Volunteer Water Quality Monitoring Program Report

2016 Results

Township of the Archipelago
April 2017

Acknowledgements

The water quality monitoring program represents a successful partnership between the Township of The Archipelago, cottager associations, and numerous volunteers in areas along the coast and inland lakes that has lasted since its inception in 1999. The volunteer-based program provides an important avenue for relaying information about our environment to ratepayers and for providing valuable information to the Township.

The Township wishes to thank all of its ratepayers, and in particular the volunteer monitors, for their keen interest and drive to ensure our high quality environment is maintained. The Township is committed to addressing environmental issues and ensuring the maintenance of the high quality environment we all enjoy. This philosophy is integrated into the day to day functioning of the municipality from public works operations to detailed planning analysis.

Data collection and report compilation by Georgian Bay Biosphere Reserve staff David Bywater and Katrina Krievins, with technical support from Bev Clark.

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Introduction

In the spring of 2016 the Township of the Archipelago (TOA) recommended changes to its water quality (WQ) monitoring program, with the main recommendation being a shift from bacteria to phosphorus monitoring. These changes came about as a result of a partnership with the Georgian Bay Biosphere Reserve (GBBR). For the past three years, as part of their *Coordinated Nutrient Monitoring Program*, GBBR has worked with partners to review existing nutrient monitoring efforts along eastern Georgian Bay and develop a new set of guidelines and recommendations to improve effectiveness and efficiency of the collective efforts of volunteers, associations, agencies and other organizations (click here for further information). Changes to the WQ monitoring program were communicated to ratepayer associations and volunteers in the spring of 2016.

Why shift away from regular bacteria monitoring?

The rationale for shifting away from bacteria monitoring is based on a Hutchinson Environmental Sciences report (available here) which raised questions about the efficacy and overall environmental meaningfulness of bacteria monitoring. Specifically, it concluded that single samples taken at one point in time do not indicate either the spatial or temporal extent of the levels of bacteria observed. This is based on the fact that survival of E. coli in the recreational water environment is dependent on many factors, including temperature, exposure to sunlight, available nutrients, water conditions (e.g., pH and salinity), and competition from, and predation by, other micro-organisms. The report recommends that should organizations wish to continue with bacteria testing, it should happen in the framework of a scientific investigation focused on testing specific hypotheses on potential sources of contamination through a focused sampling program. For example, recreational sites (e.g., beaches) could be considered for bacteria monitoring as per the province's Beach Management Guidance Document.

Why monitor total phosphorus?

Nutrient (phosphorus) monitoring requirements along eastern Georgian Bay are complex. In the past, phosphorus monitoring meant measuring concentration over time to detect any increases due to anthropogenic inputs which could lead to eutrophication and the increased likelihood of nuisance algal blooms. In recent decades there is evidence that phosphorus concentrations in inland lakes have been declining for reasons other than a reduction in anthropogenic loads (Eimers, 2009) and it has been shown by Environment Canada that this is occurring in the open waters throughout the GBBR. In addition, the invasion of Dreissenid Mussels in the Great Lakes has led to the removal of nutrients in offshore areas, which is a result of the filter feeding process of the mussels. In turn, there has been an increase in the nutrients in nearshore areas as the mussels concentrate nutrients as both biomass and waste products in some areas. These multiple stressors require nutrient monitoring for many reasons other than straightforward vigilance with respect to eutrophication. There is now the need to understand complex patterns in nutrient flux and the way these changes in phosphorus concentrations affect ecosystem function. Therefore nutrient monitoring objectives for eastern Georgian Bay are:

1. Mitigating localised water quality issues.
2. Regional characterisation of water quality.
3. Spatial and temporal trend detection.
4. Identifying the effects of regional drivers and multiple stressors to protect ecosystem function.

While the focus of the TOA's water quality program is on nutrients (i.e. phosphorus), it is understood that other contaminants of concern and emerging issues exist, such as: pesticides, herbicides, pharmaceuticals, microplastics, invasive species, etc. The "*Coordinated Nutrient Monitoring Program*" has started with Total Phosphorus and is building capacity to expand and respond to other water quality monitoring needs and concerns.

GBBR is facilitating the transition from bacteria monitoring to phosphorus monitoring by encouraging ratepayer associations and volunteers to join or continue with the Lake Partner Program (LPP). The LPP is an Ontario-wide, publically funded, free program that collects data about phosphorus, water clarity, calcium and temperature from volunteers. The LPP detects both high and low phosphorus levels, which is a very important measure for inland lakes, enclosed bays, nearshore, and offshore areas of Georgian Bay. Data collected by volunteers are analyzed by the Dorset Environmental Science Centre which makes all data available online. The simple tests for TP and water clarity provide a strong basis for assessing the health of the ecosystem, and whether TP is too high or too low. Advantages of the LPP are that it facilitates comparisons with other organizations monitoring on the Bay, as well as Ontario Ministry of Environment and Climate Change (MOECC) and Environment and Climate Change Canada (ECCC) monitoring programs. Moreover, LPP data fit into GBBR's larger State of the Bay program. With State of the Bay, GBBR uses federal, provincial, and municipal monitoring programs to communicate nutrient conditions along the coast.

Purpose and layout of this report

This report presents the results of the 2016 Water Quality Monitoring Program for the Township of The Archipelago. The main objective of this report is to present water quality data gathered in the 2016 sampling season in order to track trends over time. This type of information will enable ratepayers to examine the long-term trends from their dataset to identify outliers, discern seasonal patterns, and gain a sense of average phosphorus levels for their particular waterbody.

The remainder of this report provides a brief overview of the methods used to collect data and details the results, by ratepayer association, from data gathered in 2016 including an overview of sampling locations, water clarity, total phosphorus concentrations, calcium concentrations. The final section presents results from enhanced sampling at Sturgeon Bay and Blackstone Harbour.

Methods

Sampling locations in the TOA have been recommended for enclosed bays and inland lakes in GBBR's *Enclosed Bays and Inland Lakes Phosphorus Monitoring Guideline*. Whenever possible, volunteers are encouraged to contact GBBR prior to sampling if they have any comments or concerns about the suggested monitoring locations.

Enclosed bays that are connected to Georgian Bay, and have limited exchange of water due to convoluted connections or constricted openings, will have water chemistry characteristics that are mostly subject to influences from the upstream watershed. This will be especially true if there are major inflows or shoreline development within the bay. Even in cases where the bay is considered to be 'natural' there are multiple stressors associated with all ecosystems that occur as a result of climate change, long-range transport of pollutants, and the influx of invading species. Monitoring in these areas will help to understand the impacts of these stressors and support federal and provincial monitoring in nearby nearshore areas.

Inland lakes require TP data to help assess background concentrations relative to present day concentrations. Inland lakes should be sampled in all cases where there are no previous data collected. Developed lakes should be sampled before undeveloped lakes in the case where resources are limited. As a general rule, only one representative sampling location is required for each lake even in large convoluted lakes with multiple arms (e.g. Healey Lake). In the event that there are compelling reasons to believe that water quality in different areas of the lake would be influenced differently by rivers or development for example, or there are local observed differences or perceived problems, more sites might be recommended. Generally speaking, if the watershed influences are similar across a lake, the water quality will be similar as well.

Spring sampling (following LPP protocols) is sufficient for most locations in the TOA, as there are few areas that experience fall algal blooms. However, in some locations 'enhanced' monitoring (beyond LPP) may be required. Generally, the 'trigger' to consider additional monitoring relates to high TP and/or algal blooms. In these scenarios, further water quality parameters can be obtained with only a few additional pieces of equipment, most notably oxygen meters and specialized bottles to collect samples at distinct depths. The following two sections briefly describe the sampling method employed for regular sites and enhanced sites.

Regular monitoring sites

LPP volunteers collect one TP sample in May (during the spring-turnover period) at a deep spot. Additionally, volunteers take Secchi disc water clarity measurements at least once every two weeks throughout the summer. The black-and-white Secchi disc is lowered into the water until it is at the absolute limit of being visible. This depth is the Secchi depth of visibility, which is directly related to water clarity and can be used as a simple and effective monitoring tool for determining the effects of human activities on water clarity and, indirectly, on the nutrient content in the water.

The materials needed to take the water samples and conduct water clarity measurements are sent to volunteers by the province. Instructions and training videos are available online and additional training is provided by the Georgian Bay Biosphere Reserve. Samples are returned (postage paid) to the Dorset Environmental Science Centre (DESC) for analysis and Secchi observation sheets are mailed to DESC in November.

Enhanced monitoring sites

In some cases, further monitoring is required beyond what is recommended by the LPP. Generally, the 'trigger' to consider additional monitoring relates to high TP and/or algal blooms. The collection of additional water quality data should be determined on a case-by-case basis following a review of existing data. GBBR's *Enclosed Bays and Inland Lakes Phosphorus Monitoring Guideline* (available here) includes a decision tree to outline how further monitoring could occur under several different scenarios. It also outlines potential equipment needs and general water chemistry parameters for enhanced monitoring programs. The guideline ensures that information is collected in a standardized way that allows comparison between sites and over time.

Results – Regular Monitoring Sites

The following section includes a brief discussion on the interpretation of results, the locations of, and results for, each TOA sampling location active in 2016. Please note that only data collected after the MOECC took over coordination of the LPP (2002 to present) are shown in graphs and labelled on figures. Since 2002, LPP phosphorus samples have been analysed on a low level phosphorus analyser that has increased the precision of results from +/- 6 µg of phosphorus per litre to +/- 0.7 µg/L. This low level analysis is especially important for Georgian Bay TP samples that may have low levels of TP (e.g., 2 µg/L). Complete data for all historical and active sampling locations, including data collected prior to 2002, are available in tables in Appendix A.

Water clarity

In general, water clarity, as measured by Secchi depth, tends to be higher in open areas of Georgian Bay and in bays with good water circulation. Water clarity tends to diminish (smaller Secchi depth values) in enclosed bays, near wetlands or sources of organic material, and in lakes or areas that have higher nutrient levels either from natural or unnatural causes.

When examining the data, it is typical to see a small decline in Secchi depth throughout the year with lowest depths reading near the end of the summer and into September. However, a major decline in the readings should be evaluated more carefully. A multi-year comparison of data is of particular value here to assess the water clarity trends for a particular area.

Where more than one year of water clarity data exists for a sampling location, Secchi depth in metres is graphed and an average depth is given.

Calcium

Calcium is a nutrient that is required by all living organisms. Some organisms, for example Daphnia, which are a primary food for many fish, as well as other aquatic animals such as mollusks, clams, amphipods, and crayfish, use calcium in the water to form their calcium-rich body coverings. These organisms, and many others, are very sensitive to declining calcium levels.

Calcium concentrations have been shown to be decreasing in Canadian Shield lakes in response to depleted watershed stores of calcium caused by logging and decades of acid loading associated with acid rain. Combined with lower food availability and warmer temperatures predicted as part of a changing climate, this decrease represents an important stressor for many aquatic species.

Calcium concentrations should be considered over the long term to identify trends. Where more than one year of calcium concentration data exists for a sampling location, calcium concentration in mg/L is graphed.

In some cases, seasonal changes in calcium may be observed. For example, Sturgeon Bay appears to experience an increase of calcium from May to August, which may have to do with differences in seasonal watershed inputs.

Total phosphorus

As phosphorus is the nutrient that controls the growth of algae and most living biota in the aquatic environment, TP concentrations are used to interpret nutrient status. The nutrient status of an aquatic environment is typically described in terms of three broad categories – oligotrophic, mesotrophic, and eutrophic. TP concentrations below 10 micrograms per litre (µg/L) indicate an oligotrophic or unproductive environment. Aquatic environments with TP concentrations ranging between 10 and 20 µg/L are termed mesotrophic and are moderately enriched. Finally, TP concentrations over 20 µg/L indicate a eutrophic aquatic environment in which persistent, nuisance algal blooms are possible.

There is also a fourth nutrient status; tea stained lakes, with high dissolved organic carbon (DOC), are called dystrophic lakes and do not share the algal/TP relationships described above. Generally there can be more TP in a dystrophic lake without the occurrence of algal blooms. In the TOA, Healey Lake may contain high DOC, however a review of the provincial water quality database didn't yield any results. Therefore it is recommended that DOC results for Healey Lake be ascertained. A good explanation of dystrophic lakes is available here.

The Provincial Water Quality Objective (PWQO) for TP in lakes is 20 µg/L. The PWQO for TP is a measure for inland lakes intended to serve as a warning for, and to prevent, conditions that could result in the nuisance growth of algae. Results in this report are not compared to the PWQO because it is more important, given the environment of interest, to understand trophic condition and TP trend (e.g., upward, downward).

When interpreting data, the MOECC cautions that although only three years of data are required to establish a reliable, long-term average to measure current nutrient status, a longer data set is required to examine trends. Some aquatic environments exhibit relatively large differences in TP between years, highlighting the need for long-term data collection to distinguish between natural variation and true anomalies.

Where more than one year of TP data exists for a sampling location, TP in µg/L is graphed. Average TP is calculated for sampling locations with between three and five years of data, as well as, locations with five or more years of data for which there is no apparent trend. For sampling locations with five or more years of TP data and for which there is an apparent trend, a trend line is shown on the TP graph and average is not calculated. Visible outliers are removed for the purpose of determining whether a trend exists but are included in the graph showing Secchi depth, calcium concentration, and TP.

The LPP database (available here) contains TP data from over one thousand sampling locations across Ontario. Readers may find the database useful in understanding how TOA sampling location TP concentrations compare to other waterbodies across the province. It is important to note that LPP TP data are presented as two samples (TP1 and TP2) plus an average for each sampling date. TP1 and TP2 are duplicate TP concentrations which help to verify confidence in the results and provide a contingency against one sample being lost due to breakage during shipment or laboratory accidents. If there are major differences between TP1 and TP2, it is likely that one of the two samples was contaminated, for example by zooplankton or other debris. In this section, only averages are presented and in cases where there is a major difference between TP1 and TP2, averages are not included to avoid erroneous interpretations. TP1, TP2, and average TP are all reported in Appendix A.

Bayfield Nares Islanders' Association

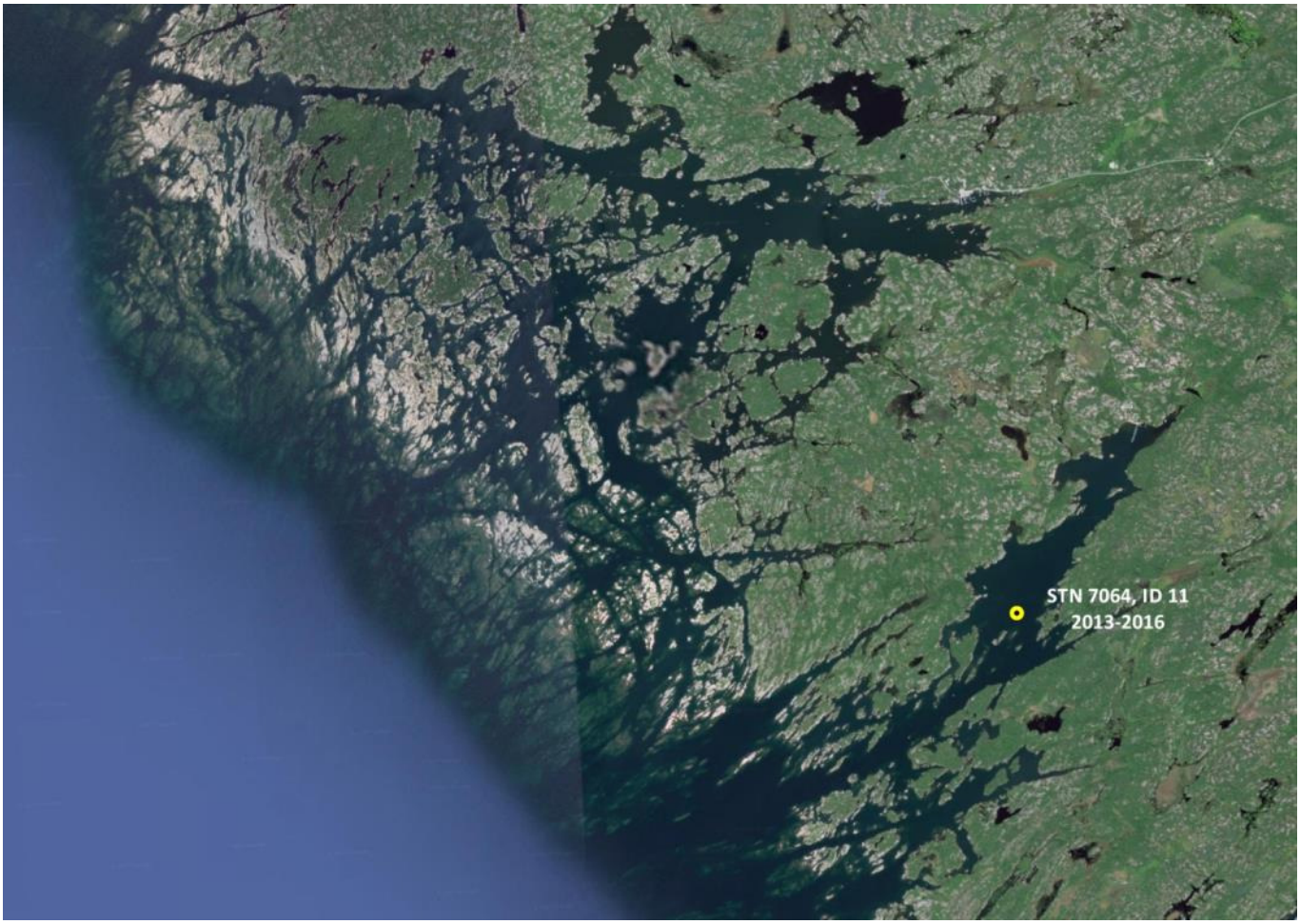
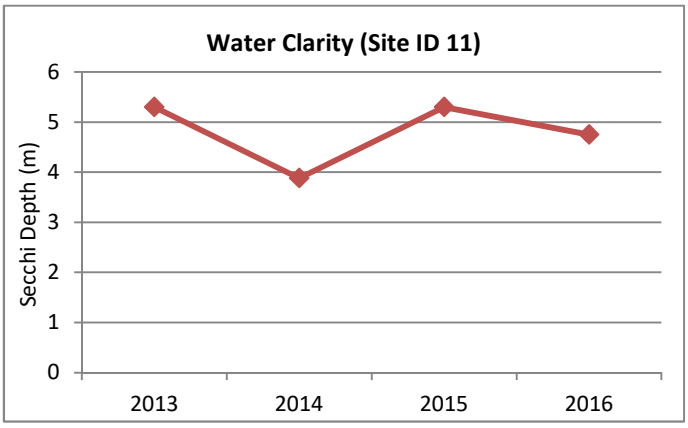


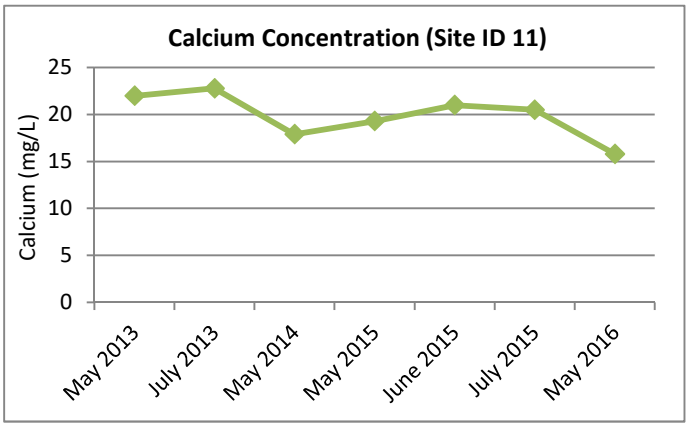
Figure 1. Active LPP sampling location.

