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2016
Water Quality Initiative Report

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A. Area Summaries

Executive Summary

The MLA Water Quality Report presents data collected at 190 locations during the summer of 2016 and compares it to data collected from 2002 to 2015. Based on our analysis of the long term data acquired to date, the water quality at most of the sampling locations remains good to excellent.

The 2016 sampling season started in mid-May, ended in late August and generally included a total of four sampling events at each location. The water quality parameters sampled during the 2016 program are the same as those sampled in 2015 and consisted of temperature, Secchi depth (clarity), Dissolved Organic Carbon (DOC), Total Phosphorus (nutrients), *Escherichia coli (E. Coli)* and Total Coliform (bacteria counts). There were a total of 159 Secchi depth measurements, 966 Phosphorus samples, 67 DOC and 309 *E.* coli samples taken.

Elevated 2016 deep-water spring phosphorus concentrations in comparison to 2015 were recorded at Gordon Bay (GNB-0), Hamer Bay (HMB-0), Lake Joseph (JOS-1), Little Lake Joseph (LLJ-0), Alport (ALL-0), Boyd Bay (BOY-0), Eilean Gowan (ELG-0), Muskoka Bay (MBA-0), Whiteside Bay (WTS-0), Brackenrig Bay (BRA-0), Morgan Bay (MGN-0), Bruce Lake (BRU-0), Gull Lake (GUL-0), Joseph River (JOR-0) and Mirror Lake (MIR-0). Of these sampling locations, elevated levels of mean yearly phosphorus in 2016 compared with 2015 were also recorded at Lake Joseph (JOS-1), Little Lake Joseph (LLJ-0), Eilean Gowan (ELG-0), Whiteside Bay (WTS-0), Brackenrig Bay (BRA-0), and Mirror Lake (MIR-0). Spring phosphorus concentrations tend to vary and these elevated levels in 2016 are generally within the range seen through the sampling years and are consistent with natural variation.

Despite flooding during spring freshet which might be expected to increase phosphorus, there was an overall downward trend in most spring phosphorus concentrations. Lower spring turnover phosphorus was measured at 62% of deep-water sites versus 2015 and lower annual average phosphorus was measured at 68% of those same sites. Spring phosphorus increases were measured at 16 deep-water sites versus 2015 and these increases were within the natural variation seen in previous years.

Increased levels of nearshore phosphorus were seen at 5 sites. Three of these sites are in the Windermere area. DOC measured at these sites indicate the phosphorus source is not from natural inputs.

Of the 309 *E. coli* tests taken, 27 (8.7%) exceeded the MLA threshold for retesting [50 cfu/100 ml]. This number of elevated single readings is higher than the 4% reported in 2015 but similar to the 8% reported in 2012 and 8% reported in 2008. Areas with multiple elevated readings include Minett, Brandy Lake and Muskoka River. On retesting, normally within 3 days, only 4 sites continued to have elevated readings.

Area Summary Sheets are used to summarize sampling results and a traffic light symbol provides a visual indication of the overall water quality at each Area as follows:

- Green light indicates the water quality remains consistently good,
- Yellow light indicates that further investigation is recommended to maintain good water quality, and

- Yellow light indicates that further investigation is recommended to maintain good water quality, and
- Red light indicates remedial action may be necessary to improve water quality.

In 2016, *E. coli* thresholds were redeveloped for each of the traffic light symbols to better quantify the data trends; green light (0-30 cfu/100mL), yellow light (31-99 cfu/100mL) and red light (>100 cfu/100mL as per MOECC geometric mean for a series of 5 samples per site per month). In 2017, following consultation with the MLA Water Quality & Environment Committee, new phosphorus thresholds may be established for the traffic light limits.

In 2016 there were 42 Areas with a green light, 12 Areas with a yellow light and 0 Areas with a red light. This year 14 Areas changed from a yellow light to a green light, 3 Areas were assigned traffic lights for the first time and 1 Area was sampled for the first time in 2016 and therefore did not receive a traffic light classification.

Following analysis of the 2016 results, Beacon recommends that the primary Focus Areas for the 2017 sampling season should continue to be Minett and Windemere (resort sites) and emphasis should also be directed to the Muskoka River (urban influenced area).

Four focus stations were sampled during the 2016 season at Minett (MIN-1, MIN-6, MIN-7 and MIN-9). This entailed sampling 8 times over the sampling program. Yearly mean *E.coli* levels were all below the traffic light limit of 30 cfu/100 ml, however re-tests were required at MIN-1 and MIN-9 on August 30th and MIN-6 and MIN-7 on both August 9th and 30th.

1. Introduction

The Muskoka Lakes Association (MLA) is a non-profit organization that was founded in 1894 to represent the interests of lakeshore residents on Lakes Rosseau, Joseph and Muskoka and many smaller surrounding lakes, and is Canada's oldest cottage association. The MLA's mission is to 'promote the responsible use, enjoyment and conservation of the unique Muskoka environment.' **The MLA objectives of monitoring lake water quality to provide data to protect vulnerable areas and promoting stewardship are carried out through the Water Quality Initiative.**

The MLA Water Quality & Environment Committee is a group of volunteers that utilize professional expertise to analyze the yearly water quality data and to provide recommendations and program modification/development options. In 2013, Beacon Environmental Limited (Beacon) was retained as the primary consultant to assist the MLA with these tasks and continues to provide professional expertise through 2016. This Water Quality Report presents the most recent data collected in 2016 and compares it to data collected from 2002 to the present. Total phosphorus (TP) concentrations, in particular, are discussed relative to historic concentrations.

Area Summary sheets have been prepared for each of the sampling areas in the 2016 program and these are presented in **Appendix A**. The Summaries provide an analysis of the data collected in 2016, and include historical total phosphorus and *E.coli* results where sampled. In addition, specific recommendations for the sampling areas are provided to continue to improve the health of the lakes.

The results, summaries and scientific opinion regarding general health presented in the 2016 Water Quality Initiative Report are based on Beacon's analysis of data provided by the MLA. This does not represent the health of the entire lake and only captures information collected at a certain time and location during the sampling year. The reader should take this into consideration when reviewing the 2016 Water Quality Initiative Report and use caution in extrapolating data to a lake or watershed as a whole.

1.1 Water Quality Initiative – Past and Present

The MLA's Water Quality Initiative (WQI) is a citizen-science based water quality monitoring program designed to measure key biological, chemical, and physical indicators of water quality in lakes throughout the District of Muskoka and parts of Parry Sound. The WQI has been running since its inception in 2001 and updates and upgrades have continued to improve the program through the years. The program is directed by the MLA Water Quality & Environment Committee, administered by support staff based at the MLA office in Port Carling, and implemented by a dedicated group of more than 100 volunteers. This program continues to be one of the most comprehensive water monitoring programs of any lake association in Canada.

Prior to the inception of the MLA's WQI, monitoring for Secchi depth and phosphorus concentrations in the lakes was undertaken by the Ministry of the Environment and Climate Change (MOECC) Lake Partner Program (LPP). The LPP Program is a province wide, volunteer-based, water quality monitoring program in which the MOECC monitors more than 600 of the province's inland lakes, dating back in excess of 20 years. The MLA's WQI continues to follow the detailed sampling protocol

of the MOECC and goes further with additional sampling for DOC, bacterial counts and calcium. At seven (7) of the deepwater sampling stations the spring phosphorus data was obtained from the LPP.

The MLA has adopted a long-term monitoring strategy for phosphorus, calcium, water clarity, and water temperature, and in 2013 introduced a monitoring strategy for dissolved organic carbon (DOC) concentrations. Additionally, bacteria monitoring activities have focused on determining whether chronically elevated conditions exist in targeted nearshore recreation areas. This document provides a comprehensive overview of the monitoring program including sampling and analytical methodologies.

Similar monitoring programs are presently being undertaken by the District of Muskoka, Lake of Bays Association, Lake Partner Program, Township of the Archipelago and other lake associations. The MLA WQI complements and expands upon other monitoring programs conducted in the region by government agencies and other volunteer groups.

The MLA WQI program is more extensive than that of the District of Muskoka and the Lake Partner Program in that it includes additional sampling parameters and additional sampling events. In recent years, there has been a major collaborative effort throughout the region to establish standardized water quality monitoring protocols and methodologies. The MLA continues to review similar monitoring programs to ensure that this program continues to keep up to date on methodologies and sampling parameters. Methodology will be revised for the 2017 sampling program in an effort to further standardize sampling protocol with the District of Muskoka and the Lake Partner Program.

The WQI has evolved over the years since its initiation as a pilot program in 2001. Changes occur to add analytical power to the existing database. For example, Calcium was sampled for in 2011 and 2012 in response to recent findings that suggested calcium was declining faster (i.e. logging and acid rain) than what would be realized under natural processes. The decline of calcium is anticipated to be associated with a long time frame (decades) and as such, it can be sampled for in intermittent years.

Another example of change is the addition of sampling for dissolved organic carbon (DOC) which has continued yearly since 2013. Research has indicated that natural levels of total phosphorus from Precambrian Shield watersheds can most likely be correlated with levels of DOC. By having background data, unnatural (human influenced) increases in phosphorus can be more easily realized.

Some of the more notable changes that have helped shape the WQI are presented below:

2001 The program was initiated in the summer of 2001 in order to gather preliminary information on innovative means of water quality determination in the Muskoka lakes. The first year's programme focussed on developing protocols for the collection of replicable data.

2002 The program confirmed the hypothesis that water quality programs should focus on near shore areas and not just on open water areas as they have done in the past. Results showed that nutrient and bacterial levels were higher in near shore areas than in open water and that there were areas of concern.

2003 In 2003 the Board of Directors made a long term commitment to the initiative, and raised funds to pay the operating expenses. Phosphorus samples started to be filtered and the Program was extended to "affiliate" partner associations.

2004 The program was focused on the residential land use activities and their effect on water quality. Monitoring efforts grew to 136 sites monitored by an all-time high number of volunteers. The program discontinued filtering the phosphorus samples because the filters appeared to significantly alter the data collected.

2005 The focus of research in 2005 was to develop a correlation between MLA total phosphorus concentration data with the data that has been collected by both the District of Muskoka and the MOECC.

2006 Statistical analysis conducted on the water quality data collected from 2002-2006 indicated that the WQI program did not have the capacity to consider highly complex relationships.

2007 Additional monitoring efforts were directed towards specific lakes and bays classified as "over-threshold" by the District of Muskoka. The MLA's attention was refocused in 2007 following recommendations of the 2006 Annual Report and the introduction of the District Municipality of Muskoka's Lake System Health Program which classifies lakes and parts of lakes based on estimated human impact on trophic status. The resources of the WQI were directed to specific sampling areas where concerns about water quality had come to light and focussed on determining the sources of phosphorus loading and other contaminants in these areas.

2008 Monitoring efforts scaled back very slightly to fewer sites monitored by over 110 volunteers. Turbidity measurements were discontinued in favour of the Secchi depth protocol that was added in 2007 in order to enable volunteers in the field to complete more of the program.

2009 The WQI monitoring program data showed a general decreasing trend over the past nine years in phosphorus concentrations in Lake Rosseau, Muskoka and Joseph.

2010 Through the support of the WQI, Stream Monitoring Action Plans were implemented for Muskoka Bay and Cox Bay. Both areas had historically been identified as areas of concern through the WQI. Data analysis revealed that land-based influences on nearshore phosphorus were only detectable at sites located in close proximity to creek outlets. The Summary Report and Technical Reports were condensed into one report.

2011 Several changes occurred in 2011 in an effort to standardize the methodology to allow comparison with other sampling programs. The changes included:

- Re introduction of filtering phosphorus samples, collection of samples at Secchi disk depth, and collection of duplicate samples.
- Sampling frequency was reduced from eight sampling events to four.
- Calcium sampling was undertaken in correlation with spring turnover phosphorus to increase the analytical ability of the WQI program.
- Twenty-three sampling areas were added to the 2011 WQI, based on volunteer input and areas identified with the potential for concern during the 2010 review.

2012 Bacteria monitoring was discontinued at selected sites that were exhibiting chronically low average bacteria levels (three or more years below the MLA upper limit of 10 cfu/100 mL). New bacteria sampling sites were established in high-use areas where potential risks to health and recreational water quality were of particular concern (e.g., beaches, popular swimming sites, etc.). Calcium concentration data collected in 2011-2012 suggested that there was limited year-to -year variation (+/- 0.18 mg/L); however, it was determined that further data was required to determine overall trends. Changes to the program were limited to modifications of the deep-water phosphorus sampling methodology, revisions to bacteria sampling sites, and the addition of new sampling areas. The deep-water sampling methodology was changed for 2012 and results suggested that 2012 deep-water total phosphorus data were in general unreliable and were not included in the report.

2013 Consultation was undertaken in the spring to look at the data from each sampling area and location and to assess each site to decide if continued sampling was necessary, or if sites should be discontinued and new sites added. The changes undertaken in 2013 included 15 sites being removed, 8 sites being added and 4 sites being modified. Additionally, Dissolved Organic Carbon was added to the parameter suite in six locations to better understand potential sources of natural phosphorus versus human impact.

2014 Each sampling area and location was reassessed at the beginning of the year to understand requirements for the sampling season. A total of 13 sites were discontinued, 8 sites were added, 8 sites restarted, 24 sites modified and sampling for DOC was continued. High *E. coli* concentrations were recorded at a number of sites including at MIN-6 in Wallace Bay. Discussion with the MLA Water Quality & Environment Committee resulted in a proposal to proceed with a second stage monitoring program for 2015.

2015 The 2014 Area Summaries were reviewed to assess each site and modifications were undertaken to restart or temporarily discontinue particular sites. The most important revision in 2015 was the initiation of a Second Stage Water Quality Assessment (SSWQA) in Wallace Bay of Lake Rosseau. The SSWQA was designed to assist in determining whether remedial action was required where elevated levels of *E. coli* had been identified at MIN-6. Compared with the total coliform and *E. coli* levels encountered at MIN-6 in 2014, those recorded in 2015 show a marked decrease.

2016 All of the sampling areas and locations were reassessed at the beginning of the year to understand requirements for the 2016 sampling season. A total of 15 sites were discontinued, 8 sites were added, 10 sites restarted, 11 sites modified and sampling for DOC was continued. *E.coli* samples were collected 3 times versus 2 times previously at routine sampling sites. Increased sampling of 8 times per summer was started at the Minett focus site. New thresholds for the 2016 analysis of *E .coli* concentrations were implemented and discussed in Table 11.

1.2 Monitoring Volunteers

In 2016, volunteers dedicated their time and continued support in collecting water quality samples at 190 different sampling locations including 159 Secchi depth measurements, 966 phosphorus samples and 67 DOC samples.

Without the continued dedication and support from the volunteers this sampling program would not be possible. Each Area Summary sheet identifies the volunteer samplers as well as the team leaders (**bolded**).

Each spring, two training workshops are offered to provide the volunteer samplers with an opportunity to review the methodology and understand any updates to the protocol.

2. Water Quality Monitoring Program

The objective of the MLA is to monitor lake water quality to provide data to protect vulnerable areas, to promote stewardship, to provide clear and appropriate communication about the annual WQI report to all interested parties, local effected area member associations, appropriate levels of government and the general community, and to take a role in action where problem areas are developing from the data analysis.

2.1 Regional Setting

The MLA sampling stations are located in the Canadian Shield Physiographic Region (Ontario Geological Survey, 2003). The bedrock throughout this region has extensive outcroppings which are primarily the result of glaciation and post-glacial events. Prominent bedrock knobs and ridges are common and dominate features in some areas. The Precambrian landform expression strongly influences the topographic patterns of the region as well as the local overland drainage characteristics.

2.2 Local Watershed Characteristics

The MLA sampling locations (**Figure 1**) are located within the Great Lakes drainage basin in central Ontario and eventually drain into Lake Huron via Georgian Bay. Within the Georgian Bay catchment area, the majority of the MLA sampling locations are within the Muskoka River watershed which drains an area approximately 4660 km^2 (Muskoka Water Web, 2013). The Muskoka River watershed is further divided into three subwatersheds: North and South subwatersheds and the Lower Muskoka subwatershed (Acres, 2006). Most of the sampling locations are within the Lower Muskoka subwatershed which originates in Algonquin Park (Acres, 2006).

Approximately 68% of the Muskoka River watershed is covered in forest and other natural vegetation; 15% consists of water (lakes, rivers and ponds), 11% is wetlands, and 2% is rock barrens and outcrops. Settlement areas only make up 2% of the watershed while developed land such as agriculture (cropland, pasture and open fields) and golf courses make up 2% of land cover within the watershed (Muskoka Heritage Foundation, 2007).

Where the bedrock is covered by soils, it is generally very thin and nutrient poor, therefore limiting the amount of nutrients that flow to the adjacent waterbodies.

Lakes with a phosphorus concentration less than 10 µg/L are considered oligotrophic (nutrient poor) (Dillon *et al.* 1986). This generally implies that the lake is very clear and deep with minimal aquatic plants and algal blooms, as well as high levels of dissolved oxygen. Lakes with a phosphorus concentration between 10 and 20 µg/L are considered mesotrophic (moderately enriched). These lakes have some aquatic vegetation and can support an array of fish species. Lakes with a phosphorus concentration above 20 µg/L are considered eutrophic (nutrient rich). These lakes have large areas of aquatic vegetation and are often subject to algal blooms, thus having lower levels of oxygen. Muskoka naturally has a range of lakes in all three categories, although the majority of lakes are oligotrophic.

Increases in the nutrient content of a lake (primarily phosphorus and nitrogen), can occur as a result of rainfall, land run-off and percolation of soil-water to the lake. Higher concentrations of these dissolved materials can cause the water to become progressively more fertile and productive, stimulating the development of free-floating microscopic plants (algae).

