Collect water from that 22 – 30 cm. depth and then bring bottle to surface.
5. Empty it slightly (if it is full to the brim) and then recap bottle.
6. Store in the cooler chest.
7. **re quality control sample (lab and field duplicates).** Quality assurance is necessary to validate that the sampling and processing protocols have been followed appropriately. It is very important that these procedures are followed in order to ensure high quality results …

If we are running duplicates (field and lab) on your site, there will be a large sampling jar, clearly marked, as well as a smaller one. Using the large jar, take your sample as per the steps outlined above. As soon as the sample is obtained, recap the jar (without touching interior of lid or jar) and shake it two or three times to ensure a uniform distribution of the discreet bacteria in the water sample. Immediately transfer some of the sample to the smaller jar. Cap both jars and store both jars. The contents of the small jar are the sample, part of the remaining content of the large jar becomes the field duplicate and the balance of water in the large jar is sent for a quality control test at the Central Ontario Analytical Laboratory in Orillia.

The last part of quality assurance is distilled water. After the site sample and field duplicate have been collected, open the distilled water jug and fill the collection jar marked Distilled Water. Cap the glass bottle and place it in the cooler with the ice pack. Distilled water is, or should be, free of coliforms and e coli, and running a distilled water sample through our process (sterilized jars, sampling volunteers, Kieran working the coliplates) is an excellent test of the scientific rigour of our program.

Near shore Phosphorus testing:

sample collected 22 – 30 cm. below the surface in water that is 1 m. in depth
Equipment and bottles for sampling total phosphorus are provided with guidance by ALS Laboratory and should be followed carefully.

1. Carefully and correctly assemble the jars required for the specific site (all should be named and number coded)
2. Remove the top from the PET jar without touching the inside of top or jar and place in a flat, stable place.
3. **Rinse the jar in surface water at site.**
4. Rinse the filter (plastic funnel and filter cloth) in surface site water (filter stored in freezer bag.)
5. Grip the bottle at the base and plunge it into the water in a downward motion to the a depth of 22 – 30 cm. (9 – 15 in). The bottle goes in **upside down** (open end to lake bottom) and the appropriate depth is roughly around your elbow.
6. Adjust the bottle position in your hand so that the bottle is now parallel to lake surface and lake bottom, facing forward and **collect sample by sweeping the bottle forward** (forward, not up). This directional motion is important so that the water being collected in the bottle/jar does not pass over your hand. Collect water from that 22 – 30 cm. depth and then bring bottle to surface.
7. Take the top off the test tube, being careful not to touch the inside of the top or the test tube interior.
8. Gently swirl the water in the PET jar (don't spill it!) and then filter the water from the PET jar into the test tube using ALS equipment provided. Fill the test tube to the line marked near the top of the test tube (want a tiny bit of air space in the tube for the lab to add some material.)
9. Cap tightly – both test tube and PET jar – and put both in the cooler.

Deep Water Phosphorus Testing

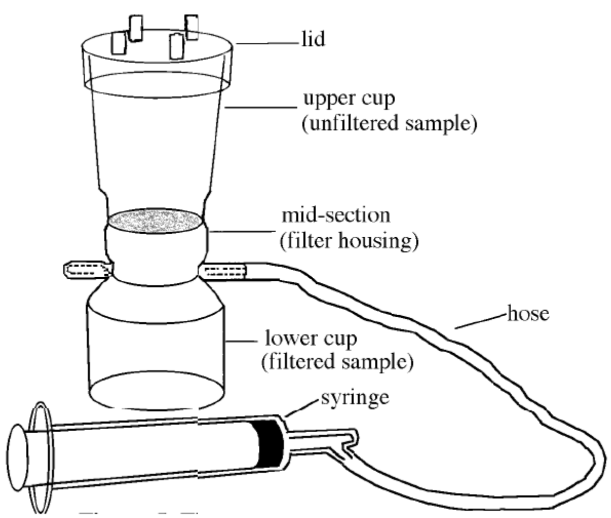
sample is collected 10 – 15 m.(metres, not centimeters) below the surface in deep water
While the process of collecting and filtering the sample is the same as that for near shore phosphorus, the sample is collected from further down in the water column. The process is as follows:

1. Attach the rope to the Secchi disc and measure the secchi depth by lowering the disc over the side of the boat until it disappears from view. It may take a bit of playing with it to verify when it actually disappears. Haul it up until you see it again and then slowly lower it. (Know that in 8 years of doing this, I have NEVER had a secchi reading anywhere on Lake of Bays of less than 4.5 metres, and have occasionally had them up to 8 metres.) As you pull the disc back to the surface, count the number of metres (the rope is calibrated in 1 metre intervals.) Record this number. Redo to

double check.
2. Record the colour of the water (orangey brown, bluey-green, etc.)
3. Attach the calibrated rope to the container for the secchi collection jar.
4. Rinse the collection jar in surface site water.
5. Lower the bottle (now in the weighted container to a distance that is **2 X** the secchi depth you observed and recorded above (the sample is being collected at a level to which light penetrates and given the refraction of light, that distance is 2 X the depth at which you could last see the disc.) The bottle should be lowered in a quick, smooth, but controlled motion (Don't let it free fall.)
6. Pull the container and collection jar back to the surface at a steady pace.
7. Use this water to rinse and fill the PET jar.
8. Swirl the water in the PET jar and then pour into the test tube **through the filter.** Fill test tube to the indicated line (just shy of full.)
9. Cap and place test tube and PET jar in cooler.