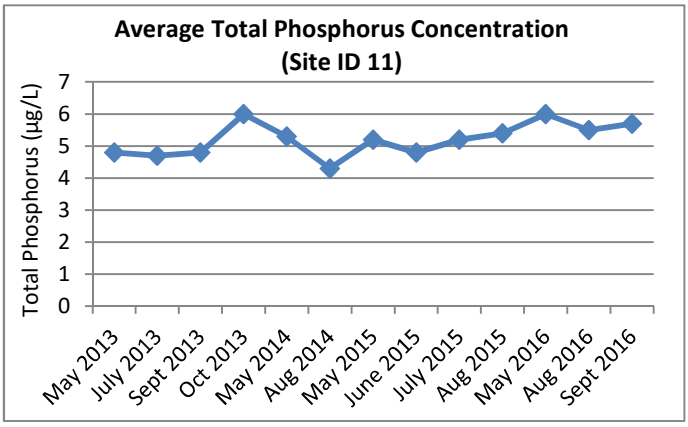
Nares Inlet

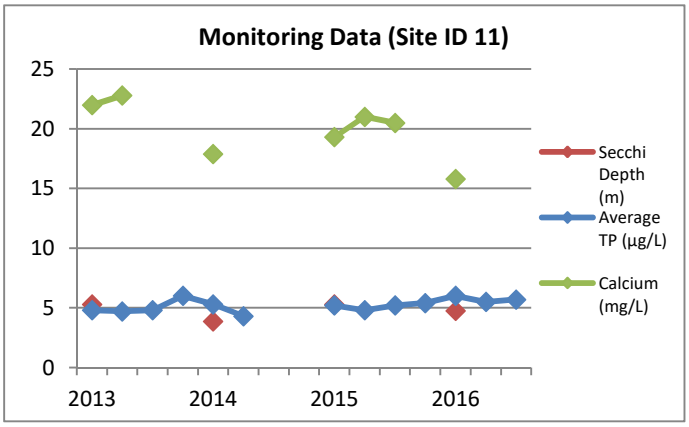
- Station: 7064
- Site ID: 11
- Description: Nares Inlet, deep spot
- Data collector: LPP volunteer
- Trophic status: oligotrophic
- Average TP: 6 µg/L
- Trend (Y/N): N
- Average Secchi depth: 4.8 m
- Visible outliers: none

Recommendation: continue with standard LPP monitoring at Site ID 11 (i.e., TP and calcium sampling once in May, water clarity measurements at least once every two weeks throughout the summer).


Water Clarity (Site ID 11)
Secchi Depth (m)
0
1
2
3
4
5
6
2013
2014
2015
2016


Calcium Concentration (Site ID 11)
Calcium (mg/L)
0
5
10
15
20
25
May 2013
July 2013
May 2014
May 2015
June 2015
July 2015
May 2016


Average Total Phosphorus Concentration (Site ID 11)
Total Phosphorus (µg/L)
0
1
2
3
4
5
6
7
May 2013
July 2013
Sept 2013
Oct 2013
May 2014
Aug 2014
May 2015
June 2015
July 2015
Aug 2015
May 2016
Aug 2016
Sept 2016


Monitoring Data (Site ID 11)
0
5
10
15
20
25
2013
2014
2015
2016
Secchi Depth (m)
Average TP (µg/L)
Calcium (mg/L)

Blackstone Lake Cottagers' Association

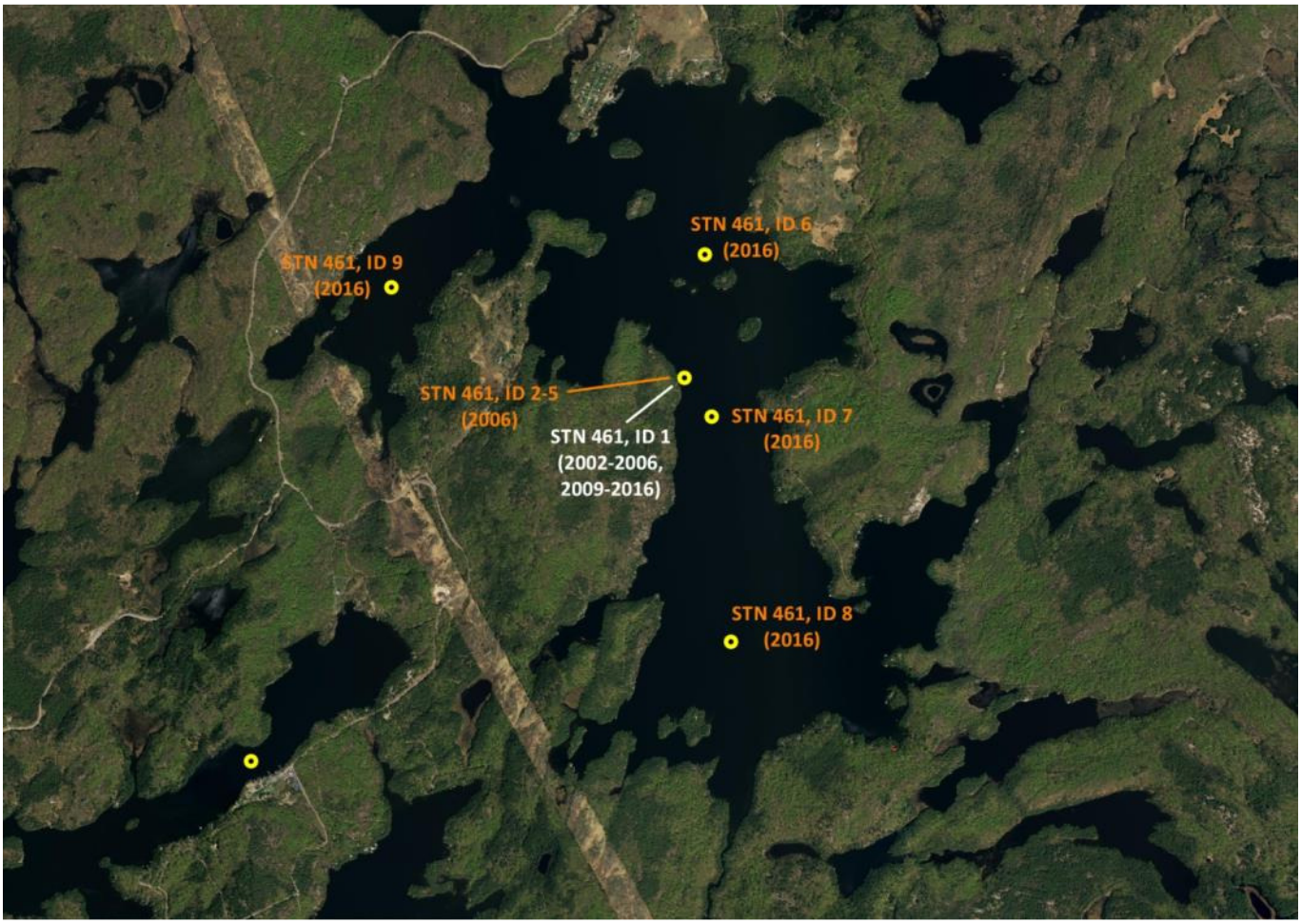
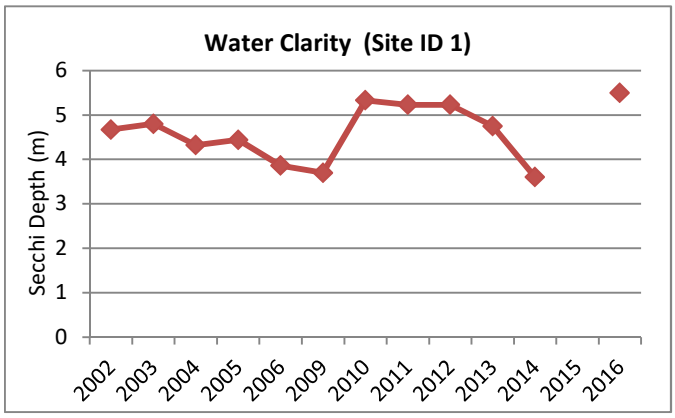


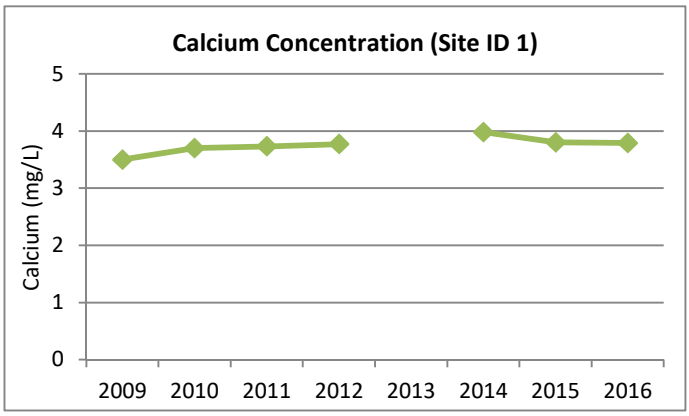
Figure 2. Active LPP sampling locations. Data collection at locations labelled in white is undertaken by LPP volunteers while data collection at locations labelled in orange is undertaken by the MOE Northern Region.

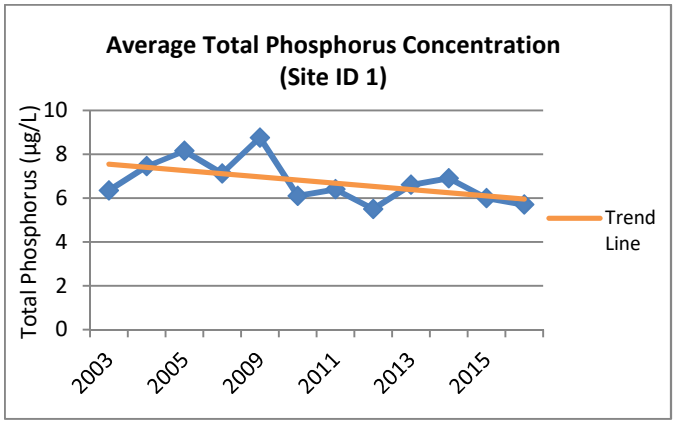
Blackstone Lake

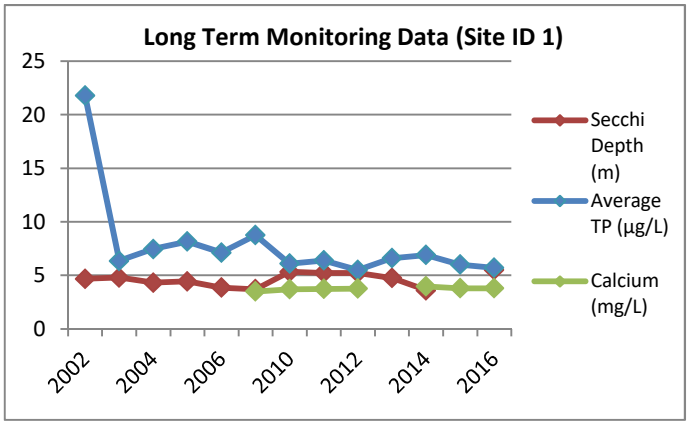
- Station: 461
- Site ID: 1
- Description: mid lake, deep spot
- Data collector: LPP volunteer
- Trophic status: oligotrophic
- Average TP: n/a
- Trend (Y/N): Y
- Average Secchi depth: 4.7 m
- Visible outliers: TP of 22 µg/L in 2002

Recommendation: continue with standard LPP monitoring at Site ID 1 (i.e., TP and calcium sampling once in May, water clarity measurements at least once every two weeks throughout the summer).









Station	Site ID	Description	2016 Average TP (µg/L)	Data Collector
461	6	BL02	5.30	MOE Northern Region
461	7	BL03	5.30	MOE Northern Region
461	8	BL04	5.00	MOE Northern Region
461	9	BL01	5.80	MOE Northern Region

Crane Lake Association

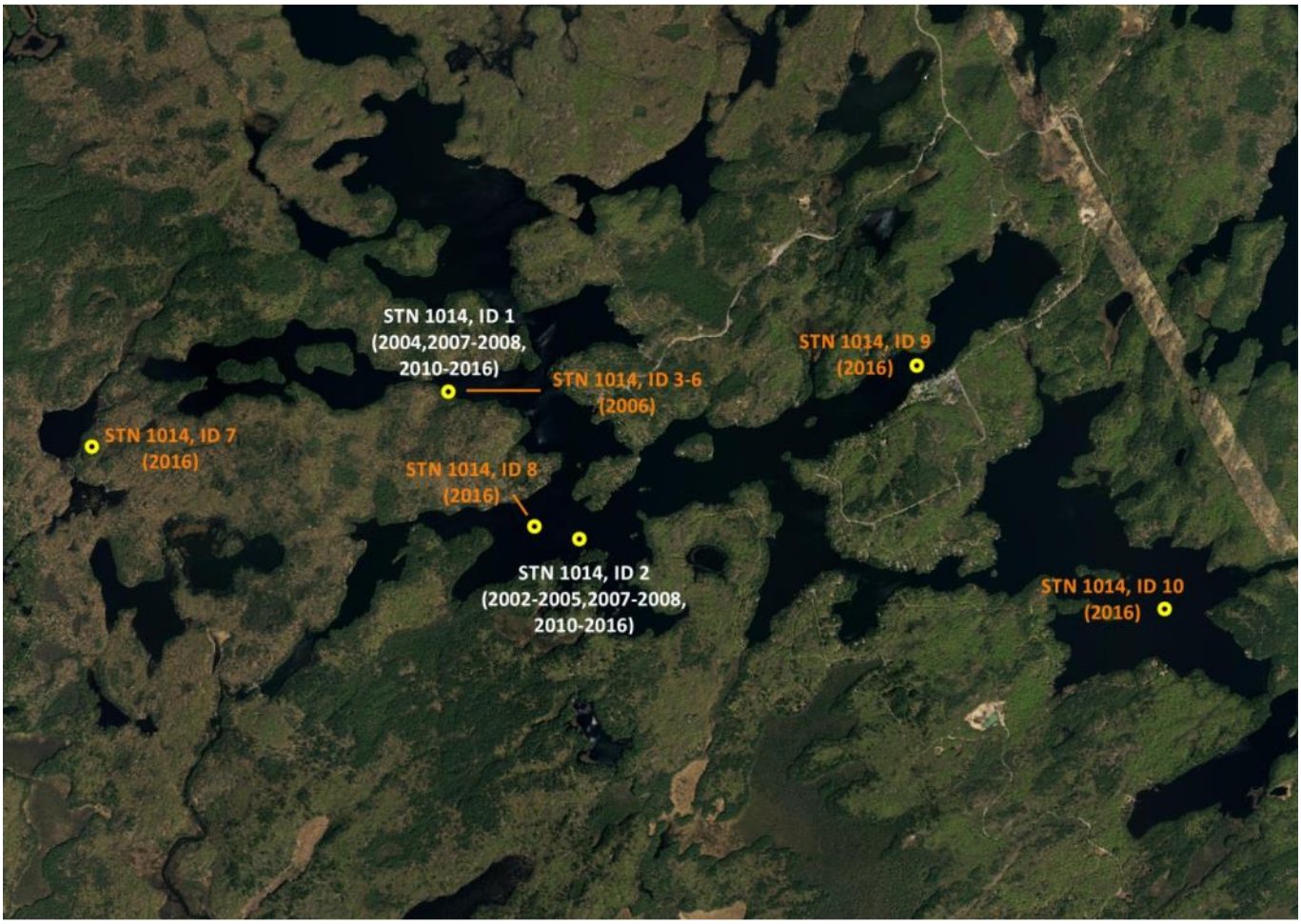
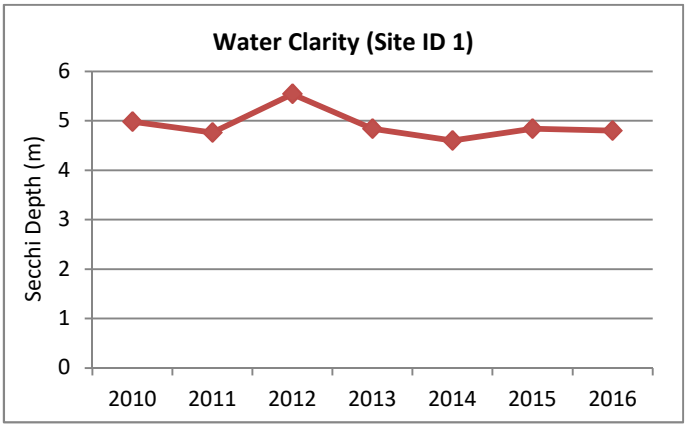


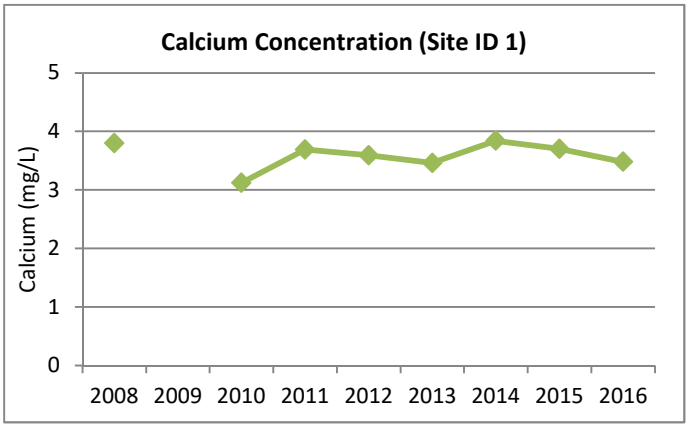
Figure 3. Active LPP sampling locations. Data collection at locations labelled in white is undertaken by LPP volunteers while data collection at locations labelled in orange is undertaken by the MOE Northern Region.