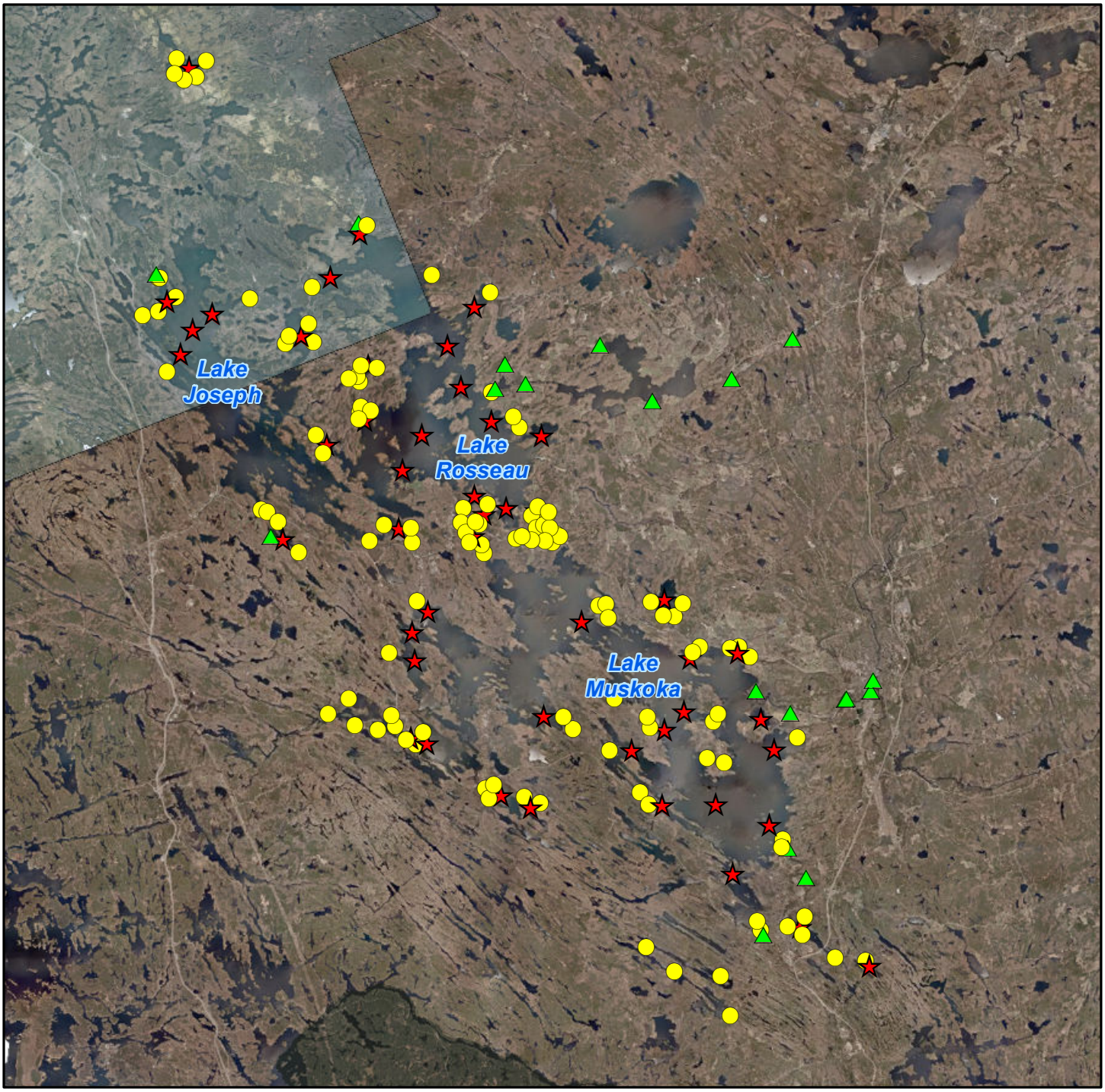
All lakes are subject to nutrient inputs, however, artificial (man-made) enrichment will increase the rate of eutrophication. Eutrophication generally promotes excessive plant growth and decay, favouring simple algae and plankton over other more complicated plants, and causes a severe reduction in water quality.

Lake Muskoka is the largest lake in the Muskoka River watershed based on total surface area and is also the receiving water body for Lake Rosseau and Lake Joseph which are also the second and third largest lakes respectively.

Water management can typically be broken down into two interrelated components; water quality and quantity. Water quality is directly affected by quantity. For example, flooding and heavy precipitation events can cause a number of contaminants to enter waterways due to overland flow picking up contaminants on adjacent lands or overflow of sewage treatment systems. Since contaminant loading fluctuates with weather events, it is important to sample continuously through different seasons and years to help understand the fluctuations.

Under normal circumstances, during rainfall events, nutrients (phosphorus and nitrogen) associated with overland flow are generally retained by physical absorption in the lands adjacent to the waterbodies.

Typically during rainfall and snowmelt conditions, water flows across the land picking up contaminants before entering waterways. As well as chemical contaminants and nutrients being flushed into natural



Legend

Station Locations

- Deep
- Nearshore
- Watercourse

Ontario Base Map Vector Base
First Base Solutions Web Mapping
District of Muskoka 2008 and West
Parry Sound Geography Network 2004

2016 Station Locations

Figure 1

Muskoka Lakes Association

UTM Zone 17 N, NAD 83

N
W E
S

0 2.5 5 10 Kilometers

1:300,000

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water systems, *E. coli* and other bacterial contaminants from flooded septic systems and warm-blooded animals may also enter waterways in this fashion.

Nutrient loading from a watershed increases significantly when precipitation rates exceed the average rate. The Muskoka River Water Management Plan (MRWMP) provides for higher spring water levels resulting from the melting snow. The MRWMP states "*High water levels in early spring are natural occurrences which help to recharge groundwater supplies, transfer nutrients and sediments to wetlands and shoreline riparian zones, and provides spring spawning fish and amphibians with access to wetlands and shoreline habitats*" (Acres, 2006).

The spring freshet of 2016 occurred over a matter of weeks in comparison to previous years. This rapid freshet was the result of less snow accumulation, heavy rainfall and warmer than usual temperatures in March. Summer conditions in 2016 included severe drought conditions and higher average temperatures. The following three tables (**Table 1**, **Table 2**, and **Table 3**) summarize the rainfall and temperature records from the Muskoka Airport from 2013 to 2016. The tables indicate that 2016 recorded the highest daily temperatures coupled with the highest average monthly rainfall in March, leading to extensive flooding. The weather data recorded in the last two years (2015 and 2016) indicate slightly warmer average temperatures but also less than average amounts of precipitation in April 2016 as well as March 2015. Total monthly precipitation in March 2016 was well above the average monthly precipitation measured in 1981 – 2010.

Table 1. Total & Average Monthly Rainfall recorded at the Muskoka Airport

Month	Total Monthly Precipitation (mm) in 2013	Total Monthly Precipitation (mm) in 2014	Total Monthly Precipitation (mm) in 2015	Total Monthly Precipitation (mm) in 2016	Average Monthly Precipitation (mm) 1981-2010
March	25.0	23.7	34.5	162.6	73.3
April	138.1	67.3	82.9	47.3	76.6

Table 2. Average Temperatures recorded at the Muskoka Airport

Month	Mean Temperature (°C) in 2013	Mean Temperature (°C) in 2014	Mean Temperature (°C) in 2015	Mean Temperature (°C) in 2016	Mean Temperature (°C) 1981-2010
March	1.8	-2.0	0.2	3.9	-3.1
April	8.9	8.8	10.6	9.2	4.8

Table 3. Highest Temperatures recorded at the Muskoka Airport

Month	Highest Temperature (°C) in 2013	Highest Temperature (°C) in 2014	Highest Temperature (°C) in 2015	Highest Temperature (°C) in 2016	Highest Temperature (°C) 1981-2010
March	9.4	11.4	8.0	12.8	25.6
April	23.0	19.3	21.3	23.3	30.2

2.3 General Methods

The WQI study area includes Lakes Muskoka, Rosseau, and Joseph and a number of smaller affiliate lakes and rivers. The study area is divided into sampling areas representative of lakes, bays, and rivers of interest. Each sampling area consists of one or more sampling sites. Most sampling areas have one reference site established in a central, deep-water location intended to exhibit "average" water quality conditions.

Sampling and Analytical Methods employed during the 2016 sampling program are unchanged from those in the previous 3 years and are provided in the Water Quality Initiative Methodology Report (http://www.mla.on.ca/MLA%20WQI%20Methodology%20Report).

2.4 Water Quality Parameters

Water samples collected for each of the sampling locations are analyzed for a variety of parameters and help to characterize the chemical composition of the waterbody and identify potential issues. The water quality parameters sampled during the 2016 program are provided below in **Table 4** along with a brief description of the parameter and reason for measuring.

Table 4. 2016 Water Quality Parameters

Water Quality Parameter	Description	Reason for Measuring
Dissolved Organic Carbon (DOC)	DOC is the most abundant dissolved substance entering lakes and rivers in Muskoka Parry Sound. DOC affects the acid-base chemistry which in turn affects the availability of some forms of nitrogen and phosphorus in lakes and rivers. Waterbodies that have a tea or brown colour tend to be high in DOC.	DOC is an important component in the carbon cycle and a primary food source for aquatic webs. Research has indicated that natural levels of total phosphorus from Precambrian Shield watersheds can most likely be correlated with levels of DOC.
Total Phosphorus	Total phosphorus measures all forms of phosphorus present in a sample. There are many sources of phosphorus which are both man-made and naturally occurring in the environment. Phosphorus is the principal nutrient causing eutrophication.	Phosphorus is an essential nutrient for all living organisms. However elevated levels of phosphorus can affect aquatic ecosystems, often leading to algal blooms and increased plant growth, therefore decreasing water quality.
***Escherichia coli* (*E. coli*) and Total Coliforms**	Total coliform bacteria are a collection of relatively harmless microorganisms that live in large numbers in soils, plants and in intestines of warm-blooded and cold-blooded animals. Fecal coliforms, particularly *Escherichia coli*, are found exclusively in the intestinal tract of warm-blooded animals.	In abundance, E. coli will indicate contamination from excreta from warm-blooded animals, including humans, and may pose an immediate health risk.

Water Quality Parameter	Description	Reason for Measuring
Secchi Depth	The Secchi disk is used to measure water clarity at the deep water sampling sites.	Clear water allows light to penetrate deeper into lakes which allows for photosynthesis and oxygen production. Secchi depth is one indicator of lake health used in conjunction with nutrient concentrations from the laboratory analyses.
Temperature	The temperature of the water is recorded during each sampling event using a thermometer and recorded in degrees Celsius.	Water temperature affects different physical, biological and chemical characteristics of a lake. Long term records assist in trend analysis.

The 2016 sampling season began in mid-May, ended in late August and generally included a total of four sampling events. Components of the program included:

- Total phosphorus (TP) samples were collected on four separate occasions throughout the sampling season. All TP samples collected within or prior to the first sampling event in May at the deep stations are considered spring turnover TP samples. This is because the lakes in this area have not yet stratified, separating the lake into layers. This allows for vertical mixing of the water column and phosphorus concentrations are mixed in the water column. The remaining TP samples in June, July and August were taken from a mix of locations including deep-water nearshore and watercourse sampling locations.

- Bacteria samples were tested for *E.coli* and total coliforms. These samples were collected from nearshore locations during the second, third and fourth sampling event. Additional sampling was to be implemented weekly if *E. coli* levels were found to be equal to or greater than 50 cfu/100mL. Focus areas were established in 2016 at Minett (MIN-1, MIN-6, MIN-7 and MIN-9). This included sampling for *E.coli* 8 times during the summer.

- A Secchi disk was used to measure water clarity at the deep-water locations, taken during each of the 4 sampling events.

- Dissolved organic carbon was sampled at 18 locations during the 4 sampling events in 2016. DOC was collected at Beaumaris (BMR-4 and BMR-6), Boyd Bay (BOY-4), Brackenrig Bay (BRA-3), Cox Bay (COX-6), Hamer Bay (HMB-8), Indian River (IND-7), Muskoka Bay (MBA-12), Minett (MIN-6), Muskoka Sands (MSN-4), Three Mile Lake (TML-1, TML-2, TML-3 and TML-4), Windermere (WIN-1, WIN-6 and WIN-7) and Willow Beach (WLB-3). Each of these nearshore sites was selected based on their proximity to potential sources of natural phosphorus.

  Water clarity in the lakes in Muskoka Parry Sound region is partially determined by DOC that imparts a tea colour in the water. DOC compounds in Precambrian Shield waters are formed by the decomposition of organic plant matter in wetland areas and concentrations in lake waters are determined by the amount of wetland in the catchment of a lake (Hutchinson 2002).

The influence of DOC is entirely natural and cannot be managed to improve water clarity (Secchi depth).

This water quality program focuses on phosphorus and *E.coli* sampling on a yearly basis and incorporates additional parameters including DOC and calcium on a rotational basis or when necessary. Algal bloom monitoring and/or sampling is not part of this monitoring program and any recommendations or classifications provided for each area are based on results as per the water quality parameters mentioned above.

A summary of the 2016 sampling program for each location is provided below in **Tables 5** through **9**, outlining which areas or affiliate lakes were included in the program, their sampling location and water quality parameters sampled for each. **Figure 1** illustrates the sampling areas in 2016.

Table 5. Summary of the Lake Joseph 2016 Monitoring Program

Sampling Area	Sampling Location	Water Quality Parameters Collected in 2016			
		Secchi Disk	TP	DOC	Bacteria
Cox Bay	COX-0	✓	✓		
	COX-2		✓		
	COX-6		✓	✓	
	COX-7		✓		
Foot's Bay	FTB-0	✓	✓		
	FTB-3				✓
Gordon Bay	GNB-0	✓	✓		
	GNB-3				✓
Hamer Bay	HMB-0	✓	✓		
	HMB-1		✓		✓
	HMB-2		✓		
	HMB-6				✓
	HMB-7				✓
	HMB-8		✓	✓	
Little Lake Joseph	LLJ-0	✓	✓		
	LLJ-6		✓		
	LLJ-7		✓		
	LLJ-12				✓
	LLJ-13				✓
Main Basin	JOS-1	✓	✓		
Stanley Bay	STN-0	✓	✓		
	STN-3		✓		
Stills Bay	STI-2		✓		

Table 6. Summary of the Lake Muskoka 2016 Monitoring Program

Sampling Area	Sampling Location	Water Quality Parameters Collected in 2016			
		Secchi Disk	TP	DOC	Bacteria
Alport Bay	ALL-0	✓	✓		
Arundle Lodge	ARN-0	✓	✓		
Bala Bay	BAL-0	✓	✓		
	BAL-2				✓
	BAL-3				✓
Beaumaris	BMR-0	✓	✓		
	BMR-4		✓	✓	✓
	BMR-5		✓		✓
	BMR-6		✓	✓	
Boyd Bay	BOY-0	✓	✓		
	BOY-3		✓		
	BOY-4		✓	✓	
	BOY-6				✓
Browning Island	BWN-1				✓
	BWN-2				✓
Dudley Bay	DUD-1		✓		
East Bay	EAS-0	✓	✓		
	EAS-2		✓		
	EAS-3		✓		
Eilean Gowan	ELG-0	✓	✓		
	ELG-3				✓
	ELG-4				✓
Main Basin	MUS-3	✓	✓		
Muskoka Bay	MBA-0	✓	✓		
	MBA-4				✓
	MBA-12		✓	✓	
	MBA-13		✓		✓
Muskoka Sands	MSN-0	✓	✓		
	MSN-1				✓
	MSN-4		✓	✓	
	MSN-5		✓		
	MSN-6				✓
North Bay	NRT-0		✓		
	NRT-4				✓
Stephen's Bay	STE-0	✓			✓
	STE-2				✓
Taylor Island	TAY-0	✓	✓		
	TAY-1				✓
	TAY-2		✓		✓
	TAY-4				✓
Walker's Point	WAK-0	✓	✓		
	WAK-2		✓		✓

Sampling Area	Sampling Location	Water Quality Parameters Collected in 2016			
		Secchi Disk	TP	DOC	Bacteria
	WAK-6		✓		✓
Whiteside Bay	WTS-0	✓	✓		
Willow Beach	WLB-0	✓	✓		
	WLB-1		✓		✓
	WLB-3		✓	✓	✓
	WLB-4		✓		

Table 7. Summary of the Lake Rosseau 2016 Monitoring Program

Sampling Area	Sampling Location	Water Quality Parameters Collected in 2016			
		Secchi Disk	TP	DOC	Bacteria
Brackenrig Bay	BRA-0	✓	✓		
	BRA-3		✓	✓	
	BRA-4				✓
	BRA-5				✓
	BRA-6		✓		
East Portage Bay	POR-0	✓	✓		
	POR-3		✓		✓
	POR-5		✓		
Main Basin	ROS-1	✓	✓		
Minett	MIN-0	✓	✓		
	MIN-1		✓		✓
	MIN-6		✓	✓	✓
	MIN-7		✓		✓
	MIN-9		✓		✓
Morgan Bay	MGN-0	✓	✓		
	MGN-2		✓		
Muskoka Lakes G&CC	MLG-0	✓			
Rosseau Falls	RFL-1		✓		
Rosseau North	RSH-0	✓	✓		
	RSH-2		✓		
	RSH-4		✓		
Royal Muskoka Island	RMI-0	✓			
Skeleton Bay	SKB-0	✓	✓		
	SKB-1		✓		✓
Tobin Island	TOB-0	✓	✓		
Windermere	WIN-0	✓	✓		
	WIN-1		✓	✓	✓
	WIN-3		✓		✓
	WIN-4		✓		✓
	WIN-5		✓		✓
	WIN-6		✓	✓	
	WIN-7		✓	✓	
	WIN-8		✓		✓