Re quality assurance for phosphorus … near shore and deep water:

Quality assurance is necessary to validate that the sampling and processing protocols have been followed appropriately. It is very important that these procedures are followed in order to ensure high quality results …
1. If we are running phosphorus duplicates on your site, there will be an extra test tube, clearly marked as the field duplicate. Simply fill that second test tube in the same manner as the first, taking the time to gently swirl the contents of the PET jar before pouring water into the second test tube through the funnel and filter cloth Cap test tubes and PET jar and store in cooler.
2. The last part of quality assurance is distilled water. After the site sample and field duplicate have been collected, open the distilled water jug and fill the clearly marked test tube to the line (7/8th full). Cap and store with rest of samples from that particular site.



Appendix B. LOBA Total Phosphorus and Bacteria Data

Site Code	Site Name	Site Type	Year	Date	TP BDL	Total Phosphorus (ug/L)	*E. coli* (cfu/100 mL)	Total Coliform (cfu/100 mL)	Bad Splits	Outliers 2023
S1	Adamson's Island	Nearshore Undisturbed	2023	3-Jul-23		4.8				
S1	Adamson's Island	Nearshore Undisturbed	2023	7-Aug-23		28.2	2	6		x
S1	Adamson's Island	Nearshore Undisturbed	2023	27-Aug-23		4.0				
B4	Bigwin Bay	Disturbed	2023	3-Jul-23		6.7				
B4	Bigwin Bay	Disturbed	2023	7-Aug-23		3.3	1	27		
B4	Bigwin Bay	Disturbed	2023	27-Aug-23		10.3				x
B1 F/D	Bigwin East	Deep Water	2023	3-Jul-23		5.8				
B1	Bigwin East	Deep Water	2023	3-Jul-23		4.5				
B1	Bigwin East	Deep Water	2023	7-Aug-23		10.7	2	13		x
B1	Bigwin East	Deep Water	2023	27-Aug-23		6.3				
B3	Bigwin North	Disturbed	2023	3-Jul-23		64.9				x
B3	Bigwin North	Disturbed	2023	7-Aug-23		7.4	1	8		
B3	Bigwin North	Disturbed	2023	27-Aug-23		6.5				
N24	Boothby's	Nearshore Undisturbed	2023	3-Jul-23		6.8				
N24	Boothby's	Nearshore Undisturbed	2023	7-Aug-23		4.7	3	35		
N24	Boothby's	Nearshore Undisturbed	2023	27-Aug-23		7.0				
N24 F/D	Boothby's	Nearshore Undisturbed	2023	27-Aug-23		38.8			bs	
N11 F/D	Britannia	Disturbed	2023	3-Jul-23		11.5			bs	
N11	Britannia	Disturbed	2023	3-Jul-23		5.0				
N11	Britannia	Disturbed	2023	7-Aug-23		22.0	5	11		x
N11 F/D	Britannia	Disturbed	2023	27-Aug-23		39.4			bs	
N11	Britannia	Disturbed	2023	27-Aug-23		25.3				x
N1	Dwight Bay	Deep Water	2023	3-Jul-23		6.2				
N1	Dwight Bay	Deep Water	2023	7-Aug-23		5.9	5	14		
N1	Dwight Bay	Deep Water	2023	27-Aug-23		4.6				
N3	Dwight Beach	Disturbed	2023	3-Jul-23		7.0				
N3	Dwight Beach	Disturbed	2023	7-Aug-23		8.3	0	16		
N3	Dwight Beach	Disturbed	2023	27-Aug-23		11.3				
N3 F/D	Dwight Beach	Disturbed	2023	27-Aug-23		37.4			bs	