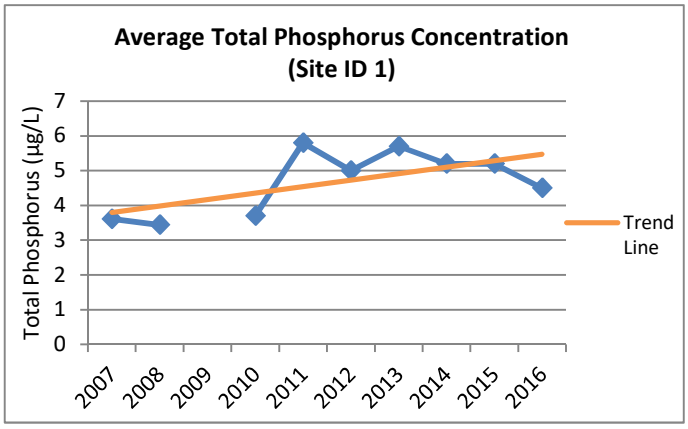
Crane Lake

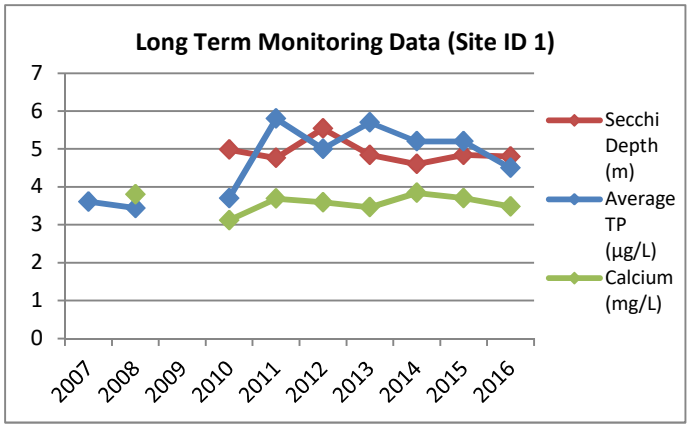
- Station: 1014
- Site ID: 1
- Description: mid-bay, deep spot
- Data collector: LPP volunteer
- Trophic status: oligotrophic
- Average TP: n/a
- Trend (Y/N): Y
- Average Secchi depth: 4.9 m
- Visible outliers: none

Recommendation: continue with standard LPP monitoring at Site ID 1 (i.e., TP and calcium sampling once in May, water clarity measurements at least once every two weeks throughout the summer).


Water Clarity (Site ID 1)
Secchi Depth (m)
0
1
2
3
4
5
6
2010
2011
2012
2013
2014
2015
2016


Calcium Concentration (Site ID 1)
Calcium (mg/L)
0
1
2
3
4
5
2008
2009
2010
2011
2012
2013
2014
2015
2016

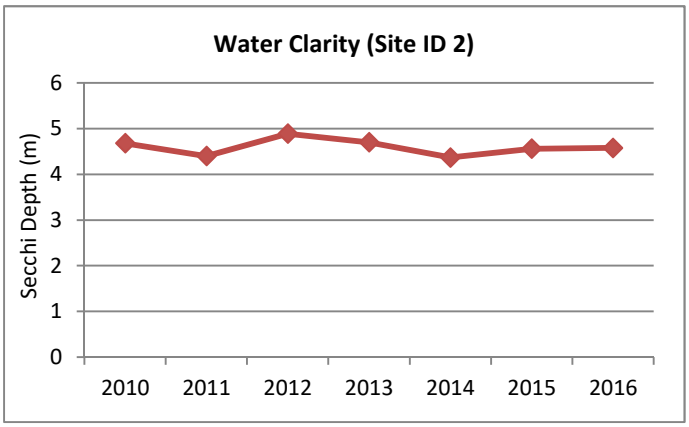

Average Total Phosphorus Concentration (Site ID 1)
Total Phosphorus (µg/L)
0
1
2
3
4
5
6
7
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Trend Line

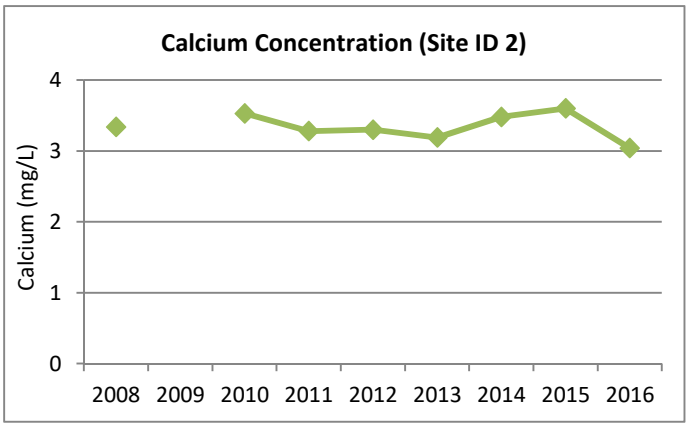

Long Term Monitoring Data (Site ID 1)
0
1
2
3
4
5
6
7
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Secchi Depth (m)
Average TP (µg/L)
Calcium (mg/L)

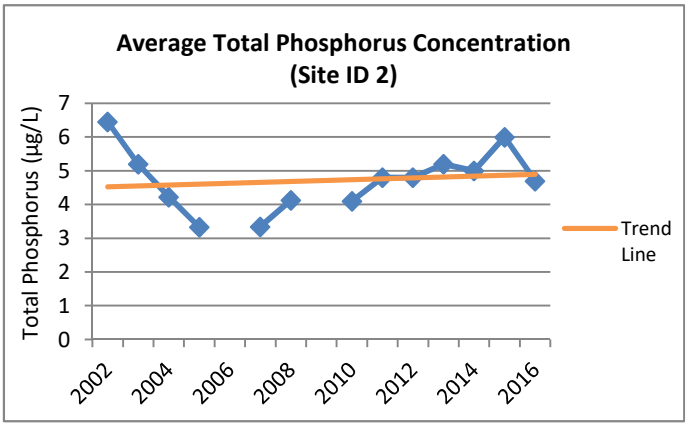
Crane Lake

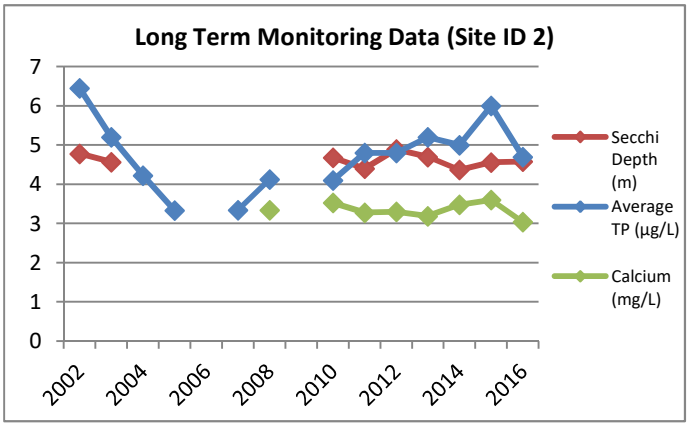
- Station: 1014
- Site ID: 2
- Description: N end, off Marsh Is.
- Data collector: LPP volunteer
- Trophic status: oligotrophic
- Average TP: n/a
- Trend (Y/N): Y
- Average Secchi depth: 4.6 m
- Visible outliers: none

Recommendation: continue with standard LPP monitoring at Site ID 2 (i.e., TP and calcium sampling once in May, water clarity measurements at least once every two weeks throughout the summer).









Station	Site ID	Description	2016 Average TP (µg/L)	Data Collector
1014	7	CR01	3.80	MOE Northern Region
1014	8	CR02	4.30	MOE Northern Region
1014	9	CR03	4.40	MOE Northern Region
1014	10	CR04	4.60	MOE Northern Region

Healey Lake Property Owners' Association

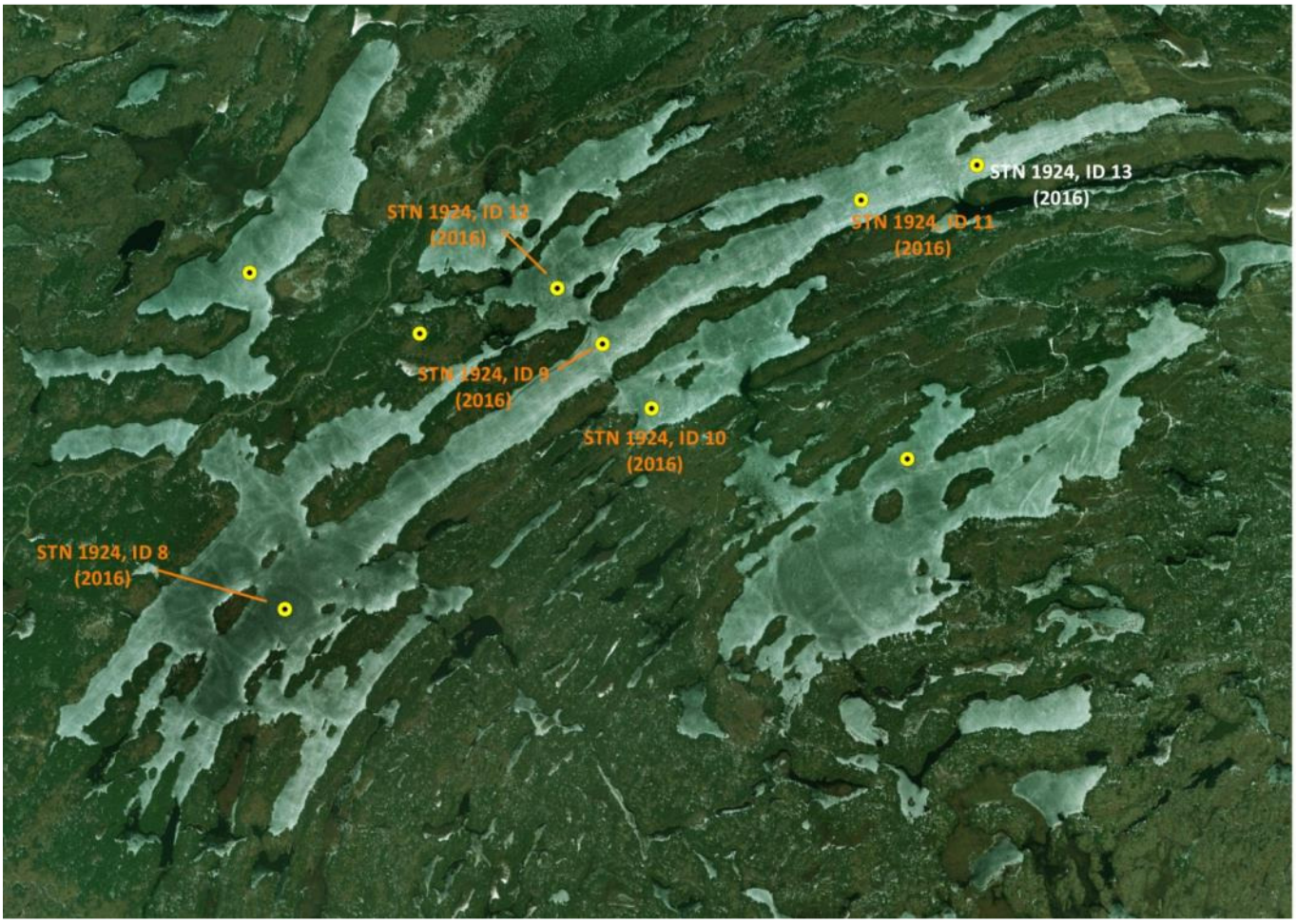


Figure 4. Active LPP sampling locations. Data collection at locations labelled in white is undertaken by LPP volunteers while data collection at locations labelled in orange is undertaken by the MOE Northern Region.

Healey Lake

Station	Site ID	Description	2016 Average TP (µg/L)	Data Collector
1924	8	HE01	5.1	MOE Northern Region
1924	9	HE02	5.2	MOE Northern Region
1924	10	HE03	4.7	MOE Northern Region
1924	11	HE04	5.6	MOE Northern Region
1924	12	HE05	5.3	MOE Northern Region
1924	13	Pinebay, Deep spot	6.6	LPP volunteer

Recommendation: continue with standard LPP monitoring at Site ID 13 (i.e., TP and calcium sampling once in May, water clarity measurements at least once every two weeks throughout the summer). Collect a water quality sample for DOC analysis (for further info contact GBBR 705-774-0978).

Iron City Fishing Club

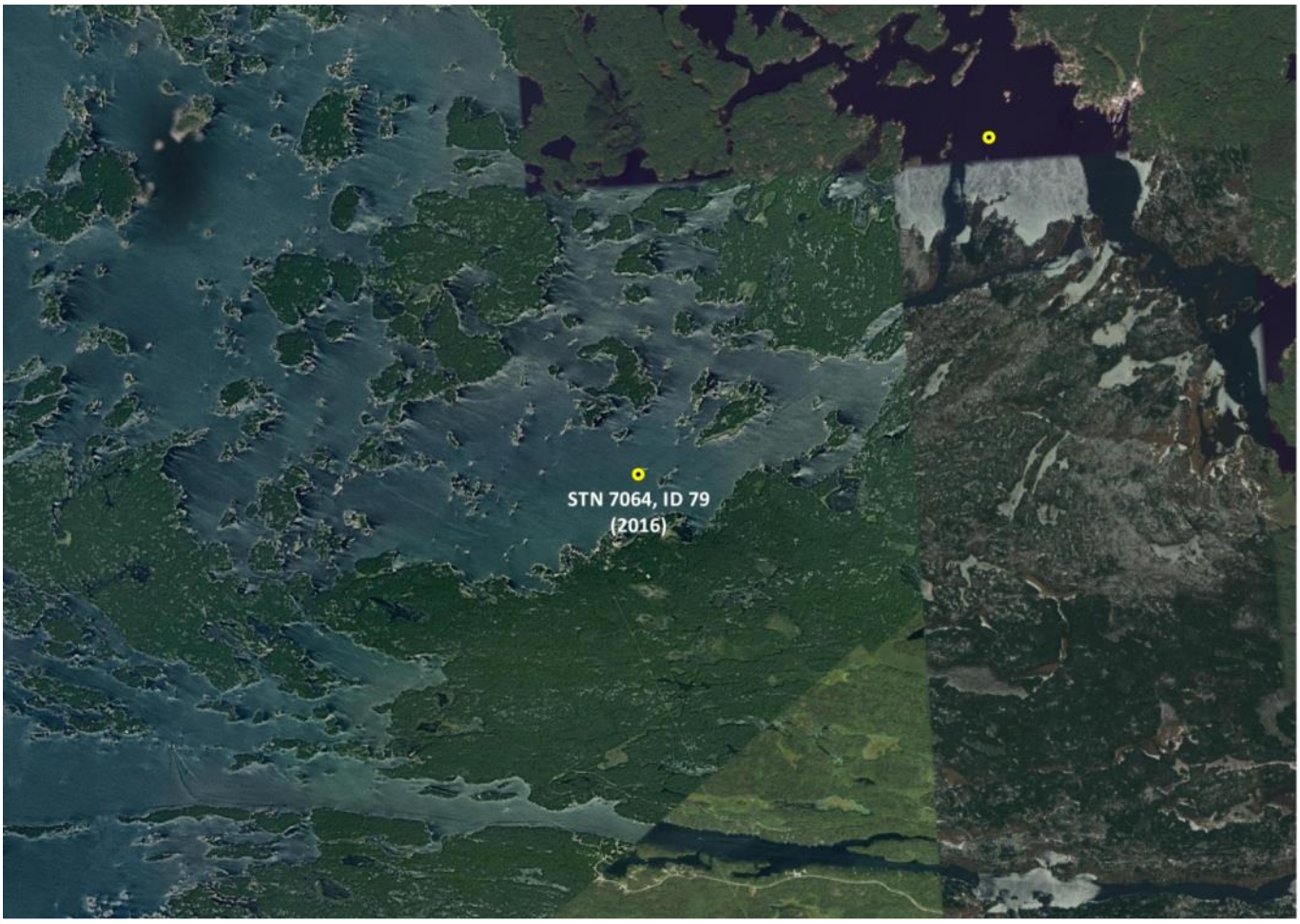


Figure 5. Active LPP sampling location.

Iron City Bay

Station	Site ID	Description	2016 Average TP (µg/L)	Data collector
7064	79	Iron City Bay, deep spot	10.30	LPP volunteer

Recommendation: continue with standard LPP monitoring at Site ID 79 (i.e., TP and calcium sampling once in May, water clarity measurements at least once every two weeks throughout the summer).

Kapikog Lake Cottagers' Association

Figure 6. Past LPP sampling location. LPP volunteers collected data during the years listed in white while the MOE Northern Region collected data during the year in orange.

Recommendation: reinitiate standard LPP monitoring at Site ID 2 (i.e., TP and calcium sampling once in May, water clarity measurements at least once every two weeks throughout the summer).