Table 8. Summary of the Watercourse 2016 Monitoring Program

Sampling Area	Sampling Location	Water Quality Parameters Collected in 2016			
		Secchi Disk	TP	DOC	Bacteria
Indian River	IND-0	✓	✓		
	IND-2				✓
	IND-3				✓
	IND-4				✓
	IND-7		✓		✓
Joseph River	JOR-0	✓	✓		
	JOR-2		✓		
	JOR-3		✓		
Mirror Lake	MIR-0	✓	✓		
	MIR-1				✓
	MIR-3		✓		✓
Muskoka River	MRV-2	✓	✓		✓
	MRV-3	✓	✓		
	MRV-4	✓	✓		
	MRV-5		✓		✓
	MRV-6		✓		✓
	MRV-7		✓		✓

Table 9. Summary of the Affiliate 2016 Monitoring Program

Sampling Area	Sampling Location	Water Quality Parameters Collected in 2016			
		Secchi Disk	TP	DOC	Bacteria
Bass Lake	BAS-2		✓		
	BAS-3				✓
	BAS-5	✓	✓		
	BAS-6				✓
	BAS-7		✓		
Brandy Lake	BDY-0	✓	✓		
	BDY-1				✓
	BDY-2				✓
	BDY-3				✓
	BDY-5				✓
	BDY-6				✓
	BDY-7				✓
	BDY-8				✓
	BDY-9				✓
	BDY-10				✓
	BDY-11				✓
Bruce Lake	BRU-0	✓	✓		

Sampling Area	Sampling Location	Water Quality Parameters Collected in 2016			
		Secchi Disk	TP	DOC	Bacteria
	BRU-1		✓		✓
	BRU-3		✓		✓
	BRU-4		✓		✓
	BRU-5		✓		✓
	BRU-6		✓		✓
Clear Lake	CLR-0	✓	✓		
	CLR-2		✓		✓
	CLR-4		✓		✓
	CLR-5		✓		✓
	CLR-7				✓
Gull Lake	GUL-0	✓	✓		
	GUL-1				✓
	GUL-2				✓
	GUL-3				✓
	GUL-4				✓
Gullwing Lake	GLW-0		✓		
	GLW-1		✓		✓
	GLW-2		✓		✓
Leonard Lake	LEO-0	✓	✓		
	LEO-1		✓		✓
	LEO-3		✓		✓
	LEO-5				✓
	LEO-6				✓
Moon River	MOO-1		✓		✓
	MOO-4		✓		✓
	MOO-6		✓		✓
	MOO-9		✓		✓
	MOO-11	✓	✓		
	MOO-12		✓		✓
	MOO-13		✓		✓
	MOO-14		✓		✓
	MOO-15		✓		✓
Silver Lake (GH)	SVR-0	✓	✓		
	SVR-1				✓
	SVR-2				✓
Silver Lake (TML)	SPC-0	✓	✓		
	SPC-1				✓
	SPC-4				✓
Star Lake	STR-0	✓	✓		
	STR-1				✓
	STR-2				✓
	STR-3				✓
	STR-4				✓
	STR-5				✓

2.5 Updates in the 2016 Monitoring Program

Sampling sites are chosen and classified according to their local environment. The three site types are **nearshore, deep-water, and watercourse**. Nearshore sites are located adjacent to land where the water depth is generally between 50 cm and 150 cm as this is the depth at which most recreational use occurs. Deep-water sites are located in deeper, open water locales. Watercourse sites are located in streams and creeks conveying flow to the larger waterbodies. Sampling methodologies differ based on the type of sampling site (see Water Quality Initiative Methodology Report, Beacon 2013).

Prior to each sampling season, a complete review of the sampling sites is conducted. Sampling sites generally remain consistent from year to year, as the main goal of the program is to discover the sources of phosphorus entering the lakes based on long term trends, while other objectives include providing additional data to support the protection of vulnerable areas, monitor Coliform and *E. coli*, and promote stewardship. However, site revisions are made as necessary based on analyses of previous data, volunteer availability, new information, and budget. Generally, bacteria monitoring is discontinued at sampling sites exhibiting chronically low bacteria levels (3+ consecutive years with average concentrations below 10 cfu/100mL). In sampling areas where bacteria monitoring is reduced, new nearshore sites are generally established as necessary.

The review of the historical data and planning for the 2016 program resulted in changes in sampling locations and water quality parameters sampled. Parameters changed include:

- Dissolved Organic Carbon was increased to eighteen (18) sampling locations to better understand potential sources of natural phosphorus versus human impact.
- Calcium was again not sampled for during the 2016 program. Calcium will be sampled for if a laboratory can be secured to undertake the calcium analysis prior to the spring sampling in 2017.

Also, a number of sampling locations were added, removed, restarted or modified from the program in 2016 (**Tables 5** through **9**). One new lake was added to the sampling program in 2016; Three Mile Lake. These changes are summarized in **Table 10** below. The changes undertaken include 15 sites being discontinued for 2016, 8 sites being added, 10 sites being restarted, 11 sites being modified and 7 sites making use of the Lake Partner Program spring phosphorus data.

Table 10. Summary of the 2016 Monitoring Program Revisions

Waterbody Name	Sampling Area	Sampling Location	Site Added	Site Restarted	Site Removed	Site Modified
Lake Joseph	Cox Bay	COX-4			✓	
	Cox Bay	COX-5			✓	
	Cox Bay	COX-7	✓			
	Hamer Bay	HMB-3			✓	
	Little Lake Joseph	LLJ-12		✓		
	Little Lake Joseph	LLJ-13		✓		
	Stills Bay	STI-0			✓	
Lake Muskoka	Beaumaris	BMR-2			✓	
	Boyd Bay	BOY-5			✓	
	Boyd Bay	BOY-5			✓	
	Muskoka Bay	MBA-13				-Increased bacteria sampling from 2 to 3; -Collected phosphorus samples
	North Bay	NRT-4				-Increased bacteria sampling from 2 to 3; -Stopped phosphorus sampling
	Walker's Point	WAK-6	✓			
	Willow Beach	WLB-4		✓		
Lake Rosseau	Brackenrig Bay	BRA-6	✓			
	East Portage Bay	POR-3				-Started bacteria sampling
	East Portage Bay	POR-4			✓	
	Minett	MIN-1				-Increased bacteria sampling from 2 to 8;
	Minett	MIN-6				-Increased bacteria sampling from 2 to 8;
	Minett	MIN-7				-Increased bacteria sampling from 2 to 8;
	Minett	MIN-8			✓	
	Minett	MIN-9				-Increased bacteria sampling from 2 to 8;

Waterbody Name	Sampling Area	Sampling Location	Site Added	Site Restarted	Site Removed	Site Modified
	Rosseau North	RSH-5			✓	
	Windermere	WIN-3		✓		
	Windermere	WIN-4		✓		
Indian River	Indian River	IND-4		✓		
Joseph River	Joseph River	JOR-1			✓	
	Joseph River	JOR-2		✓		
Affiliates	Bass Lake	BAS-2			✓	
	Clear Lake	CLR-2				-Increased bacteria sampling from 2 to 3; -Collected phosphorus samples
	Gull Lake	GUL-2		✓		
	Gullwing Lake	GLW-0				-Collected phosphorus samples
	Gullwing Lake	GLW-1				-Increased bacteria sampling from 2 to 3; -Collected phosphorus samples
	Gullwing Lake	GLW-2				-Increased bacteria sampling from 2 to 3; -Collected phosphorus samples
	Leonard Lake	LEO-1		✓		
	Moon River	MOO-10			✓	
	Moon River	MOO-15	✓			
	Silver Lake (TML)	SPC-2			✓	
	Silver Lake (TML)	SPC-5		✓		
	Silver Lake (GH)	SVR-1			✓	
	Three Mile Lake	TML-1	✓			
	Three Mile Lake	TML-2	✓			
	Three Mile Lake	TML-3	✓			
	Three Mile Lake	TML-4	✓			
TOTAL			**8**	**10**	**15**	**11**

3. 2016 Monitoring Results and Sampling Analysis

Based on the long term data acquired to date, the water quality in most of the sampling locations remains consistently good to excellent. The results from each sampling area are presented in the Area Summary Sheets (**Appendix A**). Each sheet describes the specific sampling area and provides a summary of the 2016 data, as well as graphical results of phosphorus and *E. coli* results, if sampled for. Each new area description in 2016 is based upon first-hand knowledge, historical and up to date aerial photography, as well as file information from the Ministry of Natural Resources and Forestry and the District Municipality of Muskoka.

The Area Summary Sheets summarize mean Secchi Disk depth, spring turnover phosphorus and yearly mean phosphorus concentrations, and *E. coli* and total coliform yearly geometric means. In 2013 Beacon introduced a visual indication of the overall water quality at each Area by means of a traffic light symbol. This method was well received within the MLA membership and continues to be used in this report with updated thresholds. The meaning of each symbol is described below:

Green Light
Water quality remains consistently good.

Yellow Light
Further investigation is recommended to maintain good water quality.

Red Light
Remedial action is recommended to improve water quality.

In 2016, thresholds were redeveloped for each of the traffic light symbols to better quantify the data trends for *E. coli*. In 2017, following consultation with the MLA Water Quality & Environment Committee, new phosphorus thresholds may be established. Consideration will be given to nearshore natural heritage conditions, existing land use, as well as the upcoming changes to the District of Muskoka water quality threshold.

Regarding *E. coli*, the methodology recommended in the MOECC Provincial Water Quality Objectives (PWQO) for swimming and bathing beaches is based on a geometric mean of levels of *E. coli* determined from a minimum of five samples per site collected within a one month period. If the geometric mean for a series of 5 samples in a month at a given site exceeds 100 colony forming units (cfu) of *E. coli* per 100 milliliters (mL), the site is considered to be unsuitable for swimming and bathing. While many watershed managers believe that among bacteria of the coliform group, *E. coli* is the most suitable and useful indicator of fecal coliform, others continue to require testing for total coliform. For this parameter, the PWQO for body contact recreation is 1,000 cfu per 100 mL, based on a geometric mean for a series of 5 samples per site per month. The MLA *E.coli* geometric mean is

determined over the sampling program duration (1 sample per month over 4 months). In some cases if the *E. coli* levels are found to be greater than 50 cfu/100mL, the MLA WQI includes a field protocol that requires volunteers to re-sample the site. Therefore some sites may have more than 1 *E.coli* sample per month.

The following table (**Table 11**) describes the thresholds for the 2016 analysis of *E .coli* concentrations.

Table 11. *E. coli* Thresholds for Assigning Traffic Light Limits for Area Summaries

Traffic Light	*E. coli Yearly Geometric Mean (cfu/100 ml)*	Visual Phosphorus Trend Associated with all Sampling Years
	0 - 30	Flat or decreasing visual trend
	31 - 99	Slightly increasing visual trend and/or the spring deepwater sample is noticeably elevated above the DMM Threshold or historical values
	>100 as per MOECC geometric mean for a series of 5 samples per site per month	Increasing visual trend and consistently over threshold

The traffic light symbols in each Area Summary are based on the category of symbol indicating the level of water quality related to *E.coli* and phosphorus levels as defined in Table 11.

As noted above, traffic light thresholds for phosphorus will be reviewed in discussion with the MLA Water Quality & Environment Committee in 2017. The analysis of the 2016 phosphorus data follows the previous methodology of visual linear trends of increasing or decreasing phosphorus concentrations through the sampling years. Additionally, if a phosphorus sample at a deepwater station for a particular year is noticeably elevated beyond the District Municipality of Muskoka Threshold (if available), or historical values, that will result in a Yellow traffic light for an Area.

3.1 Mean Secchi Depth Measurements

Secchi depth is a measurement of water clarity, providing water quality information. A decrease in water clarity in these sampling locations is most likely either a result of increased dissolved organic carbon (DOC) levels or increased levels of nutrients from the watershed. DOC inputs originate in wetlands and cause a naturally brown or tea colour in a water body. A decrease in water clarity can also result from increased levels of suspended sediments in turn leading to algal growth, decreasing clarity.

Water clarity can change in the short term as a result of weather, shoreline development or seasonal changes. A long term decrease in water clarity is generally an indication of an increase in nutrient (phosphorus and nitrogen) levels and therefore a decrease in water quality. Lakes with a Secchi depth

>5 m are considered oligotrophic or unenriched. Lakes with a Secchi depth between 3 and 5 m are considered mesotrophic or moderately enriched. Finally, lakes with a Secchi depth <3 m are considered eutrophic or enriched (Dillon *et al.* 1986).

Secchi depth values are determined by averaging the "up" and "down" measurements recorded by the volunteers using a Secchi disk. The mean Secchi Disk listed in the Area Summaries represents the arithmetic mean of values obtained from individual sampling sites throughout the season. The Area Summary Sheets provide the mean Secchi depth for each deep-water site sampled in 2016. Because water clarity in most lakes in Muskoka is affected by dissolved organic carbon (DOC), which results in tea coloured water, and not just by algal concentrations, the Secchi depths alone cannot be considered an indicator of nutrient (phosphorus) status; however, this data remains important for monitoring long-term water quality trends.

That said, the Secchi depths recorded in 2016 continue to remain consistent with the depths reported historically with expected minor variation (up and down) through the years.

3.2 Phosphorus

Several years of spring-turnover phosphorus data can be analysed to understand the nutrient status of the lake and understand trends through time which might indicate a change in the nutrient status of the lake.

As noted in the District of Muskoka 2012 Lake System Health Monitoring Program Year End Report "Phosphorus is the nutrient that controls the growth of algae in most Ontario lakes. For this reason, an increase in phosphorus in a lake increases the potential for algal blooms. Algal blooms detract from recreational water quality and, in some cases, affect the habitat of coldwater fish species such as Lake Trout."

Duplicate phosphorus samples collected in 2016 were analyzed for the degree of difference between the duplicates according to the District Municipality of Muskoka (DMM) phosphorus data management protocol and the MOECC interim protocol for removing what are termed bad splits. The MOECC Lakeshore Capacity User Manual (November 2011) states that if duplicate samples that differ by the higher being 30% more than the lower, or >5mg/L than the lower, then the higher sample should be deemed as a bad split and should be removed from the analysis. Beacon has analyzed the 2016 data to remove any of the bad splits from the analysis as per the present MOECC interim approach. All of the raw data will remain in the database should it be required for future consideration if for example the MOECC interim protocol for bad splits is revised.

In the 2016 phosphorus sampling, 67 of 484 samples (14%) were deemed to be bad splits. In the 2015 phosphorus duplicates, 83 of 437 samples (19%) were deemed to be bad splits, and in 2014, 16% were deemed to be bad splits. The amount of bad splits in 2016 was the lowest recorded in the last 3 years. The phosphorus sampling program in 2017 may be revised to further follow District of Muskoka sampling protocol with the anticipation of decreased occurrences of bad splits.

Following the analysis for bad splits, an outlier analysis was undertaken for all spring turnover data using the District Municipality of Muskoka (DMM) protocol. There are various approaches to outlier

detection depending on the objective of outlier detection and the number of observations in the data set. The DMM uses the Grubb's Test recommendation for outliers contained in the 2008 Gartner Lee report *Review of Long Term Water Quality Data for the Lake System Health Program*. The Grubb's Test for outliers (extreme studentized deviates) was used in previous MLA water quality reports and continues to be used to analyze the 2016 data.

Since the outlier detection is dependent on long-term data analysis, all of the dataset is used for each sampling location during each sampling analysis. Natural variation in levels of spring phosphorus is realized following the statistical analysis using Grubb's Test. A good example continues to be the May 2011 spring turnover phosphorus concentration at the Foot's Bay deep station (FTB-0). Using the Grubb's Test in 2013, the value obtained in the spring of 2011 (15 µg/L) was an outlier. Analysis of spring phosphorus, including that obtained in 2014 (5.5 µg/L), resulted in no significant outliers at the FTB-0 site. In the 2016 analysis for outliers, the value obtained in the spring of 2011 was once again an outlier, and removed from the 2016 analysis.

Following the analysis of spring phosphorus from 2002-2016, a total of eleven spring phosphorus data points were removed in 2016. The spring phosphorus data that passed the statistical analysis are plotted and presented in the Area Summary Sheets. The reader is reminded that in 2012, the 2012 deep-water total phosphorus data were deemed unreliable, were removed from the analysis, and therefore no results are presented in the Area Summary Sheets for phosphorus in 2012.

Spring turnover and yearly mean total phosphorus data have been provided for most sites monitored in 2016. Current and historical total phosphorus data for deep-water sites within each sampling Area are presented in a graph to show long-term trends. Where appropriate, graphs show MLA data in relation to the threshold concentration set by the DMM or Seguin Township. There is an overall general downward trend in most of the spring phosphorus concentrations in 2016 compared with values in 2015. At the deep-water station sites that sampled for spring phosphorus, 62% showed a lower phosphorus concentration than in 2015 while 68% of those sites with a measured yearly phosphorus mean also showed lower concentrations compared with results from 2015.

New nearshore stations were established at Cox Bay (COX-7) and Brackenrig Bay (BRA-6) in 2016 to investigate phosphorus concentrations. Additionally, new nearshore stations were established at Walker's Point (WAK-6) and Moon River (MOO-15) to monitor phosphorus and bacteria levels in 2016. One new Area (Three Mile Lake) was added to the sampling program in 2016 and consists of 4 watercourse sampling stations (TML-1, TML-2, TML-3 and TML-4); each was sampled for phosphorus and DOC (caution must be observed in reviewing data from only one year at TML sites). Beacon recommends that the new stations continue to be sampled through 2017 in order to analyse for trends.

Nearshore and watercourse yearly mean total phosphorus concentrations in 2016 were calculated as the arithmetic mean of all measurements from an individual sampling site within the sampling season, including duplicate sample measurements, where available.