B2 F/D	Fairview	Deep Water	2023	3-Jul-23		14.5				
B2	Fairview	Deep Water	2023	3-Jul-23		12.1				
B2	Fairview	Deep Water	2023	7-Aug-23		36.3	1	15		x
B2	Fairview	Deep Water	2023	27-Aug-23		38.2				x
N10	Gull Rock	Deep Water	2023	3-Jul-23		10.9				x
N10	Gull Rock	Deep Water	2023	7-Aug-23		5.6	2	25		
N10	Gull Rock	Deep Water	2023	27-Aug-23		2.7				
E13	Haystack Bay	Deep Water	2023	3-Jul-23		15.5				x
E13	Haystack Bay	Deep Water	2023	7-Aug-23		5.0	0	4		
E13 F/D	Haystack Bay	Deep Water	2023	27-Aug-23		10.6				
E13	Haystack Bay	Deep Water	2023	27-Aug-23		8.1				
E6	Hollow River Lagoon	River	2023	3-Jul-23		5.3				
E6	Hollow River Lagoon	River	2023	7-Aug-23		22.8	9	36		
E6 F/D	Hollow River Lagoon	River	2023	7-Aug-23			4	26		
E6	Hollow River Lagoon	River	2023	27-Aug-23		7.2				
E6 F/D	Hollow River Lagoon	River	2023	27-Aug-23		31.6			bs	
E18 F/D	Hollow River mouth	River	2023	3-Jul-23		11.6				
E18	Hollow River mouth	River	2023	3-Jul-23		8.6				
E18	Hollow River mouth	River	2023	7-Aug-23		7.3	3	21		
E18	Hollow River mouth	River	2023	27-Aug-23		15.5				R
S2	Menominee Bay	Nearshore Undisturbed	2023	3-Jul-23		11.0				x
S2	Menominee Bay	Nearshore Undisturbed	2023	7-Aug-23		8.4	1	3		
S2	Menominee Bay	Nearshore Undisturbed	2023	27-Aug-23		7.6				
S2 F/D	Menominee Bay	Nearshore Undisturbed	2023	27-Aug-23		7.3				
N13	Moffat's	Nearshore Undisturbed	2023	3-Jul-23		5.4				
N13	Moffat's	Nearshore Undisturbed	2023	7-Aug-23		11.6	0	6		x
N13	Moffat's	Nearshore Undisturbed	2023	27-Aug-23		15.6				x
E26	Narrows West	Nearshore Undisturbed	2023	3-Jul-23		45.7				x
E26	Narrows West	Nearshore Undisturbed	2023	7-Aug-23		34.1	2	30	bs	
E26 F/D	Narrows West	Nearshore Undisturbed	2023	7-Aug-23		24.2				x
E26 F/D	Narrows West	Nearshore Undisturbed	2023	7-Aug-23			5	37		
E26	Narrows West	Nearshore Undisturbed	2023	27-Aug-23		10.6				x
N30	Oxtongue Delta	River	2023	3-Jul-23		10.0				
N30	Oxtongue Delta	River	2023	7-Aug-23		14.1	0	2		R
N30	Oxtongue Delta	River	2023	27-Aug-23		16.0				R

N2	Oxtongue mouth	River	2023	3-Jul-23		15.0				
N2 F/D	Oxtongue mouth	River	2023	7-Aug-23		30.9			bs	
N2	Oxtongue mouth	River	2023	7-Aug-23		17.7	7	18		
N2	Oxtongue mouth	River	2023	27-Aug-23		14.8				
N26	Portage Bay	Deep Water	2023	3-Jul-23		5.8				
N26	Portage Bay	Deep Water	2023	7-Aug-23		7.6	2	36	bs	
N26 F/D	Portage Bay	Deep Water	2023	7-Aug-23		3.6				
N26	Portage Bay	Deep Water	2023	27-Aug-23	y	2.0				
N26 F/D	Portage Bay	Deep Water	2023	27-Aug-23		3.1				
N31	Portage Bay docks	Disturbed	2023	3-Jul-23		10.3				
N31	Portage Bay docks	Disturbed	2023	7-Aug-23		3.1	10	21		
N31	Portage Bay docks	Disturbed	2023	27-Aug-23	y	2.0				
N31 F/D	Portage Bay docks	Disturbed	2023	27-Aug-23		3.3				
S3	Price's Point	Deep Water	2023	3-Jul-23		30.2				x
S3	Price's Point	Deep Water	2023	7-Aug-23		11.9	0	2		x
S3	Price's Point	Deep Water	2023	27-Aug-23	y	2.0				
E30	Ten Mile Bay	Deep Water	2023	3-Jul-23		12.1				x
E30 F/D	Ten Mile Bay	Deep Water	2023	7-Aug-23		8.0				
E30	Ten Mile Bay	Deep Water	2023	7-Aug-23		6.8	3	6		
E30	Ten Mile Bay	Deep Water	2023	27-Aug-23		9.2				
E1	Trading Bay	Deep Water	2023	3-Jul-23		30.2				x
E1	Trading Bay	Deep Water	2023	7-Aug-23		34.5	0	3	bs	
E1 F/D	Trading Bay	Deep Water	2023	7-Aug-23		7.5				
E1 F/D	Trading Bay	Deep Water	2023	7-Aug-23			2	10		
E1	Trading Bay	Deep Water	2023	27-Aug-23		27.2				x