Naiscoot Lake Association

LPP monitoring has not previously been carried out on Naiscoot Lake.

Recommendation: refer to the *Enclosed Bays and Inland Lakes Phosphorus Monitoring Guideline* for information on selecting an LPP sampling location and begin standard LPP monitoring (i.e., TP and calcium sampling once in May, water clarity measurements at least once every two weeks throughout the summer).

Pointe au Baril Islanders' Association

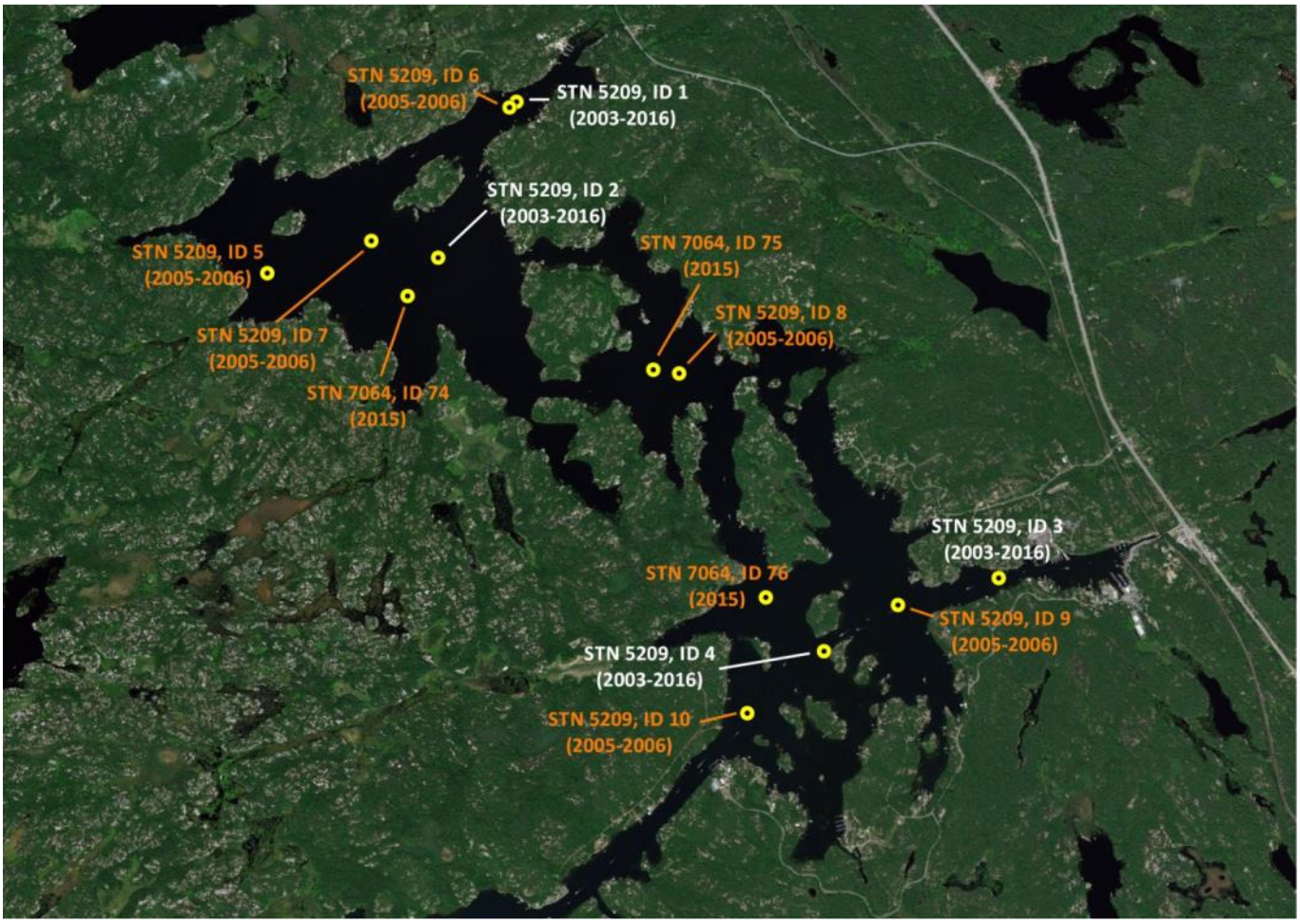
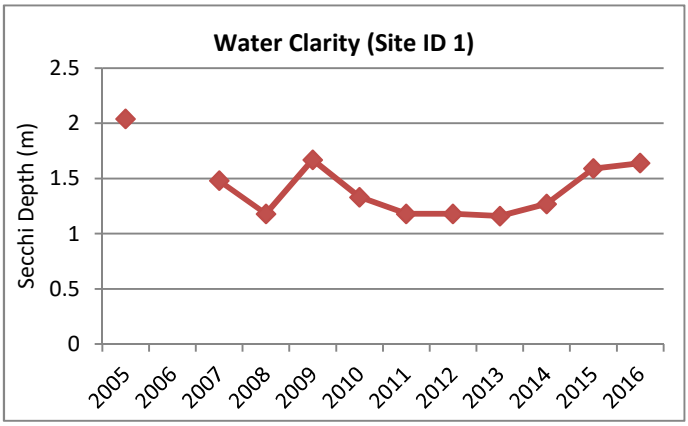


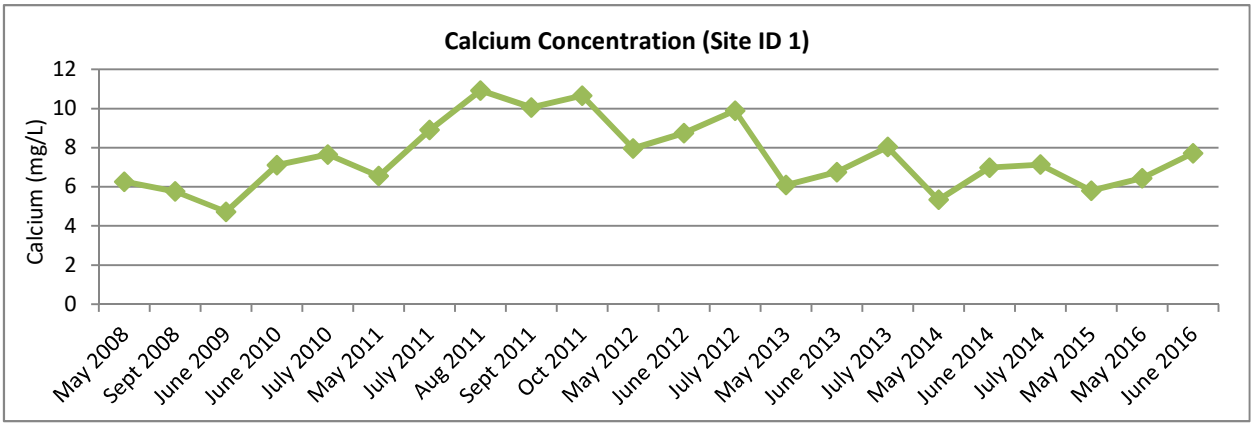
Figure 7. Past and current LPP sampling locations. Data collection at locations labelled in white is undertaken by LPP volunteers while data collection at locations labelled in orange was undertaken by the MOE Northern Region.

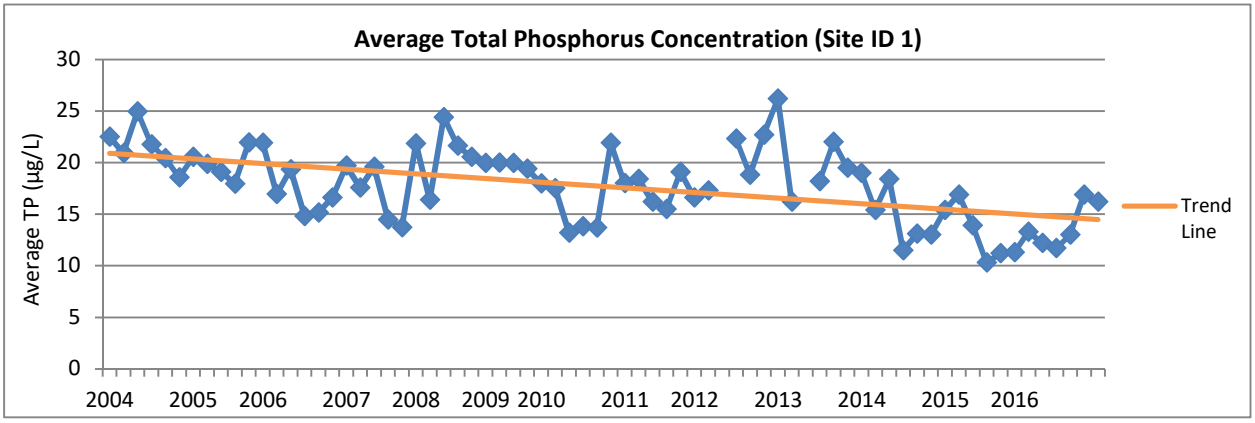
Sturgeon Bay

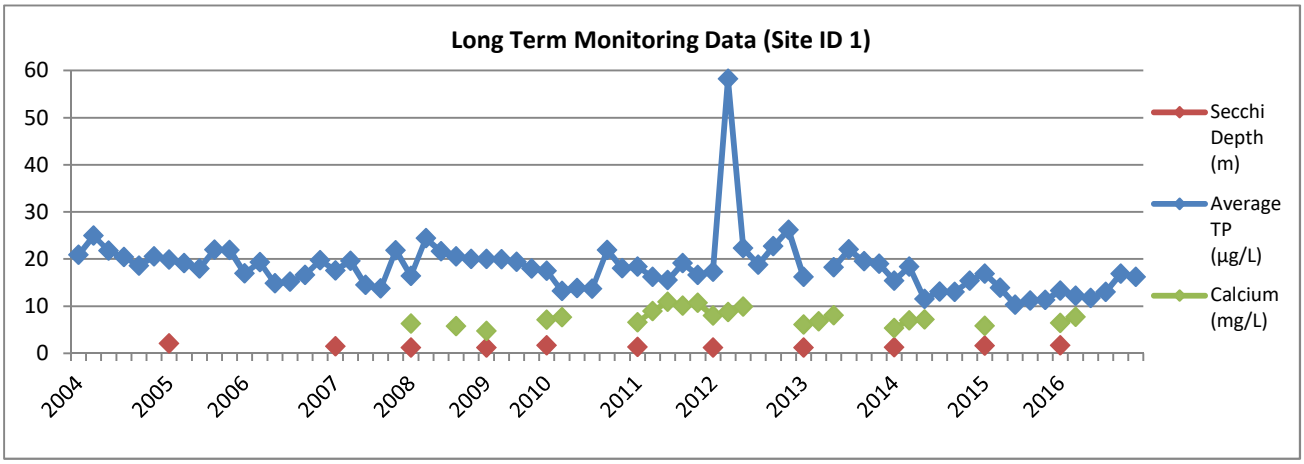
- Station: 5209
- Site ID: 1
- Description: W Sturgeon Bay Prov. Pk
- Data collector: LPP volunteer
- Trophic status: mesotrophic
- Average TP: n/a
- Trend (Y/N): Y
- Average Secchi depth: 1.4 m
- Visible outliers: TP of 58 µg/L in June 2012

Recommendation: continue LPP monitoring at Site ID 1 (i.e., monthly TP and calcium sampling, water clarity measurements at least once every two weeks throughout the summer).


Water Clarity (Site ID 1)
Secchi Depth (m)
2.5
2
1.5
1
0.5
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016


Calcium Concentration (Site ID 1)
Calcium (mg/L)
12
10
8
6
4
2
0
May 2008
Sept 2008
June 2009
June 2010
July 2010
May 2011
July 2011
Aug 2011
Sept 2011
Oct 2011
May 2012
June 2012
July 2012
May 2013
June 2013
July 2013
May 2014
June 2014
July 2014
May 2015
May 2016
June 2016

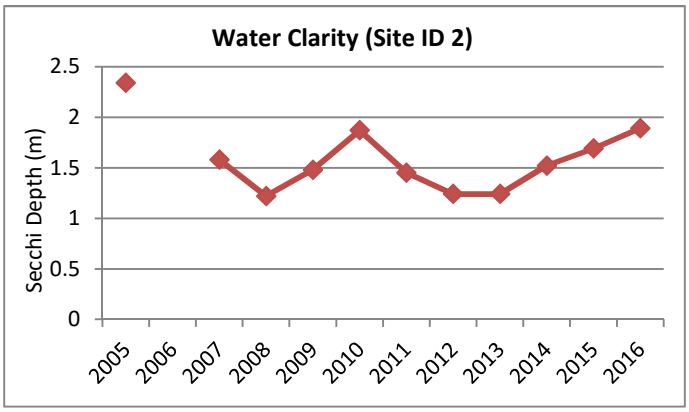

Average Total Phosphorus Concentration (Site ID 1)
Average TP (µg/L)
30
25
20
15
10
5
0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Trend Line

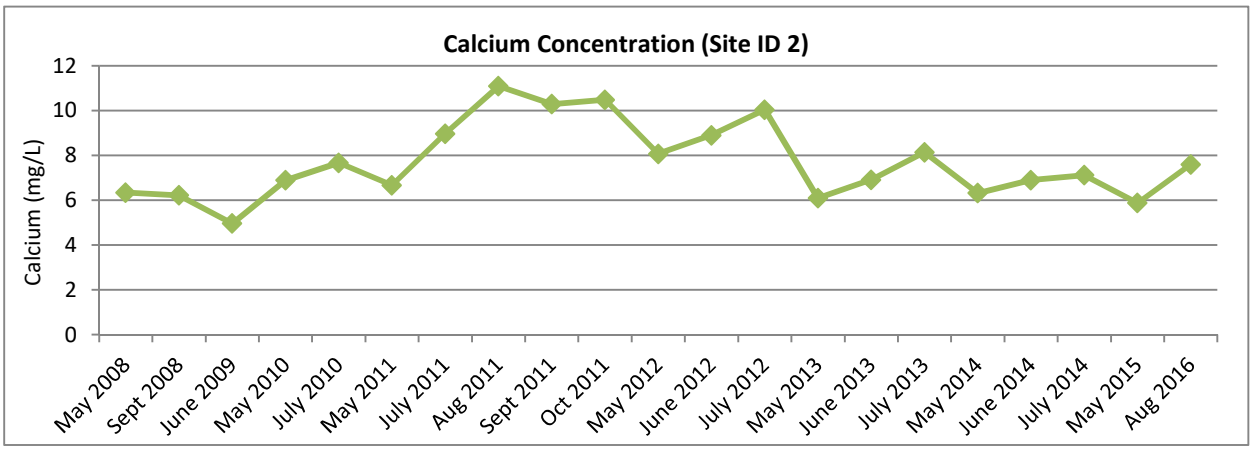

Long Term Monitoring Data (Site ID 1)
60
50
40
30
20
10
0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Secchi Depth (m)
Average TP (µg/L)
Calcium (mg/L)

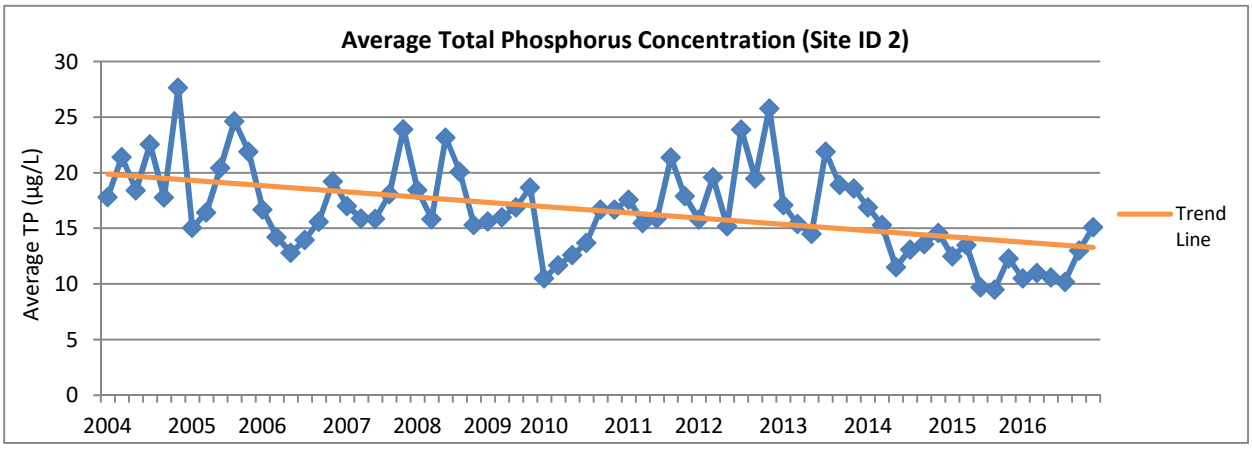
Sturgeon Bay

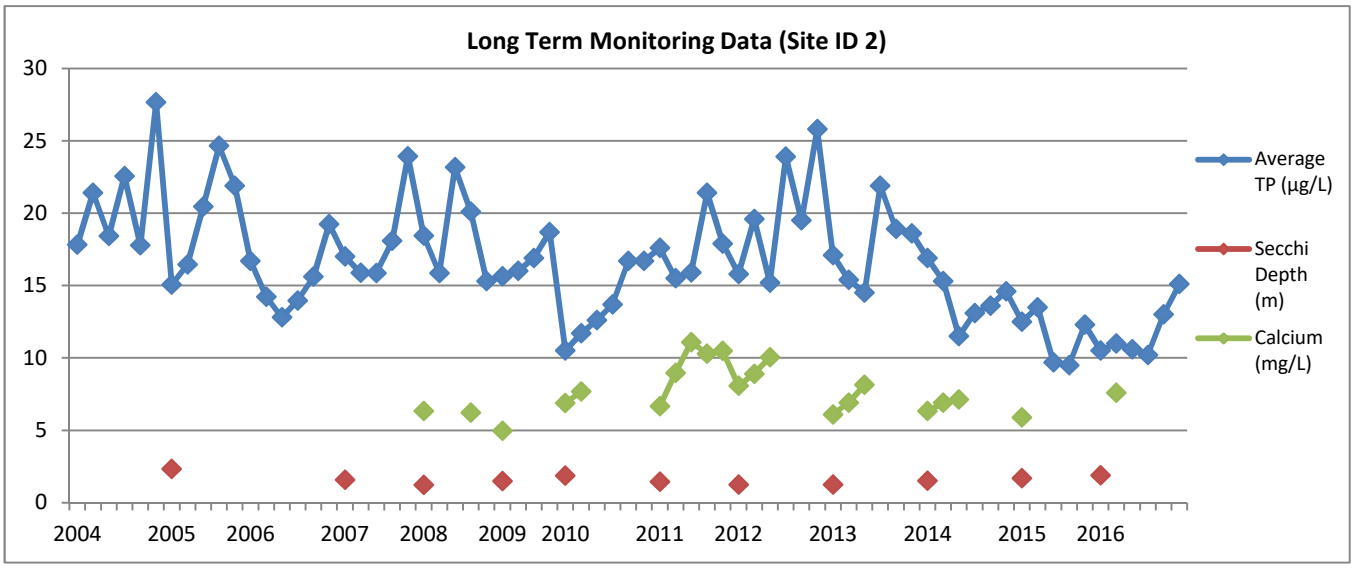
- Station: 5209
- Site ID: 2
- Description: Kenilworth & Skunk I
- Data collector: LPP volunteer
- Trophic status: mesotrophic
- Average TP: n/a
- Trend (Y/N): Y
- Average Secchi depth: 1.6 m
- Visible outliers: none

Recommendation: continue LPP monitoring at Site ID 2 (i.e., monthly TP and calcium sampling, water clarity measurements at least once every two weeks throughout the summer).