The new watercourse stations established at Windermere in 2014 to assess nutrient inputs from the lakes and ponds upstream of the long established WIN-1 site continued to be sampled in 2016. The 2016 spring phosphorus results at WIN-6, WIN-7 and WIN-8 show higher concentrations while the 2016 mean yearly phosphorus results at WIN-6, WIN-7 and WIN-8 show lower concentrations with the

exception of WIN-6 which was only sampled once. Caution must be exercised when reviewing only 3 years of data as trends are only starting to emerge. Continued sampling at all of these Windermere stations in 2017 is recommended to better assess the scale of the nutrient input from the upstream sources.

On the graphs illustrating long-term phosphorus levels, threshold concentrations have been represented by a single black dashed line. **Figure 2** shows the graph for ELG-0 for illustration purposes. For sampling areas in the DMM, the threshold values are those in previous year's reports, previously verified by the DMM. Sampling areas without graphed threshold lines have not been modelled and are not comparable to other areas as previously confirmed through consultation with the DMM. The DMM is presently reviewing their Lake System Health program and it is expected that this may form part of the updated traffic light system in 2017.

Spring turnover and yearly mean total phosphorus measured by the MLA at ELG-0 is shown in µg/L on the y-axis and sampling year is indicated on the x-axis. Spring turnover total phosphorus concentration was calculated as the arithmetic mean of the spring or mid-May duplicate sample measurements, where available for all sites. Historical spring turnover total phosphorus concentrations for the deep-water reference sites have been represented graphically as a blue line with diamonds or as single blue diamonds (**Figure 2**), if consecutive years of data were not available. Note that in previous years, duplicate spring turnover samples were not consistently collected at some sites and for these sites, a single spring turnover sample has been reported. Historical deep-water yearly mean total phosphorus concentrations have been represented graphically in the area summaries as a red line with circles or as single red circle, if consecutive years of data were not available.

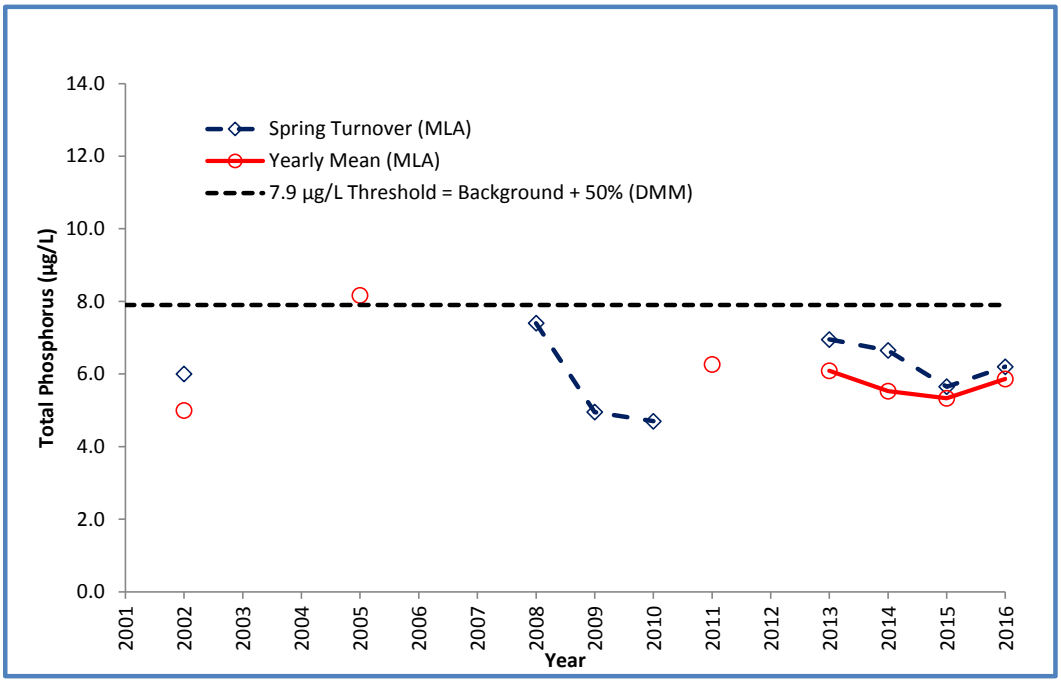

Figure 2. Illustration of ELG-0 showing long-term phosphorus levels

Elevated 2016 deep-water spring phosphorus concentrations in comparison to 2015 were recorded at Gordon Bay (GNB-0), Hamer Bay (HMB-0), Lake Joseph (JOS-1), Little Lake Joseph (LLJ-0), Allport (ALL-0), Boyd Bay (BOY-0), Eilean Gowan (ELG-0), Muskoka Bay (MBA-0), Whiteside Bay (WTS-0), Brackenrig Bay (BRA-0), Morgan Bay (MGN-0), Brandy Lake (BDY-0), Bruce Lake (BRU-0), Gull Lake (GUL-0), Joseph River (JOR-0) and Mirror Lake (MIR-0). Of these sampling locations, elevated levels of mean yearly phosphorus in 2016 compared with 2015 were also recorded at Lake Joseph (JOS-1), Little Lake Joseph (LLJ-0), Eilean Gowan (ELG-0), Whiteside Bay (WTS-0), Brackenrig Bay (BRA-0), and Mirror Lake (MIR-0).

Water level fluctuations can significantly affect lake water quality. High water levels such as those experienced in the three big lakes during the spring of 2016, can increase the concentration of nutrients from runoff and flooded lakeshore soils. Older septic systems, located near lakes, may flood when groundwater levels are high. Yet another consequence of fluctuating water levels is shoreline erosion. Each of these scenarios can increase the concentration of phosphorus in a receiving water body.

The average length of time water remains in a lake is called the retention time or flushing rate. The lake's size, water source, and watershed size primarily determine the retention time. Rapid water exchange rates allow nutrients to be flushed out of the lake quickly, or conversely, nutrients may remain within a waterbody for years.

Nutrients that accumulate over a number of years in lakes with long retention times can be recycled annually with spring and fall mixing. Reserve nutrients in lake sediments can continue to recirculate, even after the source of nutrients in the watershed has been controlled. It was noted in the 2013 report that the effects of the flooding in the spring of 2013 may not be apparent for a number of years. In the 2014 phosphorus analysis only two stations with elevated spring phosphorus concentrations in 2013 had similar high spring phosphorus concentrations in 2014; Little Lake Joseph (LLJ-0) and Muskoka Main Basin (MUS-3). These same two stations had very apparent decreases in the spring phosphorus concentrations in 2015 and 2016 (see Area Summary graphs) with levels almost returning to the Threshold value set by the DMM for both Areas.

The high water levels and flooding encountered in the spring of 2016 would have also potentially allowed the addition of nutrients to the waterbodies. From the analysis to date, there does not seem to be an increase in phosphorus concentrations that may relate to spring flooding, either in 2013 or 2016.

Although there are no clear indications of direct negative water quality impacts resulting from the 2013 and 2016 flooding, Beacon will continue review spring and yearly mean phosphorus levels at all stations to look for potential impacts and trends.

3.3 Dissolved Organic Carbon

The Lakeshore Capacity Model is a variant of the original MOECC Lakeshore Capacity Study Trophic Status Model (Dillon *et al.* 1986), which has been substantially reworked and updated over the years

to reflect improved scientific understanding of phosphorus loads to lakes and lake responses to those loads (Hutchinson 2002; Paterson *et al*. 2006). The model is a steady-state mass balance model that estimates hydrologic and phosphorus loading from natural (watershed runoff and atmospheric deposition) and human (septic systems and land disturbance) sources for all lakes within a watershed and links them together considering lake dynamics to predict phosphorus concentrations in lakes.

Dillon and Molot (1997) stated that wetlands are a rich source of DOC and TP and that annual TP export is probably a function of DOC and iron export. Hutchinson (2002) further notes that recent research on total phosphorus concentrations in Precambrian Shield lakes is significantly related to the amount of wetland in the lake's catchment and he provides a figure (reproduced below as **Figure 3**) showing that Dissolved Organic Carbon determines the level of natural phosphorus loading to a lake. Hutchinson's research concluded that total phosphorus concentrations were statistically related to the amount of wetland and DOC in the catchment of lakes in the Muskoka River watershed. **Figure 3** illustrates increasing total phosphorus is influenced by increasing concentrations of DOC.

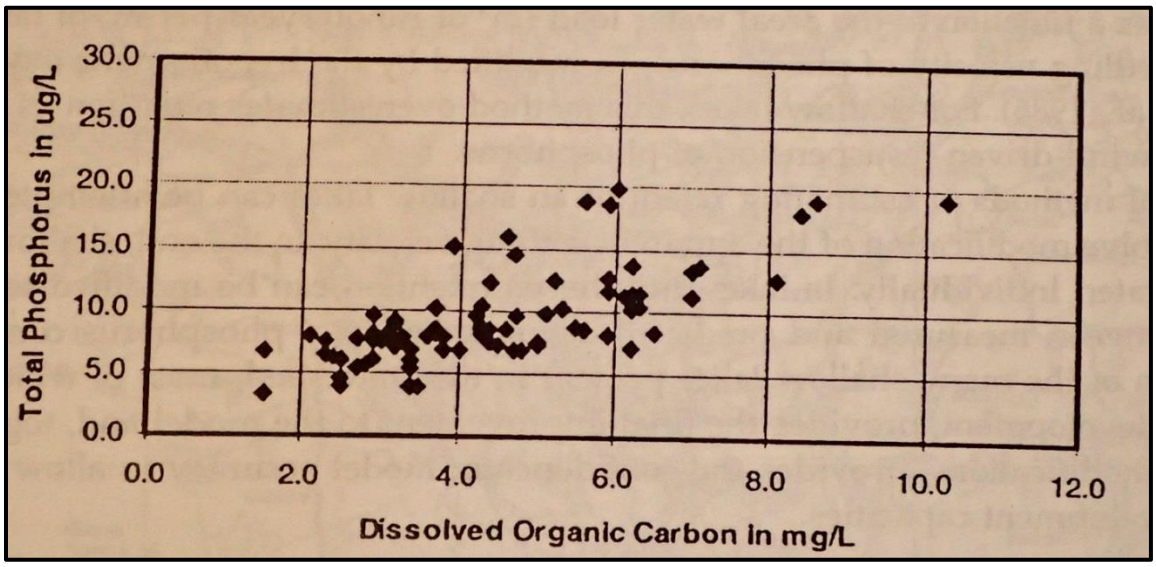

Figure 3. Reproduced from Hutchinson (2002) showing the influence of Dissolved Organic Carbon on average long-term phosphorus concentrations in Precambrian Shield lakes.

DOC was sampled at 18 sites in 2016. The analysis of the total phosphorus and DOC concentrations at the stations with at least 1.5 years of DOC data (14 sites) was undertaken this year. The sites analyzed in 2016 include Beaumaris (BMR-4 and BMR-6), Boyd Bay (BOY-4), Brackenrig (BRA-3), Cox Bay (COX-6), Hamer Bay (HMB-8), Indian River (IND-7), Muskoka Bay (MBA-12), Muskoka Sands (MSN-4), Minett (MIN-6), Windermere (WIN-1, WIN-6 and WIN-7) and Willow Beach (WLB-3).

The data at stations BMR-4, BMR-6, BOY-4, BRA-3, COX-6, IND-7, MIN-6 and WLB-3 are generally within the same range as the data presented in **Figure 3**. Using the same scale for each axis as is presented in **Figure 3**, the data from BMR-4, BMR-6, BOY-4, BRA-3, COX-6, IND-7, MIN-6 and WLB-3 is presented in **Figure 4** below. Although Beacon does not have access to the data presented in **Figure 3,** a linear trend line can be estimated through those data points in which approximately half of the points are above the line and half are below. The reader should notice that the pattern of data

points in **Figure 3** is shot-gun like and our approximated trend line is best guess and is included in **Figure 4**.

The data at stations HMB-8, MBA-12, MSN-4, WIN-1, WIN-6 and WIN-7 contain total phosphorus and DOC concentrations higher than the scale of those in **Figure 3** and **Figure 4**. As such, these stations are plotted in **Figure 5** and the same trend line is extended to this data range.

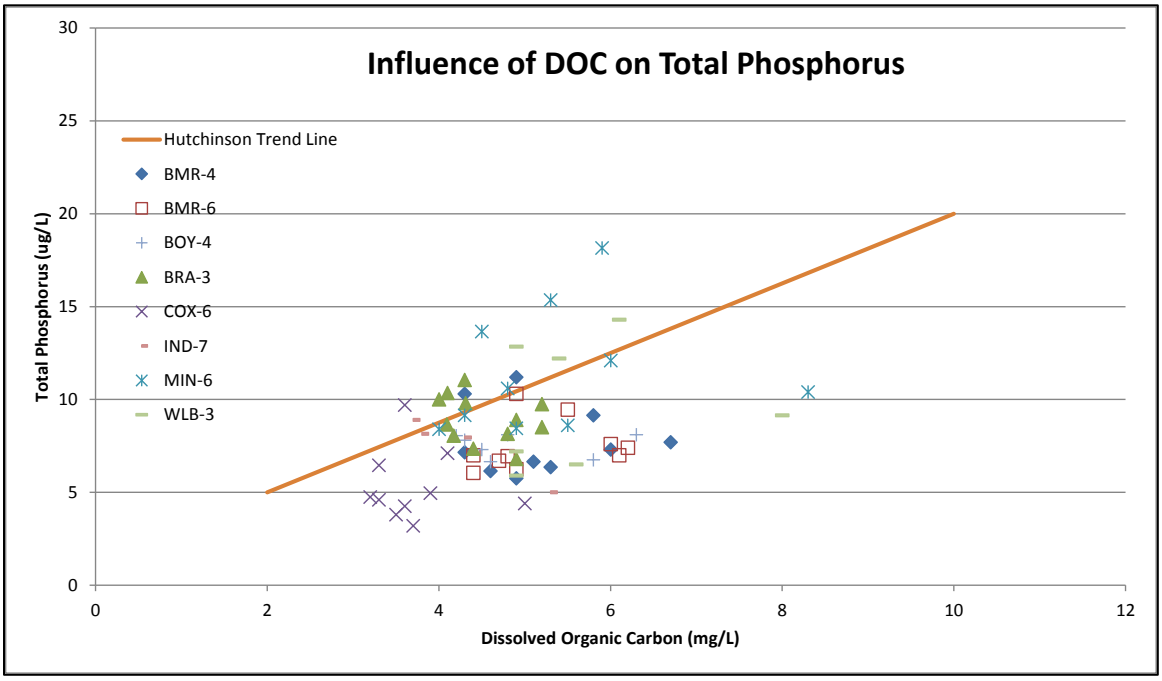

Figure 4. Total phosphorus and DOC data from stations BMR-4, BMR-6, BOY-4, BRA-3, COX-6, IND-7, MIN-6 and WLB-3.

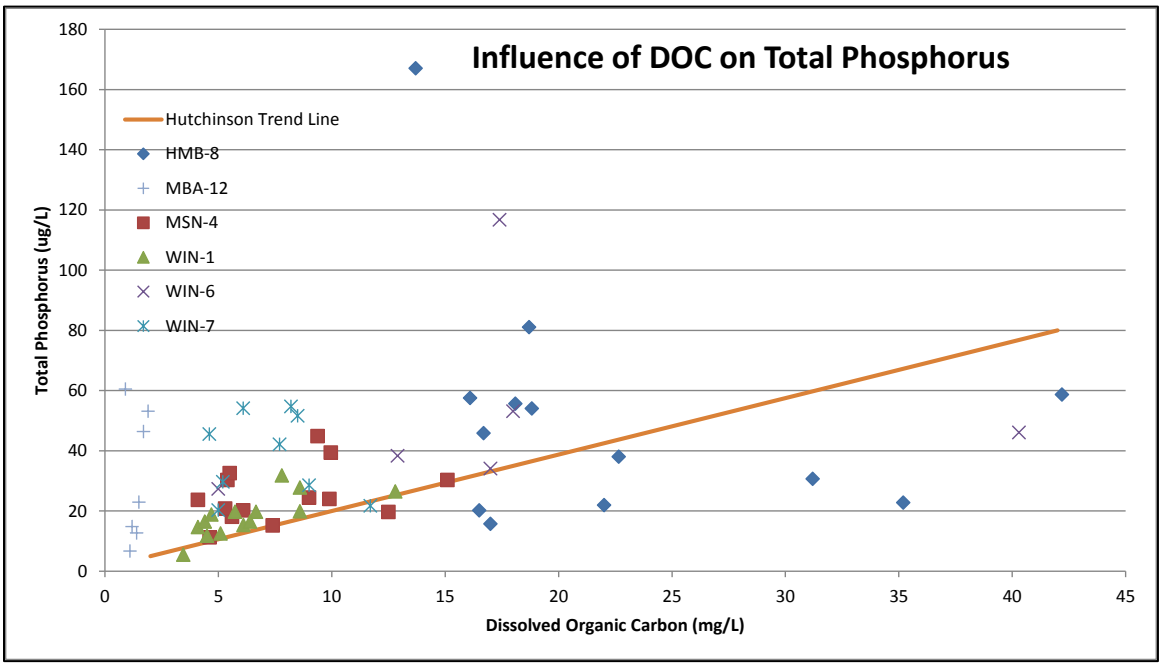

Figure 5. Total phosphorus and DOC data from stations HMB-8, MBA-12, MSN-4, WIN-1, WIN-6 and WIN-7.

In general terms, the DOC and total phosphorus (TP) are spread around the trend line in **Figure 4**, indicating that the results found at stations BMR-4, BMR-6, BOY-4, BRA-3, COX-6, IND-7, and WLB-3 are consistent with those found by Hutchinson (2002) and Paterson et al. (2006). The concentrations of phosphorus and DOC found at these stations are consistent with the data from the Muskoka River watershed and the levels of phosphorus are indicative of natural inputs. The relationship of phosphorus and DOC at MIN-6 indicates that phosphorus inputs may not be correlated to natural inputs.

Levels of DOC and TP are less consistently associated with the trend line in **Figure 5**. Increased concentrations of TP (more data points for a station above the line than below) at stations MBA-12, MSN-4, WIN-1, WIN-6 and WIN-7 are not likely related to the associated increased concentrations of DOC. This is an indication that phosphorus inputs may not be correlated to natural inputs. Beacon recommends that sampling for DOC and total phosphorus be continued at each station in 2017 to better understand the relationship of DOC and TP at these stations.

3.4 Bacteria

Total coliform and *E. coli* data have been summarized in the tables on each Area Summary Sheet for all sites monitored in 2016. Current and historical *E. coli* data continue to be presented graphically. *E. coli* concentrations are reported as the number of colony forming units (cfu) observed in 100 mL of lake water (cfu/100 mL) on the y-axis and sampling sites are indicated on the x-axis. On the *E. coli* graphs, each sampling site is represented as a cluster of bars that represent different sampling

seasons (years). Each year is represented by different coloured bars. Each graph also compares *E. coli* levels to the MLA traffic light limits (Section 3), which is represented by a black dotted line at 30 cfu/100mL and a black solid line at 100 cfu/100mL.

The Provincial Water Quality Objective (PWQO) of the Ministry of the Environment and Climate Change (MOECC) for swimming and bathing beaches is based on a geometric mean of *E. coli* determined from a minimum of five samples per site collected within a one month period. If the geometric mean for a sample series at a given site exceeds 100 colonies of *E. coli* per 100 millilitres (mL), the site is considered to be unsuitable for swimming and bathing. Additionally, the geometric mean exceeding 100 cfu is the threshold for the MLA red traffic light. As noted above, regarding *E. coli*, the methodology recommended in the MOECC Provincial Water Quality Objectives (PWQO) for swimming and bathing beaches is based on a geometric mean of levels of *E. coli* determined from a minimum of five samples per site collected within a one month period. In all cases in 2016, the MLA did not collect 5 samples in a 1 month period for any of the stations. The geometric mean reported in the Area Summaries is based on the number collected at each station.

Bacteria, including *E. coli*, may survive for weeks in water and sediment and possibly even in submerged fecal pellets. Cold temperatures generally allow bacteria to survive longer than in warm water where they may be degraded or eaten by other microorganisms. *E. coli* levels at a particular sampling date provide a snapshot of the concentration of bacteria at one point in time. Sampling though a number of months in a particular year can provide evidence of ongoing bacteria issues.

3.4.1 Total Coliforms

Total coliform data is summarized for areas where bacterial monitoring was conducted in 2016. Total coliform concentrations are reported as yearly averages calculated as the geometric mean of all available measurements, including follow-up measurements, for an individual sampling site. Total coliform measurements of <3 cfu/100 mL were assigned a value of 1 cfu/100 mL for the purpose of calculating means. Geometric means presented in the area summaries were rounded to the nearest colony forming unit.

3.4.2 E. coli

E. coli data is summarized for areas where bacterial monitoring was conducted in 2016. *E. coli* levels are presented as yearly averages calculated as the geometric mean of all available measurements, including re-test measurements, for an individual sampling site. Current and historical *E. coli* levels are also illustrated graphically in area summaries. *E. coli* measurements of <3 cfu/100 mL were assigned a value of 1 cfu/100 mL for the purpose of calculating means. For the *E. coli* graphs in the area summaries, every site that was sampled has a minimum value of 1 cfu/100 mL; where no bar is shown for a particular site/year, no data was collected or reported. Geometric means presented in the area summaries were rounded to the nearest colony forming unit.

The MLA WQI includes a field protocol that requires volunteers to re-sample a site if *E. coli* levels are found to be greater than 50 cfu/100mL. This cautious approach allows the MLA to monitor sites that demonstrate potential for ongoing concern. Following this protocol, *E. coli* levels exceeded 50 cfu/100

mL at 27 of 309 sampling sites (8.7%) reporting *E. coli* in 2016. These results are slightly higher than the 4% reported in 2015, and similar to the 8% reported in 2014 and 8% reported in 2012.

The sites that reported high *E. coli* levels (>50 cfu/100mL) in 2016 include Brandy Lake (BDY-5, BDY-8, BDY-10 and BDY-11), Beaumaris (BMR-4), Gull Lake (GUL-4), Indian River (IND-3), Muskoka River (MRV-5 and MRV-6), Muskoka Sands (MSN-1) and Windermere (WIN-4). The focus stations at Minett (MIN-1 and MIN-6,), observed high *E. coli* levels (>50 cfu/100mL) and also required re-testing.

From those sites identified in 2015 for further analysis and sampled for in 2016, the Minett sites (MIN-1 and MIN-6) and MRV-6 continue to show elevated *E. coli* levels.

The following sites are generally above the 2016 *E. coli* yearly mean MLA yellow traffic light limit (30 cfu/100ml) within the past two to three years: Beaumaris (BMR-4), Browning Island (BWN-1), Minett (MIN-1, MIN-6 and MIN-7), Windermere (WIN-4), Bruce Lake (BRU-5), Indian River (IND-3), Muskoka River (MRV-5 and MRV-6), and Star Lake (STR-1, STR-3 and STR-4).

The *E. coli* yearly mean at one station at the Muskoka River site (MRV-6) exceeded 100 cfu/100mL, although that was based on 6 samples through 4 months, with an extremely high concentration (1174 cfu) on the last sampling date. In order for a site to pass to a red light, the *E. coli* yearly mean must exceed the threshold of the MOECC geometric mean for a series of 5 samples per site per month of >100 cfu/100mL.

Beacon recommends that sampling for total coliform and *E. coli* be continued at each station in 2016 to continue to monitor bacteria levels, particularly at the stations noted above with yearly mean *E. coli* counts above the MLA traffic light limits. Beacon also recommends the continued increased sampling of the Minett focus area in 2017.

4. Conclusions

This Water Quality Report presents the most recent data collected in 2016 and compares it to data collected from 2002 to the present survey. The 2016 water quality program follows the well-established methodology most recently fine-tuned in 2013. Revisions to the methodology are anticipated in 2017.

Beacon Environmental continues as the primary consultant to assist the MLA with the data analysis. Consultation was undertaken in the spring to review the data from each sampling area and location and to assess each site to decide if continued sampling was necessary, or if sites should be discontinued and new sites added. The changes undertaken in 2016 are detailed in **Table 10** and include 15 sites being discontinued, 8 sites being added, 10 sites being restarted, 11 sites being modified and 7 sites making use of the Lake Partner Program spring phosphorus data.

Three Mile Lake was added to the sampling program in 2016. Algae blooms have been documented in Three Mile Lake historically and as recent as the summer of 2016. It is important to note that the Water Quality Initiative program focuses on phosphorus and *E.coli* sampling on a yearly basis and

incorporates additional parameters including DOC and calcium on a rotational basis or when necessary. Algal bloom monitoring and/or sampling is not part of this monitoring program and any recommendations or classifications provided for each Area are based solely on results for phosphorus and *E.coli*.

Secchi depths recorded in 2016 continue to remain consistent with the depths reported historically and continue to generally support the classification of oligotrophic.

Duplicate phosphorus samples collected in 2016 were analyzed for bad splits according to the DMM phosphorus data management protocol. In the 2016 spring phosphorus sampling, 67 of 484 samples (14%) were deemed to be bad splits. In the 2015 phosphorus duplicates, 83 of 437 samples (19%) were deemed to be bad splits, and in 2014, 16% were deemed to be bad splits. The amount of bad splits in 2016 was the lowest recorded in the last 3 years. The phosphorus sampling program may be reviewed prior to the 2017 sampling program.

Following the analysis for bad splits, an outlier analysis was undertaken for all spring turnover data using the District Municipality of Muskoka (DMM) protocol. Following the analysis, a total of eleven spring phosphorus data points were removed at eleven Areas in 2016. There is an overall general downward trend in most of the spring phosphorus concentrations in 2016. At the deep-water stations sites that sampled for spring phosphorus, 62% showed a downward trend in spring concentrations while 68% of those sites with a measured yearly phosphorus mean also showed a decreasing trend.

The new watercourse stations established at Windermere in 2014 to assess nutrient inputs from the lakes and ponds upstream of the long established WIN-1 site continued to be sampled in 2016. The 2016 mean yearly phosphorus results at WIN-6, WIN-7 and WIN-8 show lower concentrations with the exception of WIN-6 which was only sampled once, caution must be exercised when reviewing only 3 years of data as trends are only starting to emerge. Continued sampling at all of these Windermere stations in 2017 is recommended to better assess the scale of the nutrient input from the upstream sources.

Elevated 2016 deep-water spring phosphorus concentrations in comparison to 2015 were recorded at Gordon Bay (GNB-0), Hamer Bay (HMB-0), Lake Joseph (JOS-1), Little Lake Joseph (LLJ-0), Allport (ALL-0), Boyd Bay (BOY-0), Eilean Gowan (ELG-0), Muskoka Bay (MBA-0), Whiteside Bay (WTS-0), Brackenrig Bay (BRA-0), Morgan Bay (MGN-0), Brandy Lake (BDY-0), Bruce Lake (BRU-0), Gull Lake (GUL-0), Joseph River (JOR-0) and Mirror Lake (MIR-0). Of these sampling locations, elevated levels of mean yearly phosphorus in 2016 compared with 2015 were also recorded at Lake Joseph (JOS-1), Little Lake Joseph (LLJ-0), Eilean Gowan (ELG-0), Whiteside Bay (WTS-0), Brackenrig Bay (BRA-0), and Mirror Lake (MIR-0).

One substantial change to the monitoring program in 2013 was the addition of sampling for dissolved organic carbon. The analysis of the total phosphorus and DOC concentrations at the stations with at least 1.5 years of DOC data (14 sites) was undertaken this year. The sites analyzed in 2016 include Beaumaris (BMR-4 and BMR-6), Boyd Bay (BOY-4), Brackenrig (BRA-3), Cox Bay (COX-6), Hamer Bay (HMB-8), Indian River (IND-7), Muskoka Bay (MBA-12), Muskoka Sands (MSN-4), Minett (MIN-6), Windermere (WIN-1, WIN-6 and WIN-7) and Willow Beach (WLB-3). Increased concentrations of phosphorus at stations MBA-12, MSN-4, WIN-1, WIN-6 and WIN-7 are not likely related to the

associated increased concentrations of DOC. This is an indication that phosphorus inputs may not be correlated to natural inputs

The MLA WQI includes a field protocol that requires volunteers to re-sample a site if *E. coli* levels were found to be greater than 50 cfu/100mL. This cautious approach allows the MLA to monitor sites that demonstrate potential for ongoing concern. *E. coli* levels exceeded 50 cfu/100 mL at this cautious approach allows the MLA to monitor sites that demonstrate potential for ongoing concern. Following this protocol, *E. coli* levels exceeded 50 cfu/100 mL at 27 of 309 sampling sites (8.7%) reporting *E. coli* in 2016. These results are slightly higher than the 4% reported in 2015, and similar to the 8% reported in 2014 and 8% reported in 2012.

In 2016 there were 42 Areas with a green light, 12 Areas with a yellow light and 0 Areas with a red light. This year 14 Areas changed from a yellow light to a green light, 3 Areas were assigned traffic lights for the first time and 1 Area was sampled for the first time in 2016 and therefore did not receive a traffic light classification.

Following a thorough review of all data acquired since 2002, including deep-water, nearshore and watercourse total phosphorus concentrations, Secchi depths at deep-water stations and *E.coli* levels at nearshore and watercourse sampling locations, the monitored sites provide data that suggests that the water quality remains consistently good and very suitable for continued recreational use.

5. Recommendations

Beacon has had a chance to suggest and implement recommendations since 2013 and has identified areas that may need review or refinement moving into the 2017 sampling season. Recommendations are provided below.

5.1 Training

Beacon strongly encourages that ALL team leaders continue attend the annual training session held in the spring prior to the 2017 sampling. Changes to the protocol may be made for 2017 and each person must understand any revisions to the monitoring program for their particular area. This ensures consistency across the sampling teams and improves data collection through the entire year. Team leaders should actively be encouraging new members to join the sampling team.

It is important for all team leaders to properly train team members on sampling techniques and QA/QC measures for each water quality parameter. All team leaders and samplers must ensure that they understand the techniques and required number of samples for each station for each sampling date.

There was again discussion at the spring training in 2016 regarding the production of training videos that the teams could access to understand the intricacies of obtaining samples. It is recommended that training videos be created during the summer of 2017 for use in 2018 training sessions.

5.2 Methods

The Water Quality & Environment Committee should continue to review sites each winter and understand where sites should be added, restarted, modified or discontinued.

Discussions are currently underway to refocus the sampling program moving forward. There are opportunities to reduce sampling at areas that have not shown significant water quality issues (green light), and redirect effort to areas that continuously show concern (yellow or red light). Using the robust data set, Beacon will work with the MLA to identify and classify sampling areas outlined in **Table 12**.

Table 12. Water Quality Sampling Frequency

Category	Sampling Frequency	Criteria
Long-term	Every 2 to 3 years	Sites that have consistently been below any thresholds values for at least the past 5 years.
Annual	Continue with annual sampling	
Focus Sites	Increase sampling effort within a determined sampling time period (ex. 5 times per month)	At areas with concentrations consistently over thresholds/limits.

There are also opportunities to revise the sampling program to concentrate efforts on High Priority Active Sites such as large urban influenced areas (Gravenhurst Bay, Muskoka River, Indian River, Rosseau and Bala), resort areas and golf course areas.

Additionally, the District Municipality of Muskoka will be revising their water quality model and will be using the following triggers for phosphorus that will lead to a causation study being undertaken:

- If there is a statistically increasing trend in phosphorus from 2001 to current date
- If the average phosphorus concentration of most recent 10 years is >20 µg/L, and
- If there is a documented algae bloom

It is recommended that changes to the MLA thresholds should consider the Districts revised phosphorus triggers above regarding their traffic light limits for the deepwater stations. Consideration for changes to the traffic light system for phosphorus triggers for 2017 should include:

- the Districts triggers for deepwater stations;
- consideration for distance to nearby wetlands, streams and documented wildlife;
- Rate of increasing phosphorus levels; and,
- DOC relationship to phosphorus.

Sites sampled for DOC in 2016 should also be sampled for DOC in 2017 to continue to establish a robust database to help determine phosphorus outliers from human or natural factors. It is important to obtain a full set of phosphorus samples at each of the DOC sites each year.

The Field Coordinator is a great asset to maintain continuity between the Water Quality Initiative Committee and the volunteers. Having the Field Coordinator continue to compile the yearly results will continue to keep the year end data analysis costs lower.

The MLA should continue to rely on the Lake Partner Program data when it is available. The MLA should confirm with the MOECC their intended sampling locations to ensure all sampling locations for the following year are covered by the MOECC or the MLA. This discussion should happen early in the year, prior to the early stages of preparation for the coming year.

It is important to work with the District in coordinating the location of the sampling sites. It is anticipated that the MLA will work towards creating a geodatabase of sampling locations using the District GPS coordinates.

5.3 Education

The main water quality issues identified are nutrient enrichment and high bacteria concentrations. Beacon recommends that the MLA continue promoting stewardship and awareness within the community to improve water quality and understand the important connection between land use, aquatic vegetation and waterfowl. At those sites with particularly elevated levels of bacteria (Minett and Windermere) additional emphasis could be placed on providing additional educational resources.

It is important that everyone contribute to the goal of improving water quality and aesthetics of their lakes, while raising public awareness about healthy lake systems. There are a variety of landowner resources available on the MLA website which provides steps landowners can take to reduce their impact.

Any stewardship activities will benefit the watershed over the long-term, and leave a positive legacy for future generations.

5.4 Area Specific Recommendations

Area specific recommendations were developed through the analysis of the 2016 water quality data. These recommendations are provided in the Area Summary sheets and summarized below.

1. Following analysis of the 2016 results, Beacon recommends that the primary Focus Areas for the 2017 sampling season should continue to be Minett and Windermere (resort sites).
2. Three Mile Lake was added to the 2016 program and sampling should continue in 2017. Blue green algal blooms were experienced in 2016.

3. Elevated 2016 deep-water spring phosphorus concentrations in comparison to 2015 were recorded at Gordon Bay (GNB-0), Stills Bay (STI-2), Hamer Bay (HMB-0), Lake Joseph (JOS-1), Little Lake Joseph (LLJ-0), Allport (ALL-0), Boyd Bay (BOY-0), Eilean Gowan (ELG-0), Muskoka Bay (MBA-0), Whiteside Bay (WTS-0), Brackenrig Bay (BRA-0), Morgan Bay (MGN-0), Brandy Lake (BDY-0), Bruce Lake (BRU-0), Gull Lake (GUL-0), Joseph River (JOR-0) and Mirror Lake (MIR-0). Of these sampling locations, elevated levels of mean yearly phosphorus in 2016 compared with 2015 were also recorded at Lake Joseph (JOS-1), Little Lake Joseph (LLJ-0), Eilean Gowan (ELG-0), Whiteside Bay (WTS-0), Brackenrig Bay (BRA-0), and Mirror Lake (MIR-0). Sampling should concentrate on these sites to more closely monitor long-term trends.
4. Continue sampling for DOC at all identified locations.
5. The sites generally above the MLA *E.coli* yellow traffic light within the past two to three years are Minett (MIN-1, MIN-6 and MIN-7), Windermere (WIN-4), Bruce Lake (BRU-5), Indian River (IND-3), Muskoka River (MRV-5 and MRV-6). Beaumaris had increased levels due to sediment disturbance (in a wildlife area) which has since abated. Beacon recommends that sampling effort at Minett be maintained at the increased level that it was in 2016.
6. *E.coli* levels at the focus area (Minett) in 2016 were below the MLA yellow traffic light compared to previous years. Sampling should continue in 2017 to monitor long-term trends and additional emphasis could be placed on providing additional educational resources.
7. Beacon recommends that the MLA continue to rely on the data from the Lake Partner Program when it is available. The MLA should confirm with the MOECC their intended sampling locations to ensure all sampling locations for the following year are covered by the MOECC or the MLA. This discussion should happen early in the year, prior to the early stages of preparation for the coming year.