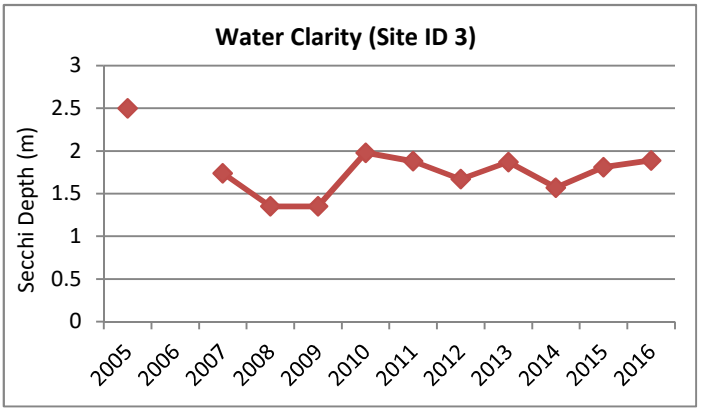


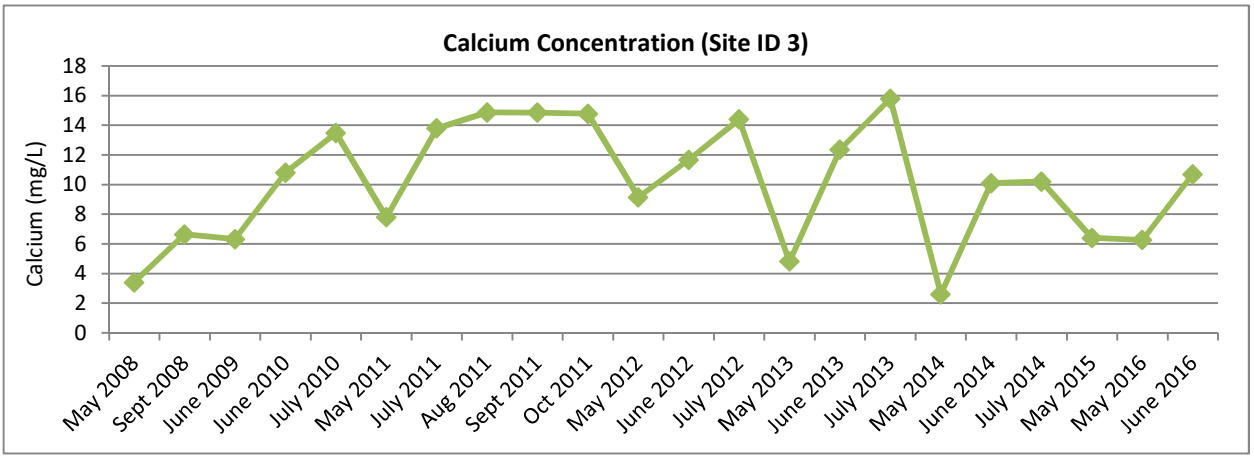

Long Term Monitoring Data (Site ID 2)
30
25
20
15
10
5
0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Average TP (µg/L)
Secchi Depth (m)
Calcium (mg/L)

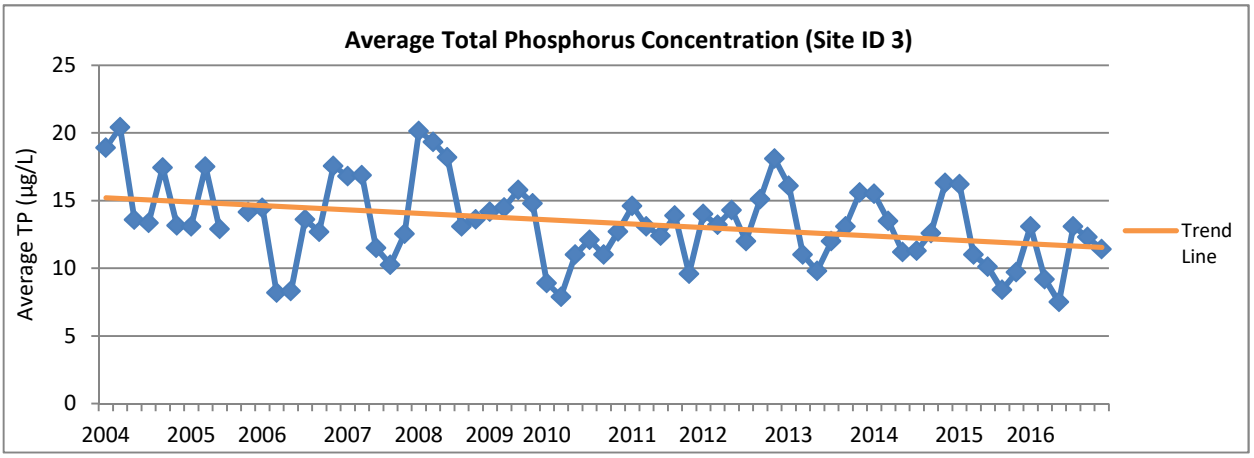
Sturgeon Bay

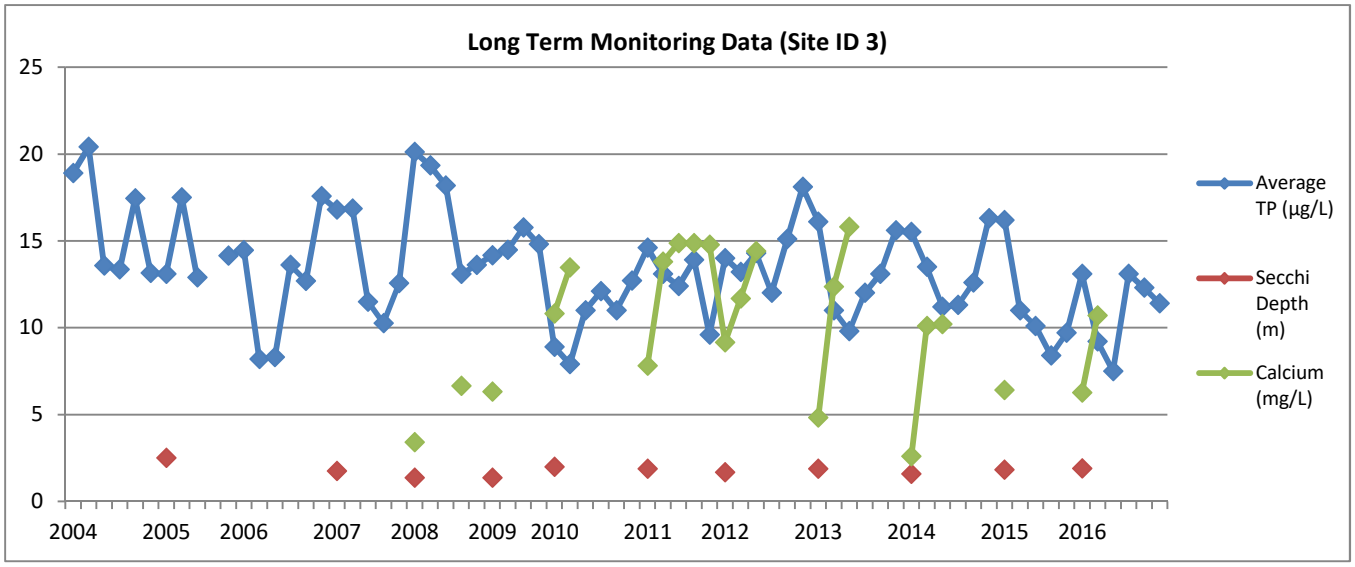
- Station: 5209
- Site ID: 3
- Description: Pointe au Baril chan
- Data collector: LPP volunteer
- Trophic status: mesotrophic
- Average TP: n/a
- Trend (Y/N): Y
- Average Secchi depth: 1.8 m
- Visible outliers: none

Recommendation: continue LPP monitoring at Site ID 3 (i.e., monthly TP and calcium sampling, water clarity measurements at least once every two weeks throughout the summer).





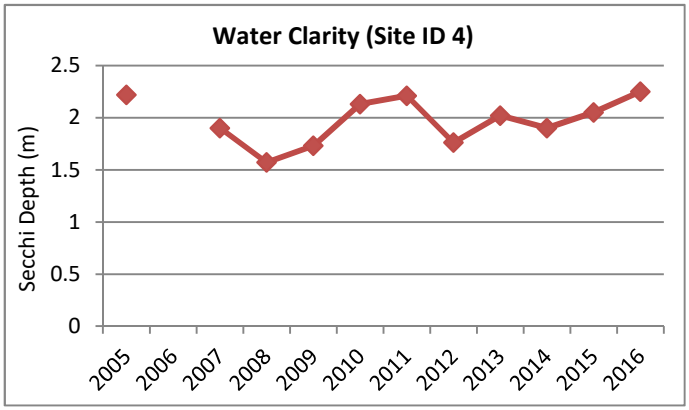


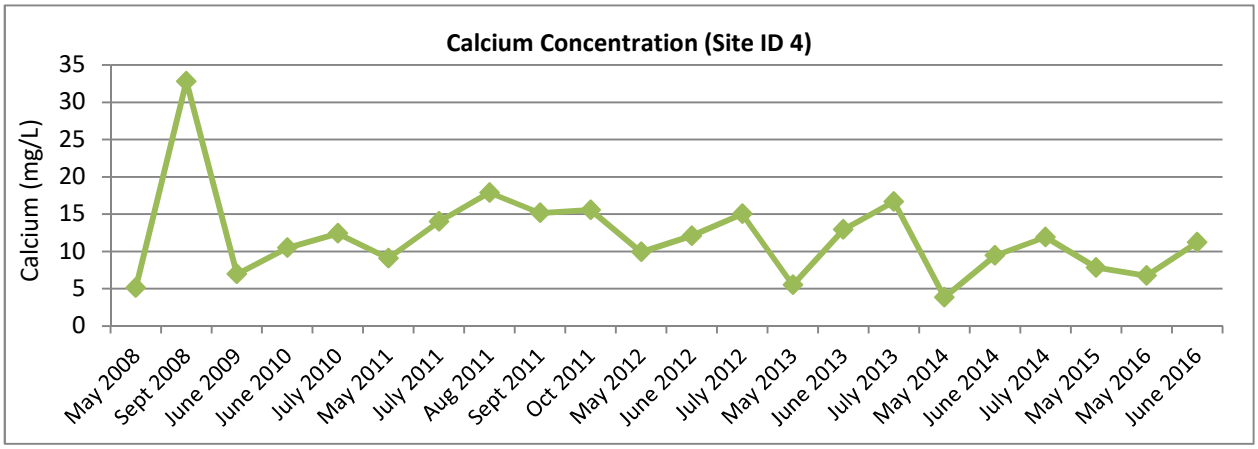

Long Term Monitoring Data (Site ID 3)
25
20
15
10
5
0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Average TP (µg/L)
Secchi Depth (m)
Calcium (mg/L)

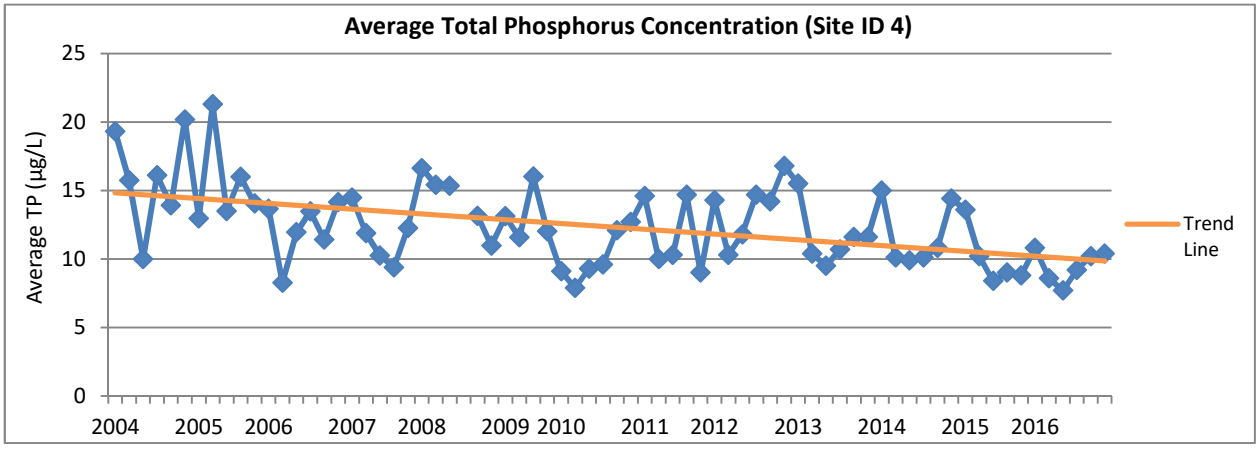
Sturgeon Bay

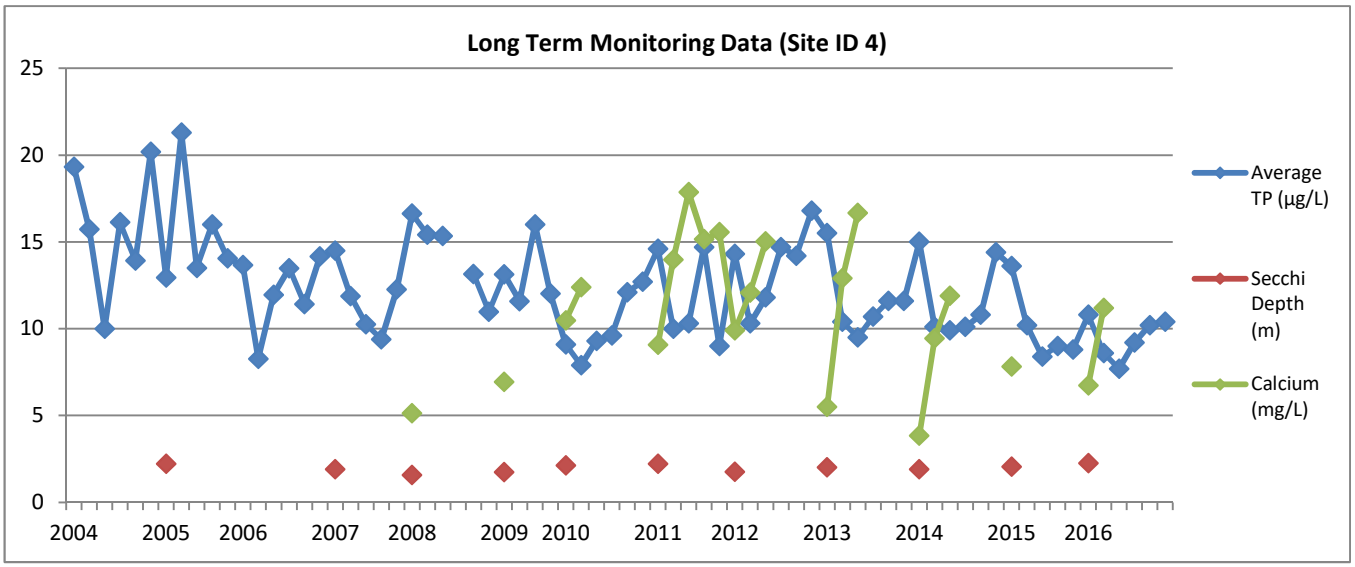
- Station: 5209
- Site ID: 4
- Description: W of School House Is
- Data collector: LPP volunteer
- Trophic status: mesotrophic
- Average TP: n/a
- Trend (Y/N): Y
- Average Secchi depth: 2 m
- Visible outliers: calcium concentration of 33 mg/L in September 2008

Recommendation: continue LPP monitoring at Site ID 4 (i.e., monthly TP and calcium sampling, water clarity measurements at least once every two weeks throughout the summer).








Long Term Monitoring Data (Site ID 4)
25
20
15
10
5
0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Average TP (µg/L)
Secchi Depth (m)
Calcium (mg/L)

Sans Souci & Copperhead Association

Figure 8. Recommended LPP sampling locations for 2017.

Recommendation: establish LPP sampling locations at recommended sites (sites 22 and 23 on page 14 of the *Enclosed Bays and Inland Lakes Phosphorus Monitoring Guideline*) and begin standard LPP monitoring (i.e., TP and calcium sampling once in May, water clarity measurements at least once every two weeks throughout the summer).

Skerryvore Ratepayers' Association

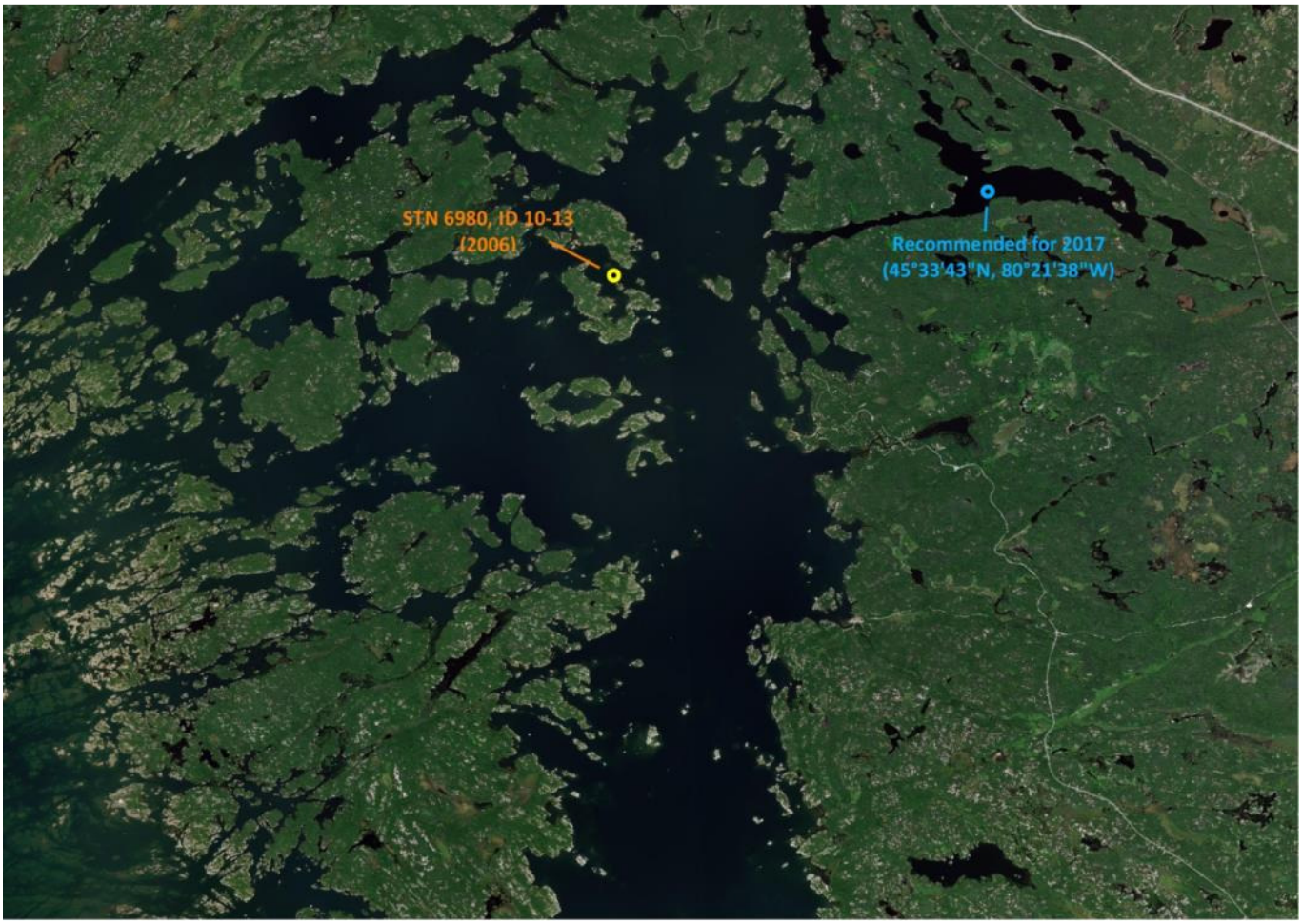


Figure 9. Past LPP sampling location with data collected by the MOE Northern Region and a recommended site for sampling in 2017.

Recommendation: establish an LPP sampling location at the recommended site (site 34 on page 17 of the *Enclosed Bays and Inland Lakes Phosphorus Monitoring Guideline*) and begin standard LPP monitoring (i.e., TP and calcium sampling once in May, water clarity measurements at least once every two weeks throughout the summer).

South Channel Association

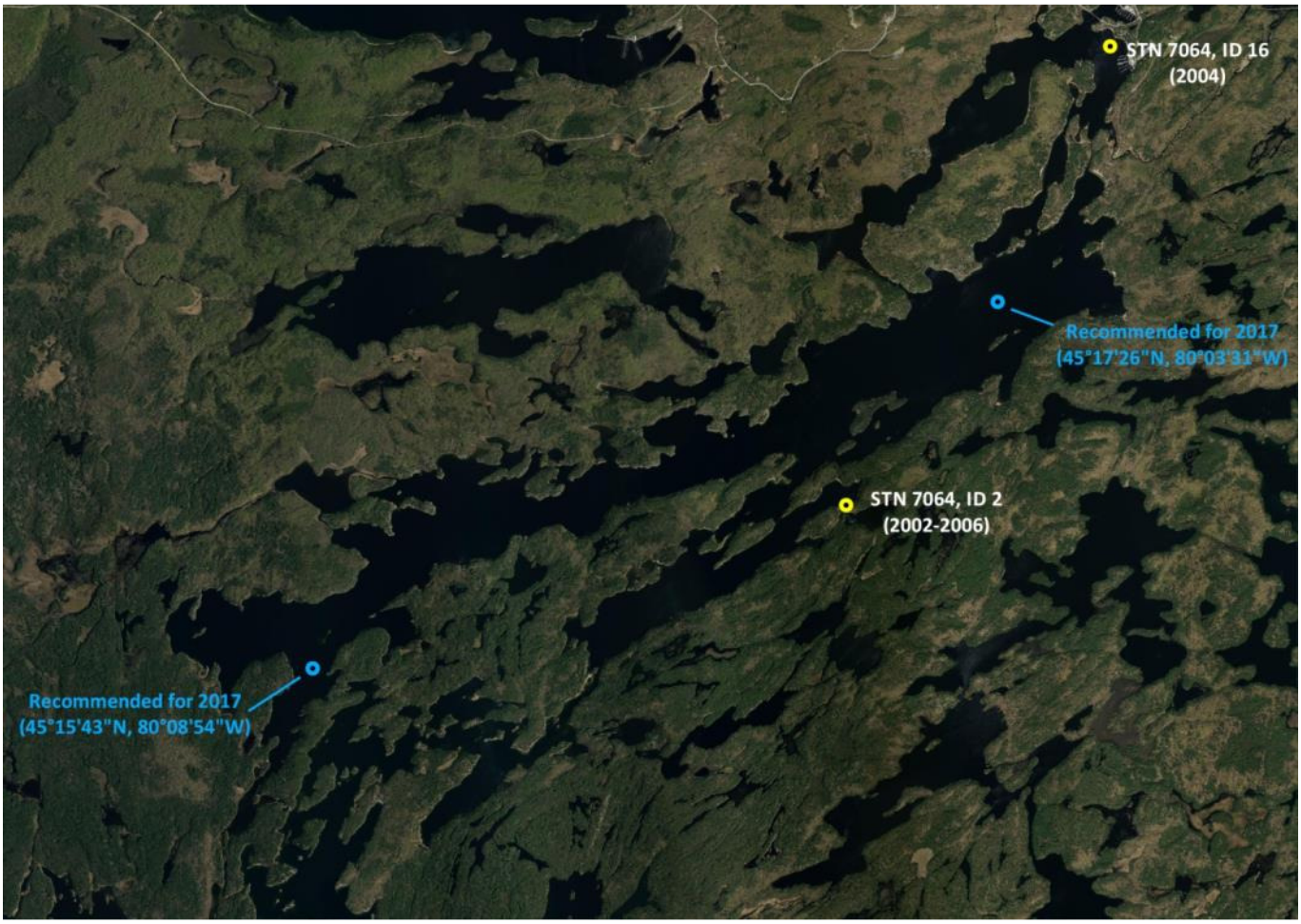


Figure 10. Past LPP sampling locations with data collected by LPP volunteers and recommended sites for sampling in 2017.

Recommendation: reinitiate standard LPP monitoring at Site ID 2 and Site ID 16 (i.e., TP and calcium sampling once in May, water clarity measurements at least once every two weeks throughout the summer). Establish LPP sampling locations at recommended sites (sites 25 and 27 on page 14 of the *Enclosed Bays and Inland Lakes Phosphorus Monitoring Guideline*) and begin standard LPP monitoring.

Three Legged Lake Association

Figure 11. Past LPP sampling locations. Data collection at the location labelled in white was undertaken by LPP volunteers while data collection at the location labelled in orange was undertaken by Seguin Township.

Recommendation: reinitiate standard LPP monitoring at Site ID 1 (i.e., TP and calcium sampling once in May, water clarity measurements at least once every two weeks throughout the summer).

Woods Bay Community Association

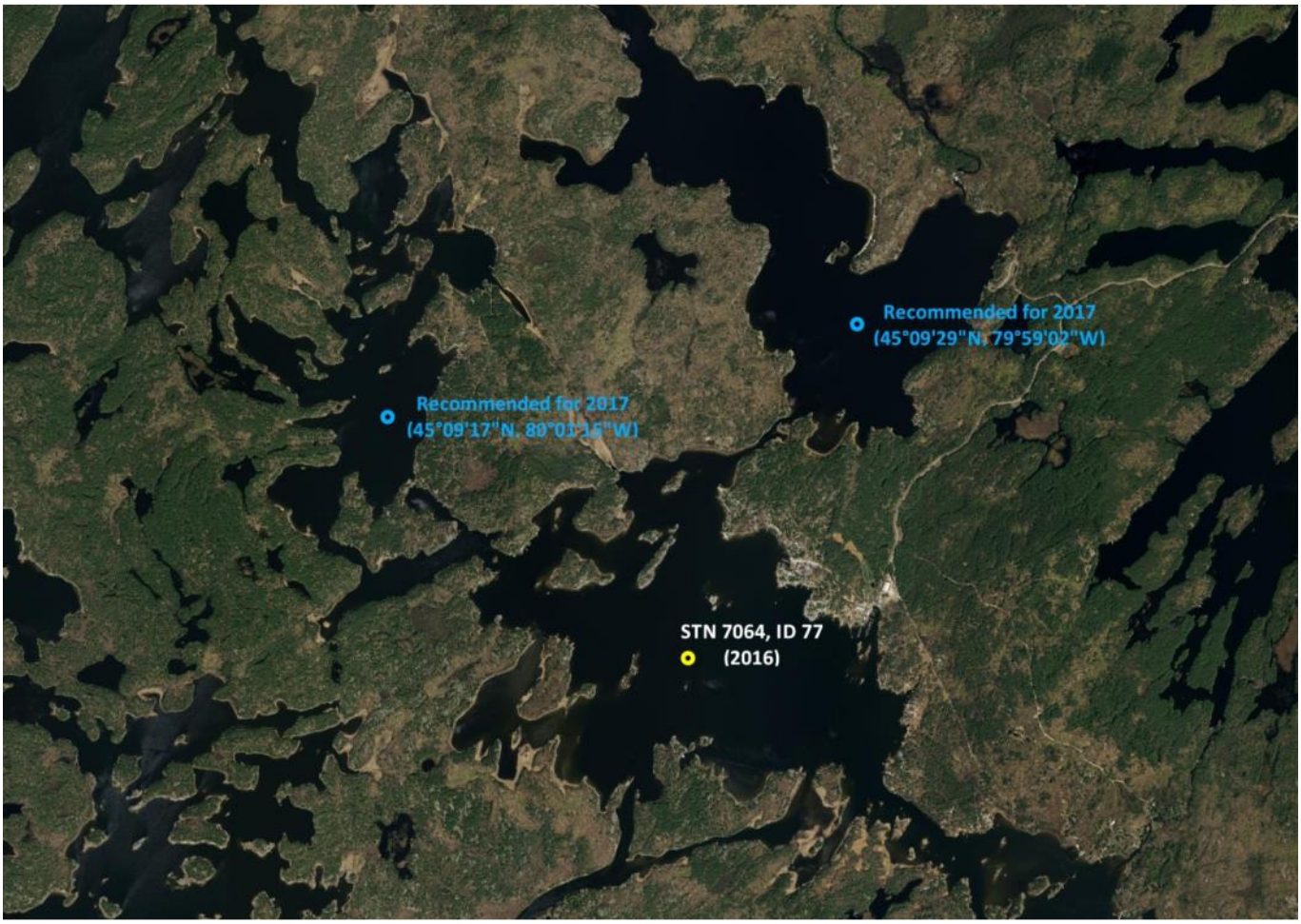


Figure 12. Active LPP sampling location with data collected by LPP volunteers and recommended sites for 2017.

Woods Bay

Station	Site ID	Description	2016 Average TP (µg/L)	Data collector
7064	77	Woods Bay, deep spot	14.80	LPP volunteer

Recommendation: continue with standard LPP monitoring at Site ID 77 (i.e., TP and calcium sampling once in May, water clarity measurements at least once every two weeks throughout the summer). Establish LPP sampling locations at recommended sites (sites 20 and 21 on page 14 of the *Enclosed Bays and Inland Lakes Phosphorus Monitoring Guideline*) and begin standard LPP monitoring.

Results – Enhanced Monitoring Sites

During the summer of 2016, GBBR and the TOA partnered with the Pointe au Baril Islanders Association (PABIA) and Woods Bay Community Association to conduct enhanced nutrient monitoring in order to better understand which areas of Sturgeon Bay and Blackstone Harbour are contributing to high phosphorus levels. This partnership involved training and loaning of equipment (with funding from ECCC). The objectives of enhanced nutrient monitoring are:

1) to map areas that 'stratify';
2) to collect vertical profiles; and
3) to collect late summer total phosphorus samples to confirm internal loads.

During summer months, many Ontario Shield lakes (that are deep enough) undergo thermal stratification (see Figure 13) whereby the surface water is mixed by wind down to a depth of ~4-7 m. This mixed layer is called the epilimnion. As the summer progresses the epilimnion will deepen to ~8-10 m. Below the epilimnion there is a zone where temperatures change very rapidly (getting colder) with depth, this is called the metalimnion. The metalimnion is usually several meters thick and the zone within it where temperature changes the most rapidly is called the thermocline. Below the thermocline is the hypolimnion where temperatures are colder and more stable with depth. During stratification these waters do not mix with surface water and cannot, therefore, be replenished if they are depleted of oxygen. If all the oxygen is used up (by bacteria) the hypolimnion is anoxic and these conditions can allow phosphorus from the sediments to enter the hypolimnion. This is called an internal load and these additional nutrients can stimulate late summer algal blooms. Therefore, it is important to assess oxygen and nutrient concentrations in the hypolimnion to help predict the onset of conditions which might lead to algal blooms.

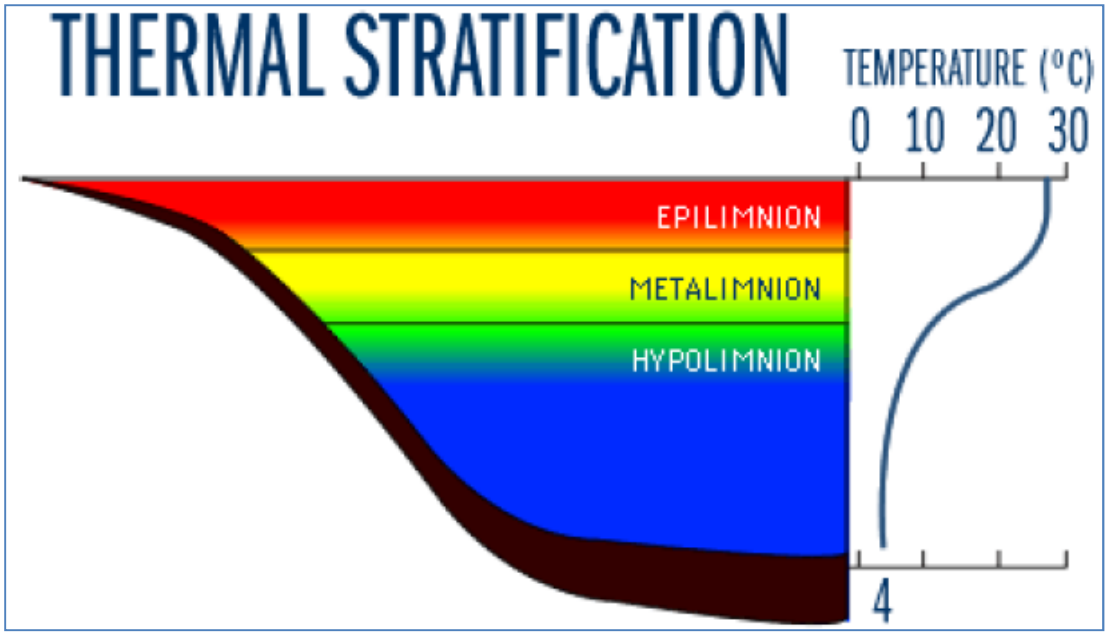


Figure 13. Thermal stratification of a lake into three identifiable layers (source: http://cfpub.epa.gov/watertrain/pdf/limnology.pdf).

Individuals interested in learning more about thermal stratification and how it changes throughout the seasons are encouraged to read the *State of the Bay Background Report* (available here).

Sturgeon Bay

Enhanced monitoring was initiated on Sturgeon Bay in 2016 as part of GBBR's *Coordinated Nutrient Monitoring Program*. Sturgeon Bay suffers from intermittent late summer cyanobacteria blooms and although there have been several in-depth studies conducted in this area (available here), there are no monitoring programs currently in place that regularly measure temperature and dissolved oxygen (DO) profiles. These measurements are necessary to evaluate the extent of hypolimnetic anoxia and the associated potential for the release of phosphorus from lake sediments into the water column (internal loading). PABIA summer staff collected temperature and oxygen profiles during the summer of 2016 at the locations shown in Figure 14. These locations represent the deepest sites and are prioritized accordingly. Additional locations can be sampled where time permits.

Figure 14. Sturgeon Bay sample locations for temperature and dissolved oxygen in 2016.

GBBR staff sampled TP at 1 m off bottom prior to turnover in the fall at the deepest location in Sturgeon Bay (SB2 on Figure 14).

LPP volunteers sampled TP monthly at several locations.