5.5 Overall Study Recommendations:

1. Sampling should continue to build a robust database, to monitor long-term trends and to expand to new Areas or sites where the need is identified.
2. When high nutrient and bacteria results are observed, look at other factors such as the local weather the day of sampling and 72 hours prior.
3. There was again discussion at the spring training in 2016 regarding the production of training videos that the teams could access to understand the intricacies of obtaining samples. It is recommended that this be implemented prior to the 2017 training sessions.
4. The MLA can rely on the Lake Partner Program data when it is available. Presently Lake Partner Program data from Stephen's Bay, Arthurlie Bay, Muskoka Lakes Golf and Country Club, Morgan Bay and Royal Muskoka Island are included in this 2016 report.
5. Continued discussions with the MLA are recommended to refocus the sampling program in regards to traffic light thresholds and areas to focus on for sampling in 2017.

5.6 Next Steps

Beacon believes that there are opportunities to take the WQI program further, and recommends that the Water Quality and Environment Committee:

1. Focus investigations on stations where the MLA can best provide influence in situations of decreasing water quality such as:
   - Larger Urban Areas
   - Resorts
   - Golf Courses
2. Focus investigations on stations with high *E. coli* levels, and at sites with particularly elevated levels of bacteria, additional emphasis could be placed on providing additional educational resources for local stakeholders.
3. Continue to compile up to date photographic records of shoreline use and structures abutting the sampling sites at Focus Areas, particularly at those sites with missing or dated records;
4. Advocate for remedial plans for Focus Areas (Minett, Windermere, Hamer Bay, and Three Mile Lake);
5. Install monitoring locations where landuse change is being contemplated;
6. Undertake additional analysis in 2017 to statistically look at long term phosphorus trends at nearshore sites.

6. Definitions

Arithmetic mean: This type of average is calculated by adding together a group of numbers and dividing the sum by the number of numbers.

District Municipality of Muskoka Threshold: The District of Muskoka classifies lakes based on their sensitivity to phosphorus inputs, as an indicator of lake health. Lakes are classified as either low, moderate or highly sensitive to phosphorus. An acceptable threshold for phosphorus has been determined for each lake in Muskoka, which is 50% above the predicted background or undeveloped value. Any existing Threshold values are shown in the Area Summary Sheets.

E. coli: Escherichia coli is one of several types of bacteria that normally inhabit the intestine of humans and animals. *E. coli* is exclusively associated with fecal waste making it a good indicator of faecal contamination. There are many different strains of ***E. coli***; most waterborne strains are themselves not harmful, but some (such as ***E. coli*** O157:H7) can cause serious illness.

Geometric mean: This type of average is calculated by multiplying together a group of *n* numbers and then taking the n^{th} root of the resulting product. The geometric mean is used to indicate the central tendency or typical value of a set of numbers. It is typically used to calculate average bacteria counts because as a living organism, bacteria counts are highly sporadic and inconsistent.

Sampling Area: A geographic location encompassing a group of WQI monitoring sites.

Sampling Site: The discrete and unique location where samples are to be collected and measurements are to be taken.

Secchi Depth: A measure of **water clarity**, measured using a Secchi disk - a small disk attached to a rope. Alternating quarters of the top side of the disk are coloured white and black. The Secchi depth is the depth of water whereby the sampler can no longer distinguish the white and black quarters of the disk.

Spring Turnover Total Phosphorus: A single phosphorus concentration measurement taken in a typically stratified lake during the spring turnover period. This measurement has been shown to adequately represent the overall phosphorus concentration in a lake (Clark, 2010). Spring turnover typically lasts for a few days following ice out when the temperature of the entire water column is consistent (usually 4˚C) allowing the water column to mix. Ontario's Ministry of the Environment experiments have indicated that there is `no appreciable difference in the P means` in long-term data derived using April (true turnover) and May (mixed layer) data. In practice, measurements taken anytime in May are considered to be adequate.

Total Coliform: Coliform includes a variety of bacteria. In practice, detectable coliform are usually enteric, found in the intestinal tracts of humans and other warm-blooded species.

Total Phosphorus: Phosphorus is a chemical element that is essential for all living cells. Total phosphorus is a measure of both inorganic and organic forms of phosphorus. Phosphorus can be present as dissolved or particulate matter. It is an essential plant nutrient and is often the most limiting nutrient to plant growth in fresh water.

Water Clarity: Water clarity is a measure of how much light penetrates through the water column. The clarity of water is influenced both by suspend particulate matter (sediment and plankton) and by coloured organic matter (tea coloured lakes). Clarity can provide some indication of a lake's overall water quality, especially the amount of algae present.

Yearly Mean Total Phosphorus: The arithmetic mean of phosphorus concentration measurements taken above a stratified water column's thermocline over the ice-free period. Note: yearly mean phosphorus concentration as reported by the WQI is for spring and summer months only.

Note: several of these definitions have been taken from previous years Water Quality Reports, including the WQI Summary Report - Citizens Environment Watch, 2009.

7. References

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Appendix A

Area Summaries

Area Description:

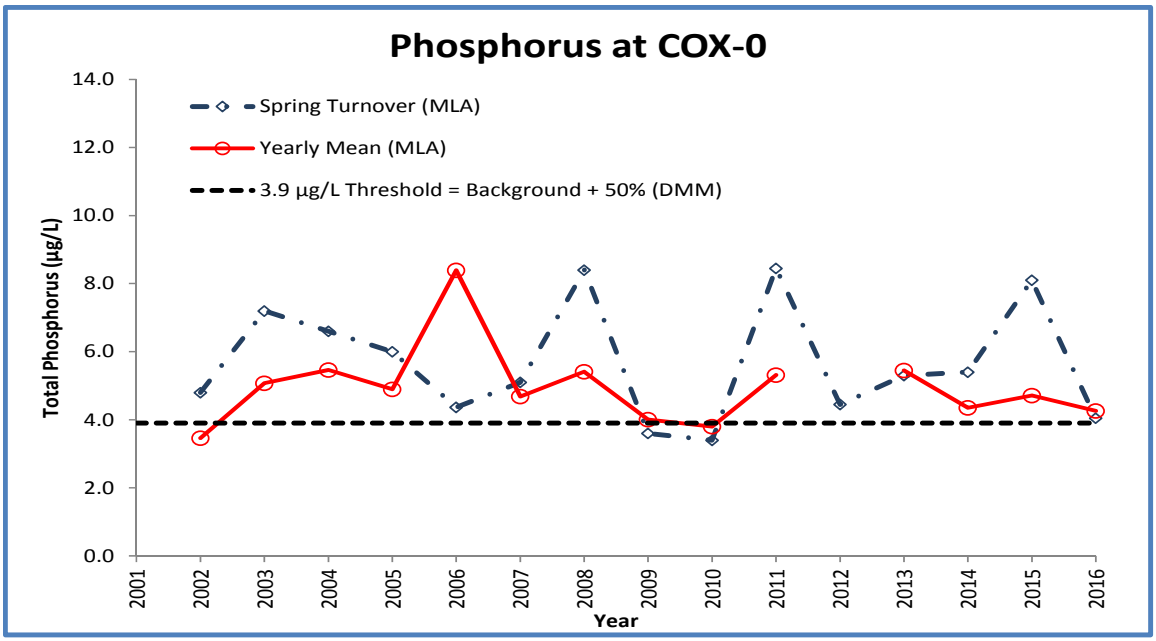
Cox Bay is the southernmost bay of Lake Joseph. The bay is 1.84 km² in area and is up to 12 m in depth. A large resort and golf course are located adjacent to the lake, along with a marina and a canal crossing into Lake Rosseau at Port Sandfield. Most of the shoreline area is developed, but many residences maintain forested cover on their properties. More than 15% of the shoreline is open lawn, pavement or is intensely landscaped. The Cox Bay Stewardship Initiative group has identified ten permanent watercourses that drain into the bay. Cox Bay is classified as moderately sensitive and over-threshold by the DMM. Monitoring started in 2002.

Volunteer Recognition: **Liz Lundell, Judy Golvin,** Guy Burry, Stuart Golvin

Cox Bay (COX)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (ug/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)	DOC Yearly Mean
		Spring Turnover	Yearly Mean			
COX-0	5.38	4.1	4.3			
COX-2		4.7	4.0			
COX-6		6.5	5.2			3.4
COX-7		6.1	4.6			



Summary and Recommendations:

Phosphorus continues to remain over the DMM threshold of 3.9 µg/L. DOC at COX-6 was sampled for in 2014, 2015 and 2016 and is discussed in Section 3.3. The mean Secchi depth in 2016 is similar to the recorded depth in 2014, which is approximately 1 m less than that recorded in 2015. The 2016 spring phosphorus mean decreased at all stations compared with the 2015 results and the yearly phosphorus mean at all stations stayed consistent. A new station COX-7 was sampled in 2016 for phosphorus. Beacon recommends sampling continue to monitor long-term trends.

Area Description:

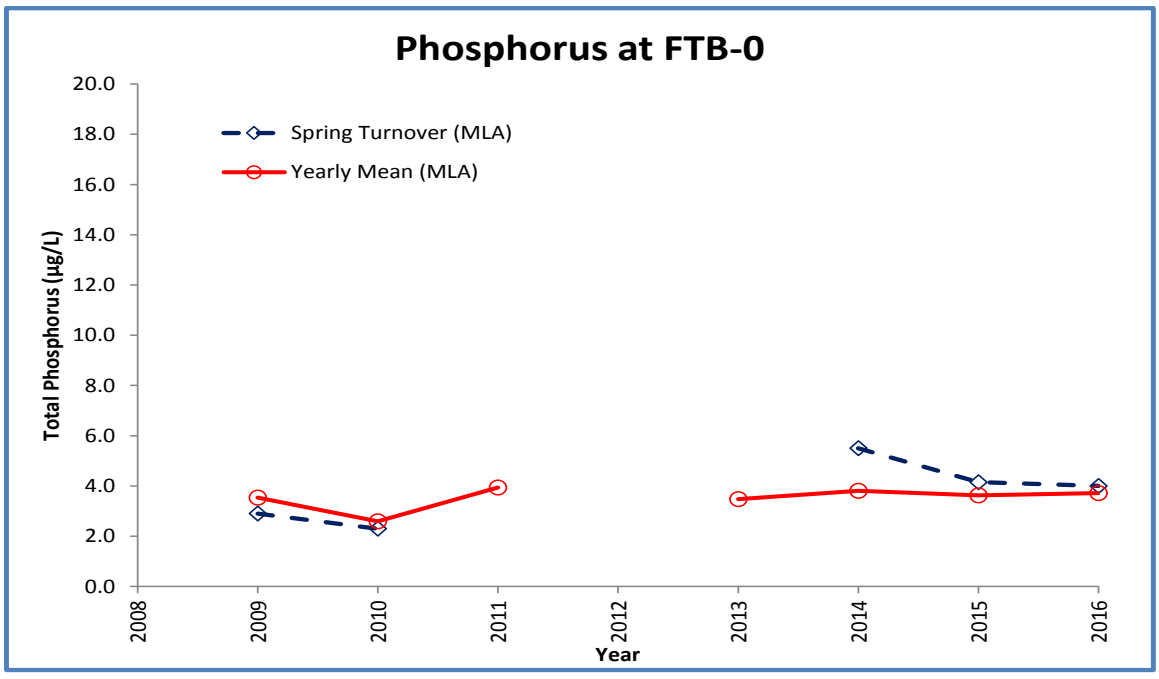
Foot's Bay is located in the south-eastern portion of Lake Joseph. Foot's Bay has a higher intensity of development in the southern section, with areas that are adjacent to the highway and a marina. There are still large areas of shoreline with mostly intact forests. The main basin of Lake Joseph is classified as highly sensitive by the DMM. Monitoring started in 2009.

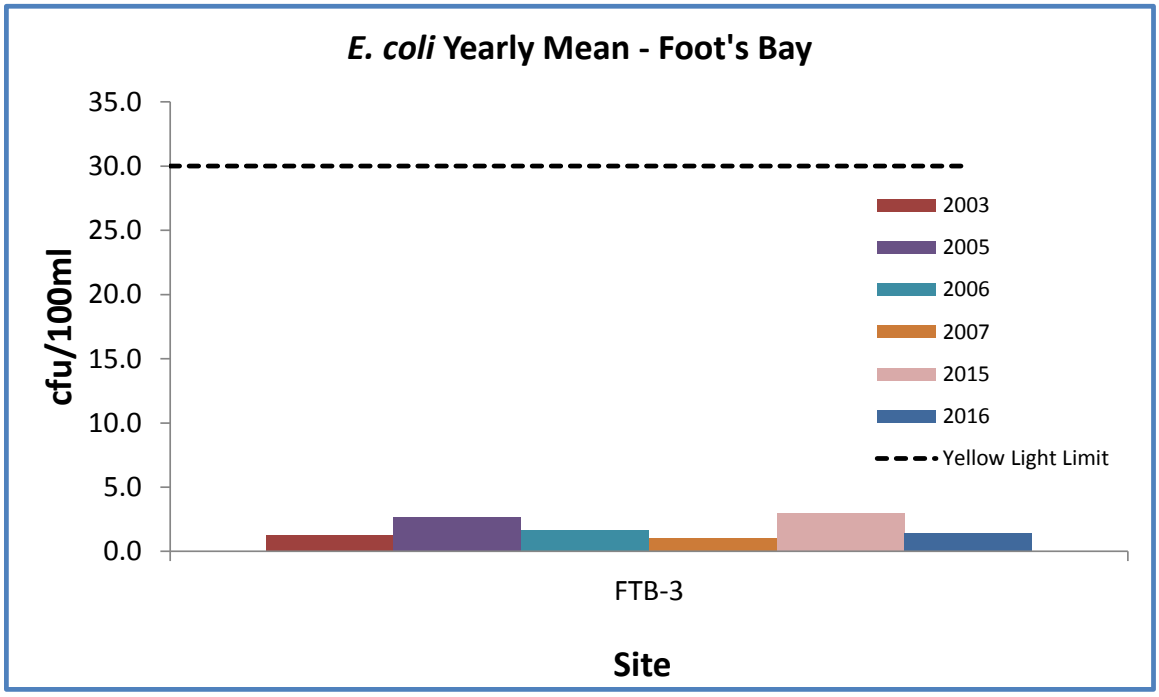
Volunteer Recognition: **Joey Brown**, Judy Benyei, Andy Benyei, Tom Laviolette and Sharon Laviolette.

Foot's Bay (FTB)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
FTB-0	6.65	4.0	3.7		
FTB-3				1.4	14.7





Summary and Recommendations:

Phosphorus results remain low over the sampling years and the 2016 yearly mean results are similar to the 2015 results. The Grubb's Test for outliers continued to identify the 2011 spring phosphorus as an outlier in 2016. Bacterial counts of *E. coli* at FTB-3 remain below the MLA stoplight limits (details in report Section 3). Beacon recommends sampling continue to monitor long-term trends.

Area Description:

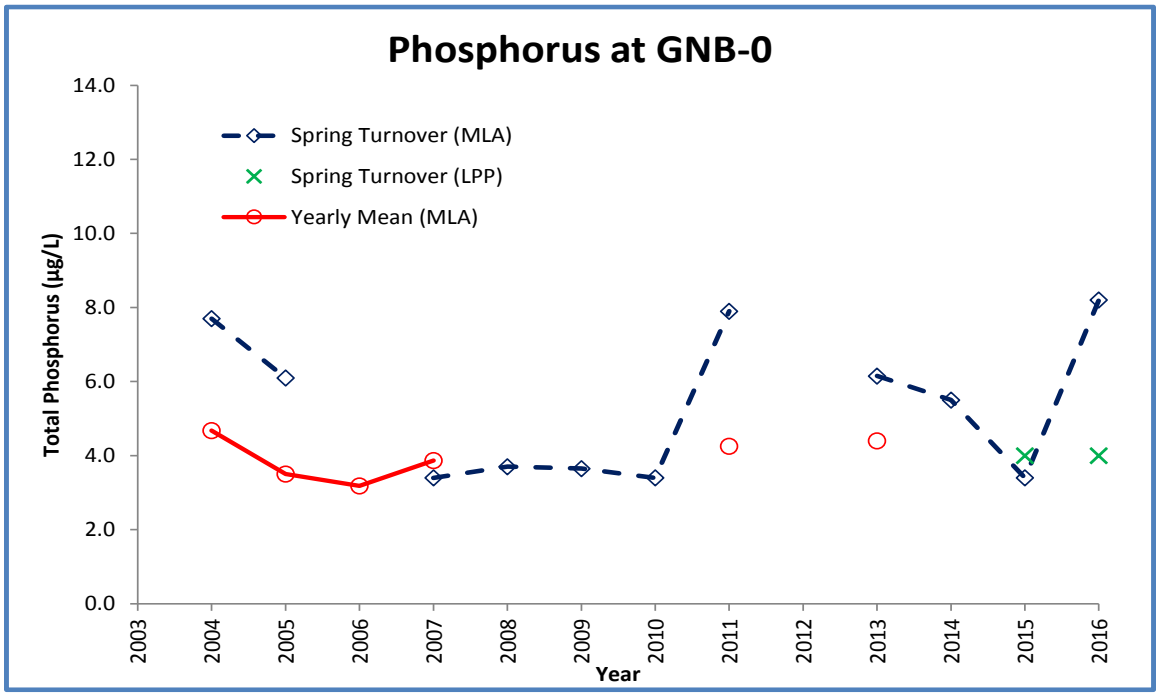
Gordon Bay is in the northwestern part of Lake Joseph. This bay is moderately developed and highway 169 follows along the shoreline for a large portion of the bay. There is a large marina in the northern part of the bay where one of three creeks discharges into the bay. The main basin of Lake Joseph is classified as highly sensitive by the DMM. Monitoring started in 2004.