Temperature/dissolved oxygen

PABIA staff collected temperature/DO profiles during routine patrols in the summer of 2016. Results are summarized in Table 1 and shown in detail in Appendix B. These data show that Sturgeon Bay is thermally stratified in the deepest locations and that an anoxic hypolimnion develops soon after stratification. It is important to note that Sturgeon Bay's maximum depth is only slightly deeper than the

average maximum mixed layer (epilimnion) depths for Shield lakes (9-11 m). Lakes shallower than this will mix to the bottom and will not stratify thermally (i.e., not develop a hypolimnion near the bottom where internal loads can develop). Sturgeon Bay develops a shallow hypolimnion (several meters deep) in relatively small areas of the lake. Over most of the waterbody's area the water will mix to the bottom and in some areas there will be a metalimnion with no stable hypolimnion near the bottom. These areas may still develop internal loads. In those areas that are deep enough to stratify (>9 m), the stratification may be weak or temporary on a seasonal basis. As a result, anoxic sediment with potential to contribute to internal loads may be present in areas of the lake at certain times of year but not at others, making it difficult to assess the extent of areas that can generate internal loads. A good example of this is shown by the temperature/DO profiles measured at SB1 and SB2 on August 23, 2016. SB1, which is more protected from wind, is mixed on that date to a depth that is 2 m less than at SB2. Anoxic water exists near the bottom at SB1 at depths that are fully oxygenated at SB2. It is therefore not possible to say that on any given date, Sturgeon Bay is anoxic below those depths that are indicated by data collected only at the deepest location. In addition, the extent of anoxic sediments that are overlain by a mixed oxygenated water column is not known. These anoxic sediments may still contribute P to the mixed water column.

More comprehensive temperature/DO data collected at numerous locations may explain why Sturgeon Bay blooms in some years but not in others.

Table 1. Summary of temperature/dissolved oxygen profiles collected in Sturgeon Bay in 2016

Site	Latitude	Longitude	Depth (m)	Date	Epi.[a] (m)	Meta.[b] (m)	Hypo.[c] (m)	Anoxic (m)
SB1	45 36.773	80 26.519	8	28-Jul-16	0-7	7-8		At 8
			9	5-Aug-16	0-7	7-8	8-9	8-9
			9	23-Aug-16	0-7	7-9		8-9
SB2	45 36.921	80 26.128	11	28-Jul-16	0-7	7-8	8-11	8-11
			12	23-Aug-16	0-9	9-10	10-12	10-12
			14	28-Sep-16	0-11	11-14		13-14
SB4	45 36.672	80 25.599	13	13-Aug-16	0-8	8-10	10-13	10-13
SB9	45 35.562	80 23.632	12	23-Aug-16	0-9	9-10	10-12	10-12

[a] Epilimnion, [b] Metalimnion, [c] Hypolimnion

Total phosphorus

GBBR staff collected TP samples at the end of the summer in 2016. The results show a deep mixed layer with elevated TP concentrations only in the bottom 1 m. TP concentrations in the anoxic layer are less than 200 µg/L which is not indicative of a large internal load (Table 2). Much of the TP that enters the lake from the sediments (in lakes that have no oxygen in the bottom waters) will enter the water column during the summer months and this can result in higher TP concentrations in mid to late summer. This is illustrated by increasing concentrations in the mixed layer at the deep location observed by LPP volunteers in 2016 (Table 3, STN 7064).

Table 2. End of summer TP concentrations at the deepest location in Sturgeon Bay in 2016. TP1 and TP2 represent duplicate analysis of split samples.

Sample Description	Sample Date	TP1(ug/L)	TP2 (ug/L)
Sturgeon Bay 1m	28-Sep-16	20.3	20.7
Sturgeon Bay 13m	28-Sep-16	18.9	21.8
Sturgeon Bay 14m	28-Sep-16	195.3	187.2

LPP volunteers have historically sampled several locations in the Sturgeon Bay area (Figure 15). Some of these locations were sampled only once and some have longer term data. These data are summarized on the LPP website. The LPP data collected in Sturgeon Bay in 2016 are shown in (Appendix A).

Figure 15. Lake Partner Program sample locations in Sturgeon Bay and Pointe au Baril.

Recommendations

The 2016 data reveal much about the interdependence between oxygen, total phosphorus and physical limnology in Sturgeon Bay. It is recommended that these collection protocols continue in future years.

Blackstone Harbour

Blackstone Harbour was identified as an enclosed embayment that thermally stratifies. Although Blackstone Harbour has never been known to have late summer algal blooms, it was selected for enhanced monitoring to investigate areas that stratify to identify potential anoxic conditions in the hypolimnion. An enhanced sampling program was initiated late in the summer of 2016 in time to observe temperature/oxygen profiles and collect TP samples from the mixed layer and 1 m off bottom at the deepest location in Blackstone Harbour (21 m). Sample location Lat 45° 09' 32", Long 79° 58' 56" is shown in Figure 16.

Figure 16. Sample location in Blackstone Harbour.

Temperature/dissolved oxygen

Blackstone Harbour is relatively deep (21 m) compared to other adjacent embayments (e.g., Woods Bay <10 m) and is well stratified. Late summer anoxia was observed in the bottom 2 m indicating the potential for an internal load. Temperature/DO data collected on September 30, 2016 is shown in Table 3.

Table 3. Temperature/dissolved oxygen data for the deepest location in Blackstone Harbour on September 30, 2016.

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)
0	17.8	9.6
1	17.9	9.4
2	17.9	9.4
3	17.9	9.3

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)
4	17.9	9.2
5	18	9.2
6	18	9.2
7	18	9.2
8	18	9.1
9	17.7	8
10	11.1	4.7
11	9.2	4.4
12	8.5	4.5
13	7.8	4.6
14	7.2	4.5
15	6.9	4.1
16	6.7	3.6
17	6.5	2.9
18	6.4	1.8
19	6.2	1.2
20	6.2	0.8
21	6.2	0.6

Total phosphorus

TP was measured at the surface on September 2 and 30, 2016 with similar results on both dates (Table 4). Concentrations ranged from 6.7 µg/L to 8.4 µg/L. More results are needed to establish long-term, mean concentrations but these values represent oligotrophic conditions with excellent water quality as it relates to trophic state. At the end of September there was a slight elevation in TP concentrations at 1 m off bottom (21.5 µg/L) indicating a weak internal load.

Table 4. Total phosphorus concentrations in Blackstone Harbour in 2016. TP1 and TP2 represent duplicate analysis of split samples.

Sample Description	Sample Date	TP1 (µg/L)	TP2 (µg/L)
Blackstone Harbour Top	02-Sep-16	8.8	7.9
Blackstone Harbour Top	30-Sep-16	6.5	6.7
Blackstone Harbour Bottom	30-Sep-16	22.7	20.5

Recommendations

Sampling for DO and TP should continue in Blackstone Harbour. TP concentrations indicate excellent water quality but anoxic conditions and evidence of an internal load warrant further investigation. At present, there is evidence that climate change can enhance the conditions required to support algal blooms. In particular, the blooms may occur in areas where they have not previously been seen and where watershed nutrient loads may not have increased.

Appendix A – LPP monitoring data for active and historical sampling locations

All Lake Partner Program monitoring data for Township of the Archipelago sampling locations, active and historical, are provided in the tables below, organized by ratepayer association.

Bayfield Nares Islanders' Association

Lake	Georgian Bay
Station	7064
Site ID	11
Description	Nares Inlet, deep spot
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
May 2013	5.30	4.20	5.40	4.80	21.98
July 2013		4.40	5.00	4.70	22.79
Sept 2013		4.80	4.80	4.80	
Oct 2013		6.60	5.40	6.00	
May 2014	3.88	5.80	4.80	5.30	17.90
Aug 2014		4.20	4.40	4.30	
Sept 2014		15.80	6.20	11.00	
Oct 2014		5.20	10.80	8.00	
May 2015	5.30	4.60	5.80	5.20	19.30
June 2015		5.20	4.40	4.80	21.00
July 2015		5.20	5.20	5.20	20.50
Aug 2015		5.20	5.60	5.40	
May 2016	4.75	4.80	7.20	6.00	15.80
Aug 2016		5.20	5.80	5.50	
Sept 2016		6.00	5.40	5.70	

*Data have been 'flagged' in yellow when there are major differences between TP1 and TP2. When there are major differences between TP1 and TP2, it is probable that one of the two samples was contaminated (usually the higher value). Contamination can occur when the sample water contains zooplankton or other debris. Use caution when interpreting TP data that has been flagged.

Blackstone Lake Cottagers' Association

Lake	Blackstone Lake
Station	461
Site ID	1
Description	Mid lake, deep spot
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2000	6.00				
2001	5.00				
2002	4.67	24.40	19.20	21.80	
2003	4.80	6.40	6.30	6.35	
2004	4.32	7.09	7.81	7.45	
2005	4.44	7.20	9.10	8.15	

2006	3.86	7.35	6.88	7.12	
2009	3.70	7.26	10.26	8.76	3.50
2010	5.33	7.20	5.00	6.10	3.70
2011	5.23	6.20	6.60	6.40	3.73
2012	5.23	5.40	5.60	5.50	3.77
2013	4.75	6.80	6.40	6.60	
2014	3.60	8.40	5.40	6.90	3.98
2015		6.20	5.80	6.00	3.80
2016	5.50	5.00	6.40	5.70	3.79

Lake	Blackstone Lake
Station	461

Year	Site ID	Description	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Data Collector
2006	2	Driscoll 1	5.0	4.6	4.84	MOE Northern Region
2006	3	Driscoll 2	4.4	4.7	4.54	MOE Northern Region
2006	4	Driscoll 3	4.2	4.9	4.52	MOE Northern Region
2006	5	Driscoll 4	3.3	6.5	4.91	MOE Northern Region
2016	6	BL02	5.2	5.4	5.30	MOE Northern Region
2016	7	BL03	5.2	5.4	5.30	MOE Northern Region
2016	8	BL04	5.2	4.8	5.00	MOE Northern Region
2016	9	BL01	5.8	5.8	5.80	MOE Northern Region

Crane Lake Association

Lake	Crane Lake
Station	1014
Site ID	1
Description	Mid-bay, deep spot
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2004	4.67				
2007		3.21	4.02	3.61	
2008		3.40	3.47	3.44	3.80
2009					
2010	4.98	3.60	3.80	3.70	3.12
2011	4.76	6.00	5.60	5.80	3.69
2012	5.54	5.20	4.80	5.00	3.59
2013	4.84	5.60	5.80	5.70	3.46
2014	4.60	5.40	5.00	5.20	3.84
2015	4.84	5.20	5.20	5.20	3.70
2016	4.80	4.60	4.40	4.50	3.48

Lake	Crane Lake
Station	1014
Site ID	2
Description	N end, off Marsh Is.
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2002	4.78	6.90	6.00	6.45	
2003	4.57	4.50	5.90	5.20	
2004		3.95	4.50	4.23	
2005		3.06	3.60	3.33	
2006					
2007		3.31	3.38	3.35	
2008		4.00	4.25	4.13	3.34
2009					
2010	4.68	4.20	4.00	4.10	3.53
2011	4.40	4.80	4.80	4.80	3.28
2012	4.89	4.40	5.20	4.80	3.30
2013	4.70	5.00	5.40	5.20	3.19
2014	4.37	5.00	5.00	5.00	3.48
2015	4.56	5.80	6.20	6.00	3.60
2016	4.58	5.40	4.00	4.70	3.04

Lake	Crane Lake
Station	1014

Year	Site ID	Description	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Data Collector
2006	3	Driscoll-1	2.80	3.14	2.97	MOE Northern Region
2006	4	Driscoll-2	3.02	2.81	2.92	MOE Northern Region
2006	5	Driscoll-3	6.09		6.09	MOE Northern Region
2006	6	Driscoll-4	2.82	3.94	3.38	MOE Northern Region
2016	7	CR01	3.80	3.80	3.80	MOE Northern Region
2016	8	CR02	4.20	4.40	4.30	MOE Northern Region
2016	9	CR03	4.40	4.40	4.40	MOE Northern Region
2016	10	CR04	4.60	4.60	4.60	MOE Northern Region

Healey Lake Property Owners' Association

Lake	Healey Lake
Station	1924

Year	Site ID	Description	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Data Collector
2006	4	Driscoll-1		5.85	6.55	6.20	MOE Northern Region
2006	5	Driscoll-2		6.54	7.29	6.92	MOE Northern Region
2006	6	Driscoll-3		10.25	9.50	9.88	MOE Northern Region
2006	7	Driscoll-4		5.62	4.86	5.24	MOE Northern Region
2016	8	HE01		5.2	5.0	5.10	MOE Northern Region
2016	9	HE02		5.2	5.2	5.20	MOE Northern Region

2016	10	HE03		4.8	4.6	4.70	MOE Northern Region
2016	11	HE04		5.6	5.6	5.60	MOE Northern Region
2016	12	HE05		5.4	5.2	5.30	MOE Northern Region
2016	13	Pinebay, Deep spot	2.67	6.6	6.6	6.60	LPP volunteer

Iron City Fishing Club

Lake	Georgian Bay
Station	7064
Site ID	79
Description	Iron City Bay, deep spot
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2016		10.20	10.40	10.30	

Kapikog Lake Cottagers' Association

Lake	Kapikog Lake
Station	2230
Site ID	1
Description	Stn 1, W end
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
1991	3.45				
1992	4.29				
1993	3.94				
1994	4.31				
1995	4.08				
1996	3.96				

Lake	Kapikog Lake
Station	2230
Site ID	2
Description	Stn 2, mid-lake
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
1991	3.50				
1992	3.96				
1993	3.84				
1994	4.36				
1995	3.88				
1996	4.53				
1997	4.38				
1998	4.38				
1999	4.51				
2000	4.36				

2001	4.25				
2002	4.44	6.61	7.44	7.03	
2003	4.5	4.53	4.86	4.7	
2004	4	11.01	7.24	9.13	
2005		5.21	5.48	5.35	

Lake	Kapikog Lake
Station	2230
Site ID	3
Description	Stn 3, E end
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
1991	3.44				
1992	3.71				
1993	3.47				
1994	4.04				
1995	3.64				
1996	4.24				

Lake	Kapikog Lake
Station	2230

Year	Site ID	Description	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Data Collector
2006	4	Driscoll-1	4.56	5.53	5.04	MOE Northern Region
2006	5	Driscoll-2	3.94	4.23	4.08	MOE Northern Region
2006	6	Driscoll-3	4.41	4.38	4.39	MOE Northern Region
2006	7	Driscoll-4	4.71	5.18	4.95	MOE Northern Region

Pointe au Baril Islanders' Association

Lake	Sturgeon Bay
Station	5209
Site ID	1
Description	WSturgeonBay Prov.Pk
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
May 2003		23.45	21.65	22.50	
May 2004		19.24	22.59	20.91	
June 2004		25.15	24.74	24.95	
July 2004		22.46	21.03	21.75	
Aug 2004		20.87	19.95	20.41	
Sept 2004		18.46	18.67	18.57	
Oct 2004		20.17	20.92	20.55	
May 2005	2.04	20.00	19.70	19.85	
June 2005		18.80	19.40	19.10	
Aug 2005		17.40	18.50	17.95	
Aug 2005		20.40	23.50	21.95	

Oct 2005		22.40	21.40	21.90	
May 2006		17.10	16.78	16.94	
June 2006		18.77	19.90	19.34	
July 2006		15.31	14.32	14.82	
Aug 2006		15.28	15.02	15.15	
Sept 2006		17.01	16.20	16.61	
Oct 2006		19.60	19.79	19.70	
June 2007	1.48	17.87	17.25	17.56	
July 2007		19.75	19.42	19.59	
July 2007		14.13	14.84	14.48	
Aug 2007		13.71	13.76	13.73	
Oct 2007		20.85	22.87	21.86	
May 2008	1.18	15.86	16.89	16.38	6.26
June 2008		23.19	25.61	24.40	
Aug 2008		21.44	21.79	21.62	
Sept 2008		20.71	20.38	20.55	5.76
Nov 2008		18.93	21.01	19.97	
June 2009	1.18	20.25	19.74	19.99	4.72
July 2009		19.64	20.28	19.96	
Aug 2009		19.47	19.31	19.39	
Sept 2009		16.95	18.99	17.97	
June 2010	1.67	17.80	17.20	17.50	7.11
July 2010		13.40	13.00	13.20	7.65
July 2010		13.60	14.00	13.80	
Aug 2010		13.80	13.60	13.70	
Sept 2010		22.00	21.80	21.90	
Oct 2010		19.00	17.00	18.00	
May 2011	1.33	18.60	18.20	18.40	6.55
July 2011		16.40	16.00	16.20	8.90
Aug 2011		16.00	15.00	15.50	10.92
Sept 2011		19.80	18.40	19.10	10.06
Oct 2011		17.40	15.80	16.60	10.66
May 2012	1.18	17.60	17.00	17.30	7.96
June 2012		63.60	52.80	58.20	8.75
July 2012		22.20	22.40	22.30	9.89
Aug 2012		19.20	18.40	18.80	
Sept 2012		23.40	22.00	22.70	
Oct 2012		25.20	27.20	26.20	
May 2013	1.16	15.80	16.60	16.20	6.09
June 2013		19.80	31.00	25.40	6.75
July 2013		18.80	17.60	18.20	8.04
Aug 2013		20.40	23.60	22.00	
Sept 2013		19.40	19.60	19.50	
Oct 2013		19.20	18.80	19.00	
May 2014	1.27	15.60	15.20	15.40	5.34
June 2014		18.40	18.40	18.40	6.98
July 2014		11.60	11.40	11.50	7.14
Aug 2014		12.60	13.60	13.10	
Sept 2014		12.80	13.20	13.00	

Oct 2014		15.40	15.40	15.40	
May 2015	1.59	17.20	16.60	16.90	5.80
Aug 2015		13.80	14.00	13.90	
Sept 2015		10.20	10.40	10.30	
Sept 2015		11.20	11.20	11.20	
Oct 2015		10.80	11.80	11.30	
May 2016	1.64	13.00	13.60	13.30	6.44
June 2016		11.80	12.60	12.20	7.72
Aug 2016		12.40	11.00	11.70	
Aug 2016		12.80	13.20	13.00	
Sept 2016		17.00	16.80	16.90	
Oct 2016		15.60	16.80	16.20	

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Lake	Sturgeon Bay
Station	5209
Site ID	2
Description	Kenilworth & Skunk I
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
May 2003		22.57	26.72	24.65	
May 2004		17.00	18.63	17.82	
June 2004		20.25	22.56	21.41	
July 2004		19.01	17.82	18.42	
Aug 2004		22.22	22.89	22.56	
Sept 2004		17.36	18.19	17.78	
Oct 2004		28.33	26.99	27.66	
May 2005	2.34	15.00	15.10	15.05	
June 2005		16.50	16.40	16.45	
Aug 2005		19.60	21.30	20.45	
Aug 2005		26.00	23.30	24.65	
Oct 2005		21.90		21.90	
May 2006		16.14	17.26	16.70	
June 2006		14.82	13.64	14.23	
July 2006		13.44	12.16	12.80	
Aug 2006		13.64	14.29	13.97	
Sept 2006		15.32	15.90	15.61	
Oct 2006		19.32	19.16	19.24	
June 2007	1.58	15.51	18.52	17.02	
July 2007		15.97	15.78	15.88	
July 2007		15.75	15.97	15.86	
Aug 2007		18.84	17.32	18.08	
Oct 2007		23.23	24.63	23.93	
May 2008	1.22	17.89	19.00	18.45	6.34
June 2008		17.92	13.77	15.85	

Aug 2008		22.43	23.93	23.18	
Sept 2008		19.78	20.40	20.09	6.22
Nov 2008		14.80	15.82	15.31	
June 2009	1.48	15.95	15.33	15.64	4.96
July 2009		16.33	15.68	16.01	
Aug 2009		17.18	16.62	16.90	
Sept 2009		19.92	17.47	18.70	
May 2010	1.87	10.40	10.60	10.50	6.89
July 2010		12.00	11.40	11.70	7.67
July 2010		12.40	12.80	12.60	
Aug 2010		14.20	13.20	13.70	
Sept 2010		17.40	16.00	16.70	
Oct 2010		16.60	16.80	16.70	
May 2011	1.45	17.00	18.20	17.60	6.67
July 2011		15.40	15.60	15.50	8.97
Aug 2011		15.80	16.00	15.90	11.09
Sept 2011		22.40	20.40	21.40	10.29
Oct 2011		18.00	17.80	17.90	10.48
May 2012	1.24	15.40	16.20	15.80	8.07
June 2012		18.00	21.20	19.60	8.90
July 2012		15.60	14.80	15.20	10.04
Aug 2012		23.00	24.80	23.90	
Sept 2012		20.20	18.80	19.50	
Oct 2012		25.40	26.20	25.80	
May 2013	1.24	18.00	16.20	17.10	6.09
June 2013		15.60	15.20	15.40	6.91
July 2013		14.80	14.20	14.50	8.14
Aug 2013		21.60	22.20	21.90	
Sept 2013		18.80	19.00	18.90	
Oct 2013		17.20	20.00	18.60	
May 2014	1.52	16.40	17.40	16.90	6.32
June 2014		15.60	15.00	15.30	6.90
July 2014		11.20	11.80	11.50	7.12
Aug 2014		13.80	12.40	13.10	
Sept 2014		13.20	14.00	13.60	
Oct 2014		14.80	14.40	14.60	
May 2015	1.69	12.40	12.60	12.50	5.88
Aug 2015		13.40	13.60	13.50	
Sept 2015		9.80	9.60	9.70	
Sept 2015		9.60	9.40	9.50	
Oct 2015		12.40	12.20	12.30	
May 2016	1.89	10.60	10.40	10.50	
June 2016		10.80	11.20	11.00	7.60
Aug 2016		10.80	10.40	10.60	
Aug 2016		10.40	10.00	10.20	
Sept 2016		13.40	12.60	13.00	
Oct 2016		15.00	15.20	15.10	

Lake	Sturgeon Bay
Station	5209
Site ID	3
Description	Pointe au Baril chan
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2003		24.40	18.86	21.63	
May 2004		17.61	20.19	18.90	
June 2004		18.02	22.80	20.41	
July 2004		13.74	13.41	13.58	
Aug 2004		13.53	13.16	13.35	
Sept 2004		16.22	18.66	17.44	
Oct 2004		12.91	13.39	13.15	
May 2005	2.5	12.90	13.30	13.10	
June 2005		19.20	15.80	17.50	
Aug 2005		12.30	13.50	12.90	
Aug 2005		13.70	19.20	16.45	
Oct 2005		14.00	14.30	14.15	
May 2006		13.88	15.04	14.46	
June 2006		8.38	8.01	8.20	
July 2006		7.59	9.02	8.31	
Aug 2006		13.30	13.91	13.61	
Sept 2006		12.56	12.82	12.69	
Oct 2006		17.06	18.07	17.57	
June 2007	1.74	16.92	16.66	16.79	
July 2007		16.34	17.38	16.86	
July 2007		12.14	10.86	11.50	
Aug 2007		10.82	9.70	10.26	
Oct 2007		12.58	12.53	12.56	
May 2008	1.35	18.84	21.41	20.13	3.40
June 2008		18.89	19.78	19.34	
Aug 2008		17.14	19.24	18.19	
Sept 2008		13.35	12.85	13.10	6.64
Nov 2008		13.00	14.21	13.61	
June 2009	1.35	14.50	13.84	14.17	6.32
July 2009		15.18	13.78	14.48	
Aug 2009		16.06	15.49	15.78	
Sept 2009		14.98	14.62	14.80	
June 2010	1.98	9.00	8.80	8.90	10.81
July 2010		8.00	7.80	7.90	13.47
July 2010		10.60	11.40	11.00	
Aug 2010		12.00	12.20	12.10	
Sept 2010		11.40	10.60	11.00	
Oct 2010		12.20	13.20	12.70	
May 2011	1.88	14.60	14.60	14.60	7.80
July 2011		14.40	11.80	13.10	13.80
Aug 2011		13.60	11.20	12.40	14.87
Sept 2011		13.40	14.40	13.90	14.86

Oct 2011		10.20	9.00	9.60	14.78
May 2012	1.67	14.20	13.80	14.00	9.15
June 2012		12.60	13.80	13.20	11.67
July 2012		14.60	14.00	14.30	14.40
Aug 2012		11.80	12.20	12.00	
Sept 2012		15.00	15.20	15.10	
Oct 2012		17.80	18.40	18.10	
May 2013	1.87	16.00	16.20	16.10	4.82
June 2013		10.80	11.20	11.00	12.36
July 2013		9.60	10.00	9.80	15.80
Aug 2013		12.20	11.80	12.00	
Sept 2013		13.40	12.80	13.10	
Oct 2013		15.40	15.80	15.60	
May 2014	1.57	15.60	15.40	15.50	2.60
June 2014		13.40	13.60	13.50	10.10
July 2014		11.40	11.00	11.20	10.20
Aug 2014		11.40	11.20	11.30	
Sept 2014		12.60	12.60	12.60	
Oct 2014		15.80	16.80	16.30	
May 2015	1.81	16.20	16.20	16.20	6.40
Aug 2015		11.00	11.00	11.00	
Sept 2015		9.80	10.40	10.10	
Sept 2015		8.40	8.40	8.40	
Oct 2015		10.00	9.40	9.70	
May 2016	1.89	12.80	13.40	13.10	6.26
June 2016		9.00	9.40	9.20	10.70
Aug 2016		7.40	7.60	7.50	
Aug 2016		13.20	13.00	13.10	
Sept 2016		12.40	12.20	12.30	
Oct 2016		11.40	11.40	11.40	

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Lake	Sturgeon Bay
Station	5209
Site ID	4
Description	W of School House Is
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
May 2003		21.33	17.90	19.62	
May 2004		20.48	18.17	19.33	
June 2004		16.33	15.13	15.73	
July 2004		10.75	9.24	10.00	
Aug 2004		15.30	16.95	16.13	
Sept 2004		13.96	13.89	13.93	
Oct 2004		21.26	19.12	20.19	

May 2005	2.22	13.00	12.90	12.95	
June 2005		17.10	25.50	21.30	
Aug 2005		14.10	12.90	13.50	
Aug 2005		16.40	15.60	16.00	
Oct 2005		13.40	14.70	14.05	
May 2006		13.32	14.02	13.67	
June 2006		7.80	8.73	8.27	
July 2006		10.88	13.03	11.96	
Aug 2006		12.51	14.46	13.49	
Sept 2006		12.13	10.69	11.41	
Oct 2006		13.86	14.46	14.16	
June 2007	1.9	14.46	14.52	14.49	
July 2007		11.89	11.87	11.88	
July 2007		10.52	10.00	10.26	
Aug 2007		9.69	9.10	9.40	
Oct 2007		11.90	12.61	12.26	
May 2008	1.57	17.09	16.17	16.63	5.12
June 2008		16.39	14.45	15.42	
Aug 2008		14.61	16.08	15.35	
Sept 2008					32.80
Sept 2008		13.38	12.92	13.15	
Nov 2008		11.17	10.79	10.98	
June 2009	1.73	13.05	13.20	13.13	6.94
July 2009		11.62	11.54	11.58	
Aug 2009		16.31	15.71	16.01	
Sept 2009		12.58	11.47	12.03	
June 2010	2.13	9.20	9.00	9.10	10.47
July 2010		8.00	7.80	7.90	12.39
July 2010		9.60	9.00	9.30	
Aug 2010		10.60	8.60	9.60	
Sept 2010		12.00	12.20	12.10	
Oct 2010		12.80	12.60	12.70	
May 2011	2.21	14.20	15.00	14.60	9.07
July 2011		10.00	10.00	10.00	13.98
Aug 2011		10.00	10.60	10.30	17.86
Sept 2011		12.40	17.00	14.70	15.15
Oct 2011		9.40	8.60	9.00	15.56
May 2012	1.76	14.60	14.00	14.30	9.90
June 2012		10.40	10.20	10.30	12.07
July 2012		11.60	12.00	11.80	15.02
Aug 2012		14.20	15.20	14.70	
Sept 2012		14.20	14.20	14.20	
Oct 2012		16.40	17.20	16.80	
May 2013	2.02	14.80	16.20	15.50	5.49
June 2013		10.60	10.20	10.40	12.91
July 2013		9.60	9.40	9.50	16.66
Aug 2013		10.60	10.80	10.70	
Sept 2013		12.20	11.00	11.60	
Oct 2013		12.20	11.00	11.60	

May 2014	1.90	15.20	14.80	15.00	3.84
June 2014		10.20	10.00	10.10	9.44
July 2014		9.60	10.20	9.90	11.90
Aug 2014		10.20	10.00	10.10	
Sept 2014		10.60	11.00	10.80	
Oct 2014		14.20	14.60	14.40	
May 2015	2.05	13.20	14.00	13.60	7.82
Aug 2015		10.20	10.20	10.20	
Sept 2015		8.40	8.40	8.40	
Sept 2015		9.00	9.00	9.00	
Oct 2015		9.00	8.60	8.80	
May 2016	2.25	11.20	10.40	10.80	6.74
June 2016		9.00	8.20	8.60	11.20
Aug 2016		7.60	7.80	7.70	
Aug 2016		9.00	9.40	9.20	
Sept 2016		10.80	9.60	10.20	
Oct 2016		10.20	10.60	10.40	

Lake	Sturgeon Bay
Station	5209
Site ID	5
Description	N basin W-Sein/Driscoll 1
Data Collector	MOE Northern Region

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2005	2.20	14.44	13.82	14.13	
2006		11.96	12.61	12.29	

Lake	Sturgeon Bay
Station	5209
Site ID	6
Description	N basin E-Sein/Driscoll 2
Data Collector	MOE Northern Region

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2005	2.30	13.94	14.54	14.24	
2006		13.21	14.44	13.82	

Lake	Sturgeon Bay
Station	5209
Site ID	7
Description	N basin Mid-Sein/Driscoll 3
Data Collector	MOE Northern Region

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2005	2.40	16.22	14.79	15.50	
2006		13.22	13.24	13.23	

Lake	Sturgeon Bay
Station	5209
Site ID	8
Description	Mid bay narrows-Sein/Dris4
Data Collector	MOE Northern Region

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2005	2.20	15.32	15.78	15.55	
2006		13.30	15.93	14.62	

Lake	Sturgeon Bay
Station	5209
Site ID	9
Description	S basin E -Sein/Driscoll 5
Data Collector	MOE Northern Region

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2005	2.10	14.95	14.43	14.69	
2006		13.33	13.99	13.66	

Lake	Sturgeon Bay
Station	5209
Site ID	10
Description	S basin W -Sein/Driscoll 6
Data Collector	MOE Northern Region

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2005	1.60	14.67	13.96	14.32	
2006		11.86	11.80	11.83	

Lake	Georgian Bay
Station	7064

Year	Site ID	Description	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Data Collector
2015	74	Sturgeon Bay SB1	12.40	13.40	12.90	MOE Northern Region
2015	75	Sturgeon Bay SB2	14.20	13.60	13.90	MOE Northern Region
2015	76	Sturgeon Bay SB3	13.20	13.40	13.30	MOE Northern Region

Skerryvore Ratepayers' Association

Lake	Lake Huron
Station	6980

Year	Site ID	Description	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Data Collector
2006	10	Sein-Rathlyn Is	4.69	3.81	4.25	MOE Northern Region
2006	11	Sein-Rathlyn Is	3.76	3.95	3.86	MOE Northern Region
2006	12	Sein-Rathlyn Is	2.77	3.64	3.21	MOE Northern Region
2006	13	Sein-Rathlyn Is	3.44	3.32	3.38	MOE Northern Region

South Channel Association

Lake	Georgian Bay
Station	7064
Site ID	2
Description	South Chan-Nutter Bay
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2002	6.00	6.40	5.40	5.90	
2003	5.20				
2004		6.35	5.92	6.13	
2005		7.66	4.53	6.10	
2006	8.50	6.99	4.60	5.79	

Lake	Georgian Bay
Station	7064
Site ID	16
Description	Rose Pt.-Glen Burnie Mar
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2004		10.61	11.13	10.87	

Three Legged Lake Association

Lake	Three Legged Lake
Station	5360
Site ID	1
Description	Mid lake, deep spot
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2001	5.80				
2002		7.11	4.28	5.70	
2003	5.00	4.67	5.56	5.12	
2004	5.20	3.50	3.20	3.35	
2005	7.00	9.28	8.46	8.87	
2005		3.11	3.22	3.17	
2006	6.20				
2012	6.85	2.70	2.60	2.65	1.65
2013	6.20	3.20	3.40	3.30	
2014		4.00	4.00	4.00	1.58

Lake	Three Legged Lake
Station	5360
Site ID	2
Description	Mid lake, deep spot
Data Collector	Seguin Township

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2013		5.20	3.80	4.50	
2015		3.20	3.00	3.10	

Woods Bay Community Association

Lake	Georgian Bay
Station	7064
Site ID	77
Description	Woods Bay, deep spot
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2016	4.13	15.40	14.20	14.80	2.96

Other

Lake	Conger Lake (pine)
Station	963
Site ID	1
Description	Mid lake, deep spot
Data Collector	LPP volunteer

Year	Secchi Depth (m)	TP1 (µg/L)	TP2 (µg/L)	Average TP (µg/L)	Calcium (mg/L)
2002		7.63	7.28	7.46	
2003	4.25	5.70	5.70	5.70	
2004	4.30	7.17	5.69	6.43	

Appendix B – Temperature/dissolved oxygen results for Sturgeon Bay

SB1	2016-07-28		2016-08-05		2016-08-23	
Depth	T (°C)	DO (mg/L)	T (°C)	DO (mg/L)	T (°C)	DO (mg/L)
0	25.6	8.22	25.3	8.2	23.4	7.6
1	25.4	8.22	25.3	8.2	23.4	7.6
2	25.1	8.17	25.3	8.17	23.4	7.5
3	24.9	8.15	24.9	7.78	23.4	7.5
4	24.8	8.04	24.4	7.2	23.3	7.6
5	24.6	7.93	24.2	6.7	23/1	6.82
6	24.4	7.81	23.5	5	23.1	6.55
7	23.3	5.41	22.5	2.18	22.8	4.82
8	17.7	0.2	19.3	0.15	21.6	0.58
9			16	0.5	20.7	0.2

SB2	2016-07-28		2016-08-23		2016-09-28		
Depth	T (°C)	DO (mg/L)	T (°C)	DO (mg/L)	T (°C)	DO (mg/L)	
0	25.6	8.22	23.6	7.83	18.1	9.5	(TP 28th)
1	25.4	8.22	23.4	7.79	18.1	9.4	
2	25.3	8.21	23.4	7.76	18.1	9.4	
3	24.9	8.17	23.4	7.73	18.1	9.3	
4	24.7	8.01	23.4	7.71	18.1	9.3	
5	24.3	7.52	23.4	7.69	18.1	9.2	
6	23.2	5.37	23.3	7.69	18.1	9.2	
7	22.3	3.9	23.3	7.67	18.1	9.2	
8	20.9	1.6	23.3	7.65	18.1	9.2	
9	15.6	0.16	23.2	7.61	18.1	9.2	
10	13.5	0.11	17.4	0.24	18	9.2	
11	12.4	0.07	13.5	0.13	18	9.1	
12			13.6	0.12	17.3	4.3	
13					15.5	0.8	(TP 28th)
14					13.1	0.4	(TP 28th)

SB4	2016-08-13	
Depth	T (°C)	DO (mg/L)
0	24	8.08
1	23.9	8.07
2	23.8	8.07
3	23.8	8.05
4	23.7	8.04
5	23.7	8.02
6	23.5	7.75
7	23.4	7.55
8	23.3	7.05
9	22.4	4.22
10	15.5	0.25
11	13.5	0.17
12	12.5	0.12
13	12	0.11

SB9	2016-08-23	
Depth	T (°C)	DO (mg/L)
0	24	8.37
1	24	8.36
2	24	8.35
3	24	8.33
4	23.9	8.32
5	23.9	8.29
6	23.9	8.24
7	23.9	8.22
8	23.8	8.15
9	23.7	7.86
10	17.3	0.22
11	16.2	0.17
12	16.2	0.14