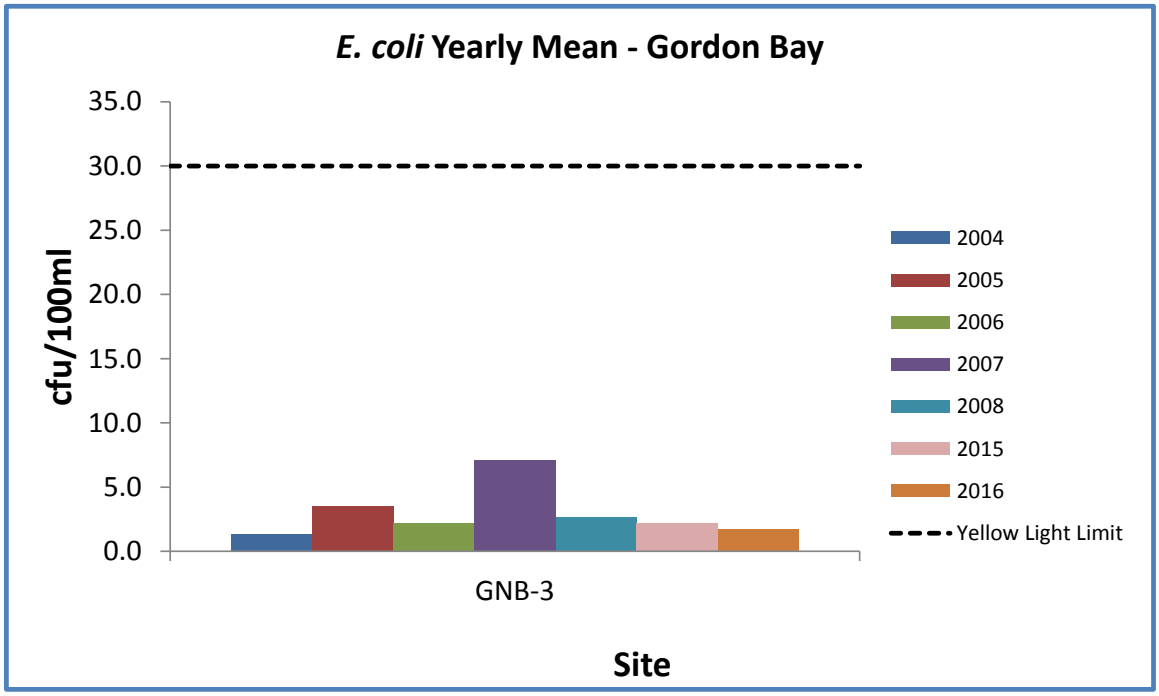
Volunteer Recognition: **Alex Magditsch,** Cecil Hayhoe, John Offutt, Juliana Magditsch, Zoe Forte, and Lynda McCarthy.

Gordon Bay (GNB)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

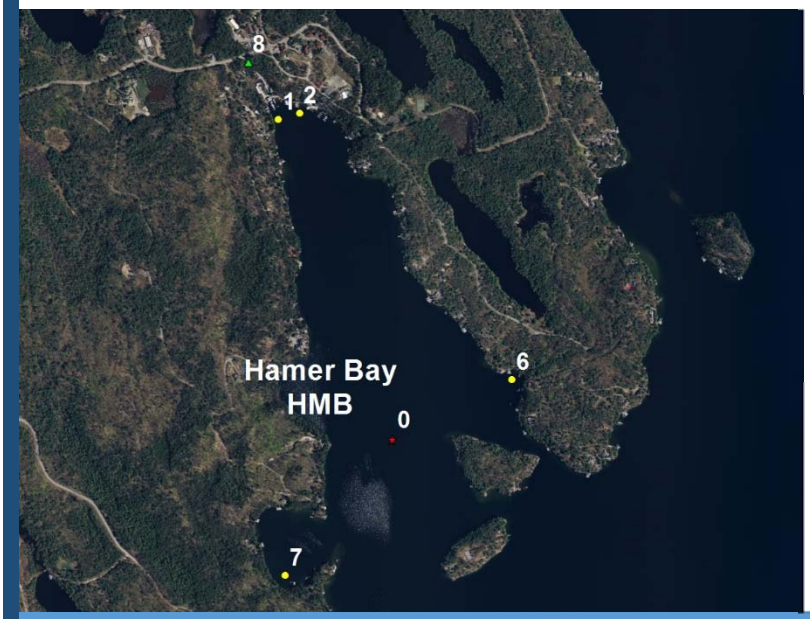
Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
GNB-0	6.00	8.2			
GNB-3				2.1	28.2





Summary and Recommendations:

Phosphorus results remain consistent over the sampling years. Lake Partner Program spring phosphorus data was available in 2015 and is included in the graph. *E. coli* sampling was restarted at GNB-3 in 2015 and the concentrations in 2016 continued to be below the MLA stoplight limits (details in report Section 3). **Beacon recommends sampling continue to monitor long-term trends.**



Area Description:

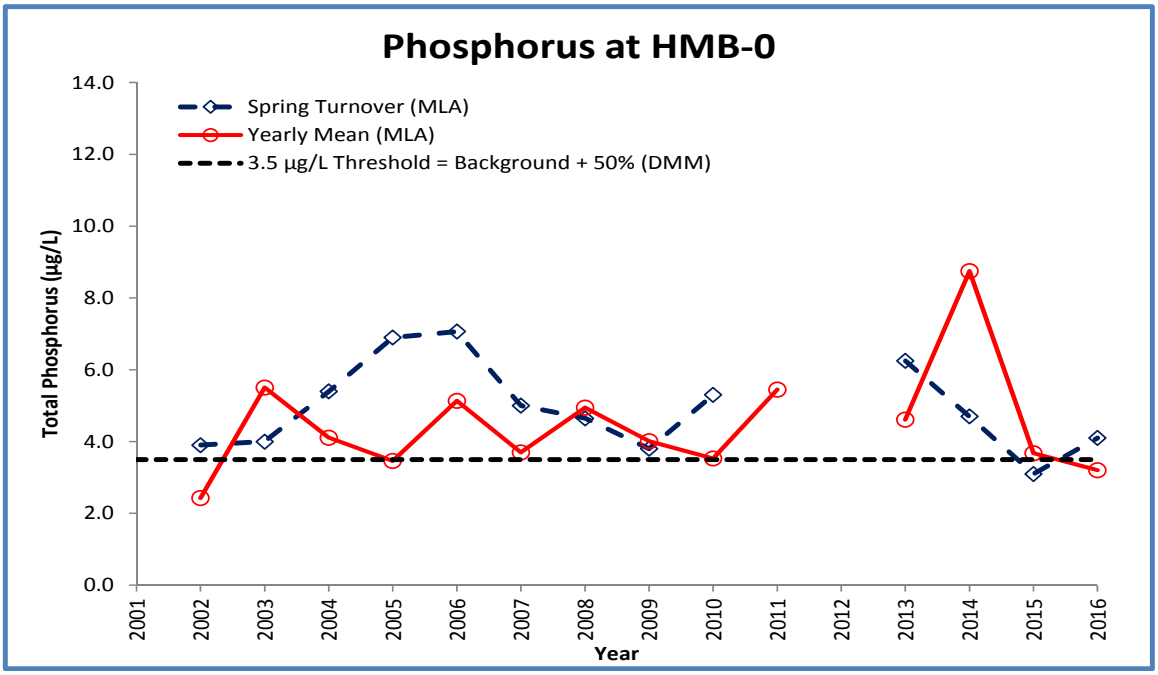
Hamer Bay is a large bay in the northern part of Lake Joseph. This bay receives drainage from a variety of natural and anthropogenic sources. There are three creeks that outlet into the bay, one flows through a large golf course and wetland in the north, and the others through smaller lakes and wetlands. There is a large marina with several parking lots, a resort, and many residential properties along most of the available shoreline. The main basin of Lake Joseph is classified as highly sensitive by the DMM.

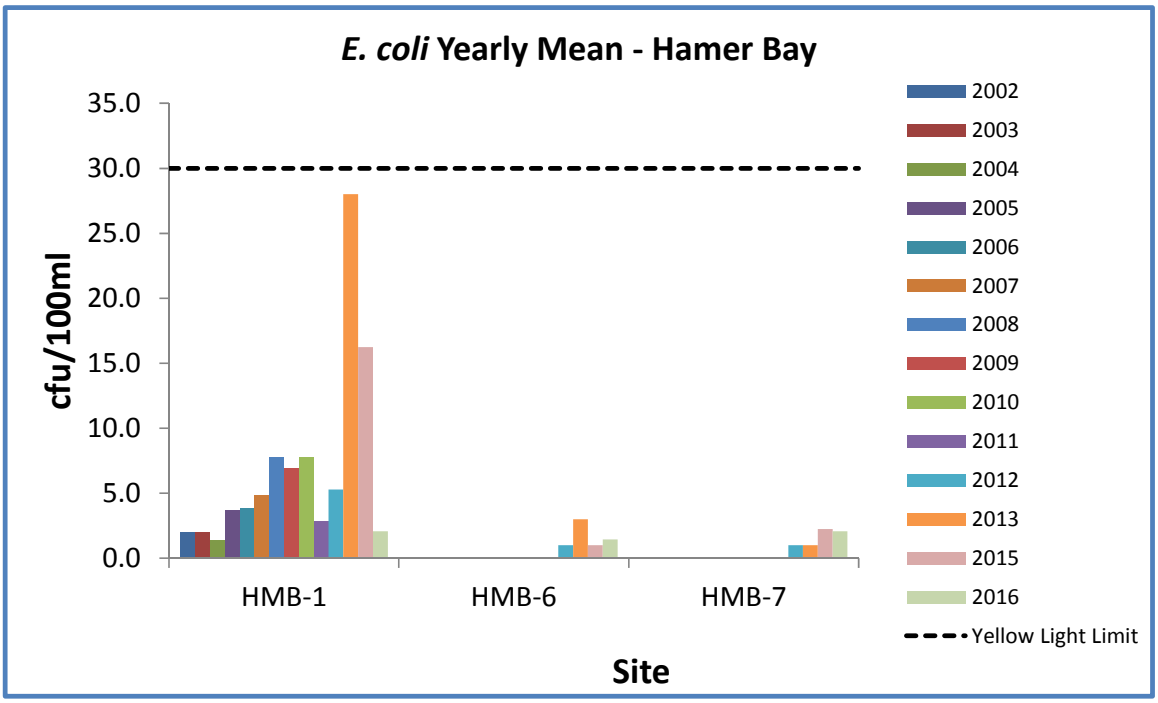
Volunteer Recognition: **Alex Magditsch,** Cecil Hayhoe, John Offutt, Juliana Magditsch, Zoe Forte, and Lynda McCarthy.

Hamer Bay (HMB)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)	DOC Yearly Mean
		Spring Turnover	Yearly Mean			
HMB-0	6.42	4.1	3.2			
HMB-1		9.0	5.1	2.1	85.4	
HMB-2		4.9	3.6			
HMB-6				1.4	36.4	
HMB-7				2.1	28.3	
HMB-8		20.2	53.9			23.9





Summary and Recommendations:

The spring phosphorus concentration remains consistent through the sampling years and the yearly mean phosphorus concentration recorded in 2016 at HMB-0 was slightly below the DMM threshold of 3.5 µg/L. The spring phosphorus sample in 2011 remains removed from the analysis following the Grubb's Test analysis for outliers in 2016. Phosphorus results at HMB-1 and HMB-2 were consistent with previous year's results. Spring phosphorus results at HMB-8 were elevated from the 2015 value however the yearly mean at HMB-8 was lower than that observed during sampling in 2015. DOC at HMB-8 was sampled for in 2013, 2015 and 2016 and is discussed in Section 3.3. Bacterial counts of *E. coli* at all three sites remain well below the MLA stoplight limits (details in report Section 3). Sampling at HMB-3 was discontinued for 2016. **Beacon recommends sampling continue to monitor long-term trends.**

Area Description:

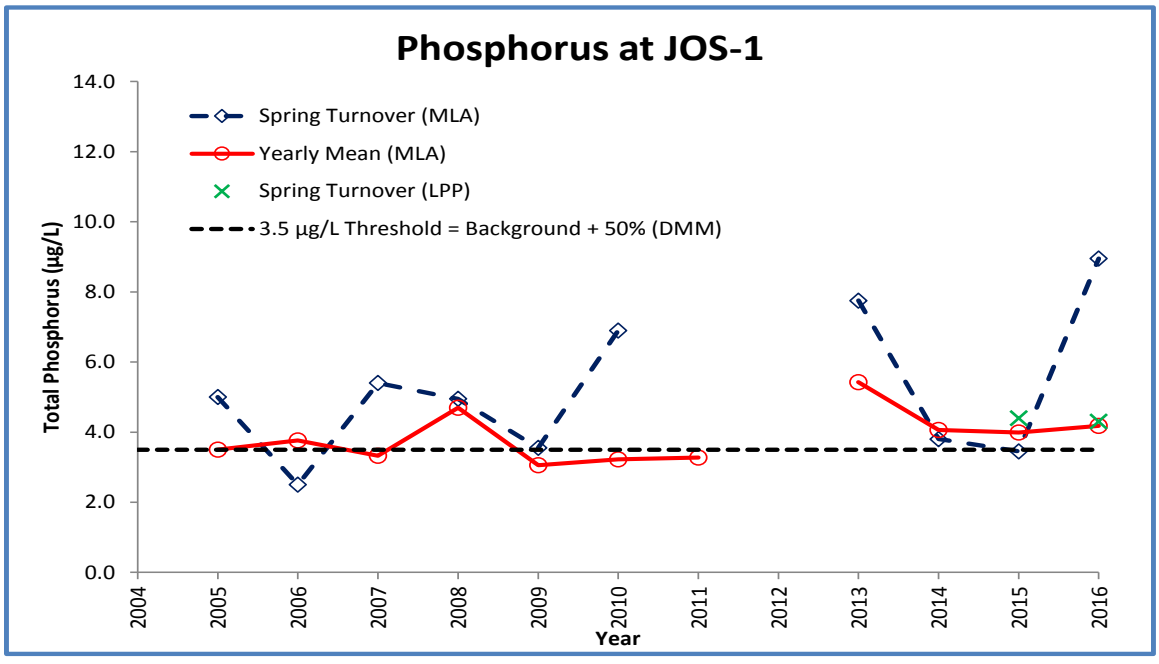
Lake Joseph is a large lake with a surface area of 50.9km² and water depths of up to 60 m. Wetlands account for a small portion of the lake area at about 5%. The lake has various points of inflow and outflow, with drainage from north to south. The Lake Joseph watershed area is 55 km² and has a coldwater fishery. The DMM has classified the main basin of the lake as highly sensitive. Monitoring started in 2005.

Volunteer Recognition: **Alex Magditsch,** Cecil Hayhoe, John Offutt, Juliana Magditsch, Zoe Forte and Lynda McCarthy.

Lake Joseph (JOS)

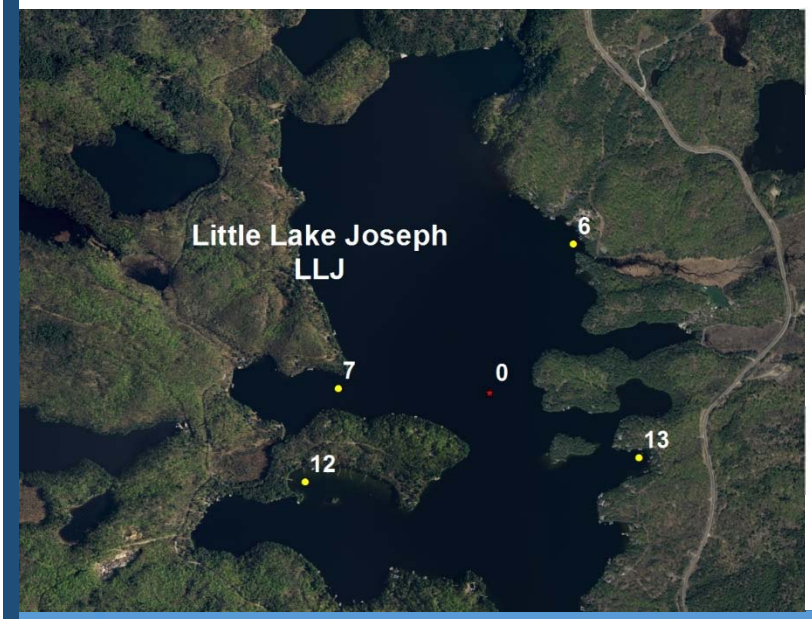
2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
JOS-1	6.75	9.0	4.2		



Summary and Recommendations:

Phosphorus yearly mean results remain consistent over the sampling years, while the 2016 spring turnover results are the highest recorded to date at 9.0 µg/L. **Beacon recommends sampling continue to monitor long-term trends.**



Area Description:

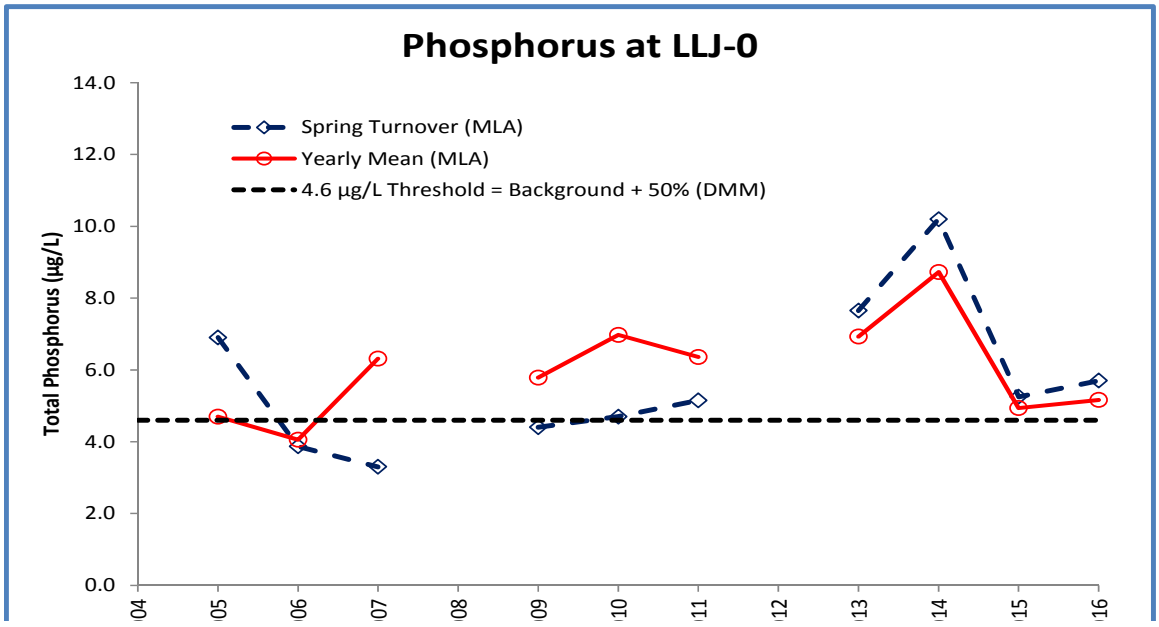
Little Lake Joseph is an isolated arm 2.8 km² in size off the eastern side of Lake Joseph. This is a deep bay with depths of up to 40 m. Most of the shoreline is in a natural state despite many cottages. Three small wetlands outlet into the bay and the DMM has classified Little Lake Joseph as moderately sensitive. Monitoring started in 2005.

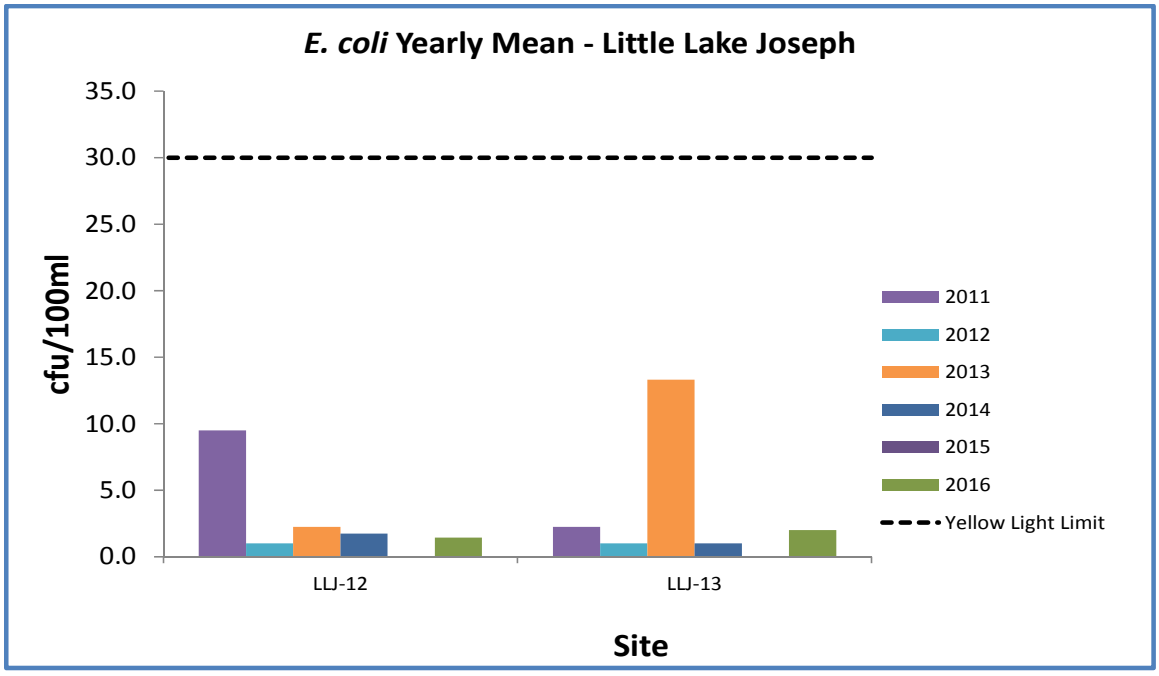
Volunteer Recognition: **Dirk Soutendijk**, and Westley Begg.

Little Lake Joseph (LLJ)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
LLJ-0	4.94	5.7	5.2		
LLJ-6		13.3	6.6		
LLJ-7		5.1	4.4		
LLJ-12				1.4	15.7
LLJ-13				2.0	19.9





Summary and Recommendations:

Phosphorus concentrations were elevated in both 2013 and 2014, while 2015 and 2016 concentrations dropped back to being consistent with the DMM threshold. *E.coli* sampling has been restarted in 2016 and concentrations are well below the MLA stoplight limits (details in report Section 3). Beacon recommends continued sampling to monitor long-term trends.

Area Description:

Stanley Bay is located on the north-east side of Lake Joseph. This deepwater bay has evenly distributed development with largely intact forest cover along the shoreline. STN-3 is located in a shallow, sandy area at the end of a small bay where a creek outlets. There are several roads around this bay and a moderate level of residential development, but no marinas, large resorts, commercial development, or agricultural development which could negatively impact water quality.

Volunteer Recognition: **Alex Magditsch,** Cecil Hayhoe, John Offutt, Juliana Magditsch, Zoe Forte and Lynda McCarthy.

Stanley Bay (STN)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
STN-0	6.75				
STN-3		4.1	3.8		

Summary and Recommendations:

Phosphorus results remain consistent over the sampling years. Using Grubb's Test for outliers, the spring 2011 phosphorus sample was identified as an outlier in 2013 and remains out of the dataset in 2016. **Beacon recommends sampling continue to monitor long-term trends.**

Area Description:

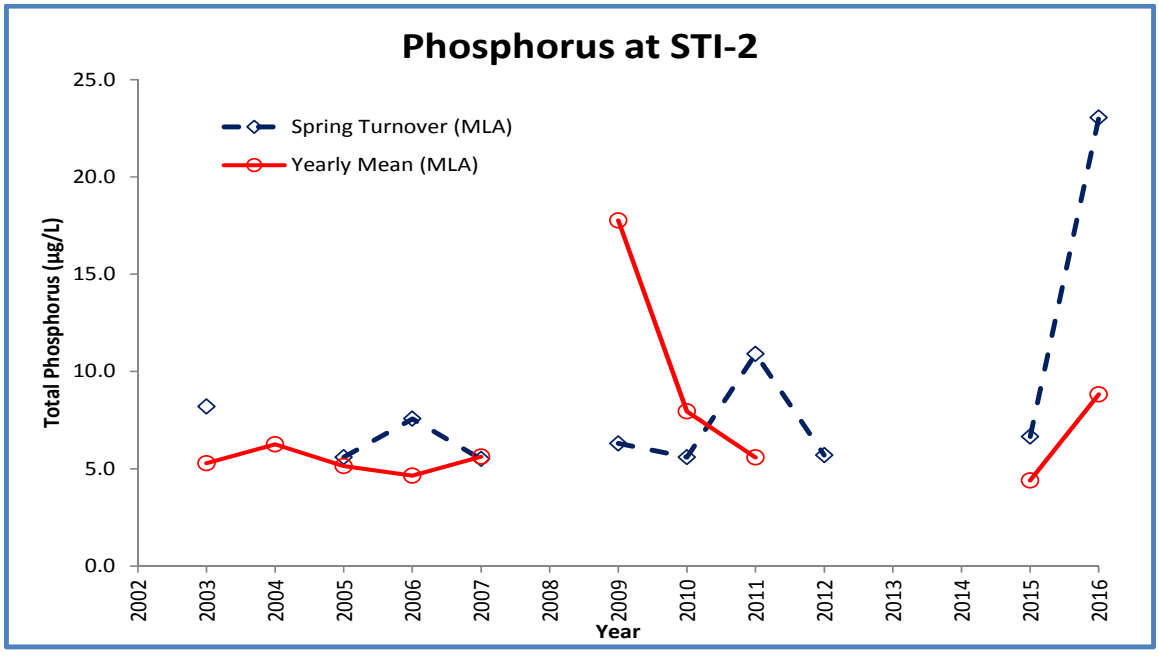
Stills Bay is located in the south-eastern portion of Lake Joseph. Stills Bay is long, narrow, and moderately developed. The southern end of the bay is directly adjacent to highway 169. This bay receives drainage from watercourses that are adjacent to a golf course. There are still large areas of shoreline with mostly intact forests. The main basin of Lake Joseph is classified as highly sensitive by the DMM. Monitoring started in 2003.

Volunteer Recognition: **Joey Brown**, Tom Laviolette, Andy Benyei, Judy Benyei, and Sharon Laviolette.

Stills Bay (STI)

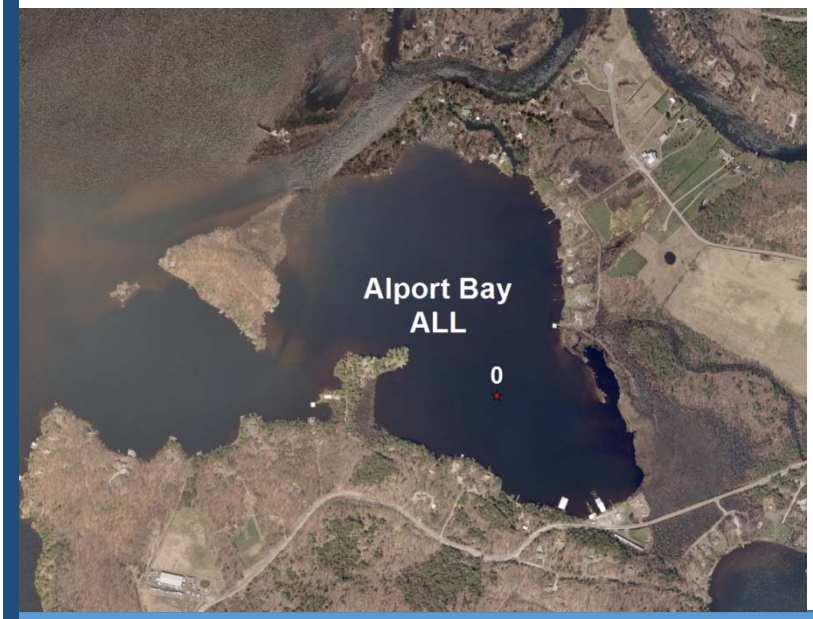
2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
STI-2		23.1	8.8		



Summary and Recommendations:

The nearshore spring phosphorus concentration was elevated in 2016; however, the remainder of the 2016 phosphorus data was low and consistent with most yearly mean results since 2003. Using Grubb's Test for outliers, the spring 2004 phosphorus sample (76.3 µg/L) at STI-2 was identified as an outlier in 2013 and remains out of the dataset in 2016. **Beacon recommends that all sampling be continued to monitor long-term trends.**



Area Description:

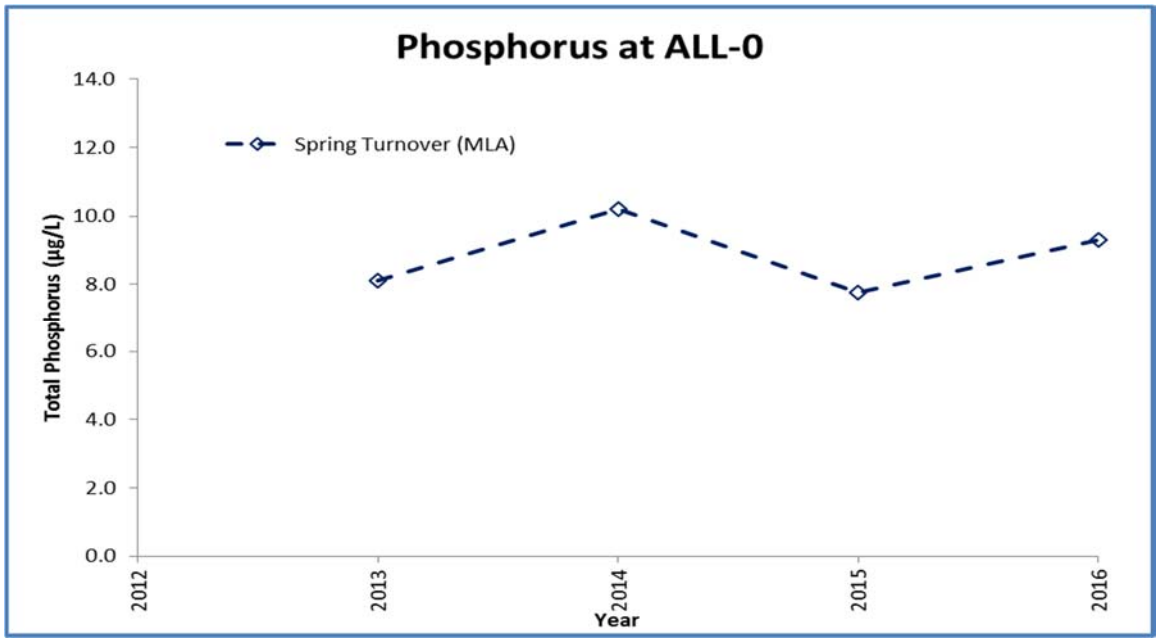
Alport Bay (also known as Alport Lake) is a small bay in the central part of eastern Lake Muskoka, at the mouth of the Muskoka River. The water quality in Alport Bay is influenced by several natural and man-made features, including a marina in the south, a large wetland as well as agriculture in the east, and inflow from the mouth of the Muskoka River. The inflow from the River is highly influenced by a larger portion of the upstream catchment. Much of the shoreline is developed with a high proportion of the residential properties maintaining manicured lawns and minimal vegetation along the shoreline. Monitoring started in 2013.

Volunteer Recognition: **John Wood**, Rayma Blaymires and Chris Blaymires

Alport Bay (ALL)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
ALL-0	1.85	9.3			



Summary and Recommendations:

After a fourth year of data collection, spring phosphorus results and Secchi measurements remain consistent. Beacon recommends sampling continue to monitor long-term trends.

Area Description:

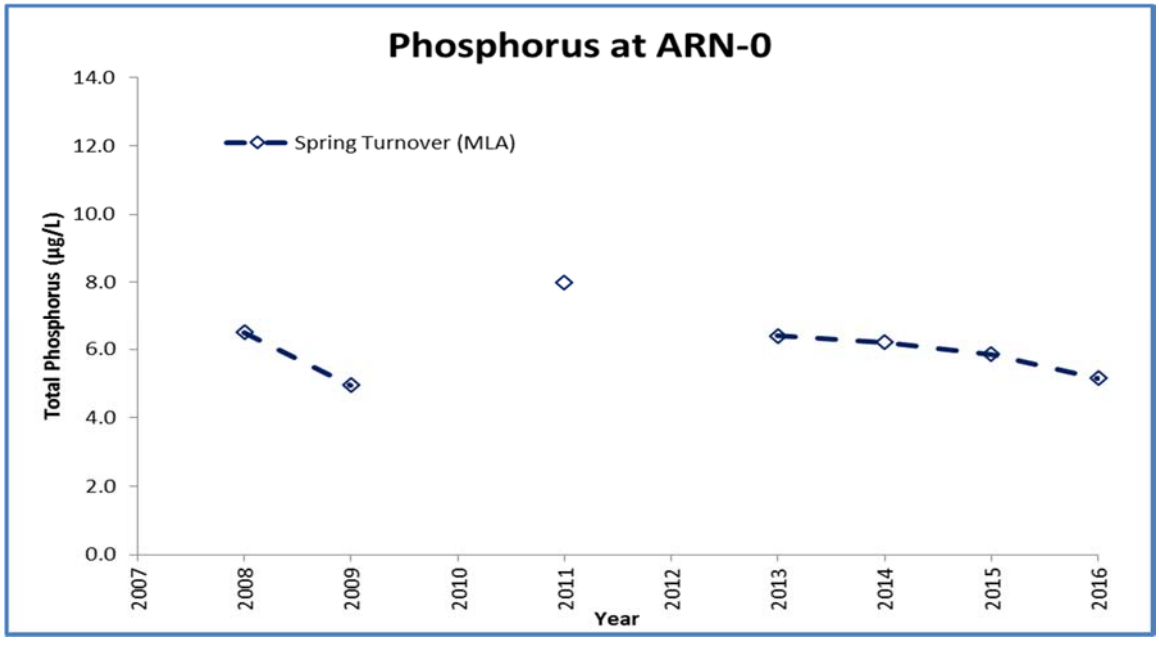
The Arundle Lodge sampling area is in south-central Lake Muskoka, east of Hardy Lake Provincial Park and south of Walker's Point. ARN-0 is located in Skinner Bay, adjacent to Miller Island and Firebrand Island. A creek draining three wetland areas runs along part of Arundle Lodge Rd. and outlets northeast of this site. Monitoring started in 2008.

Volunteer Recognition: **Susan Murphy,** Stephan Sims, Doug Tate, Peter McMullin and Sydney Sims

Arundle Lodge (ARN)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
ARN-0	3.10	5.2			



Summary and Recommendations:

Spring phosphorus concentrations remain consistent through the sampling years. Beacon recommends continued sampling at this site in 2016.

Area Description:

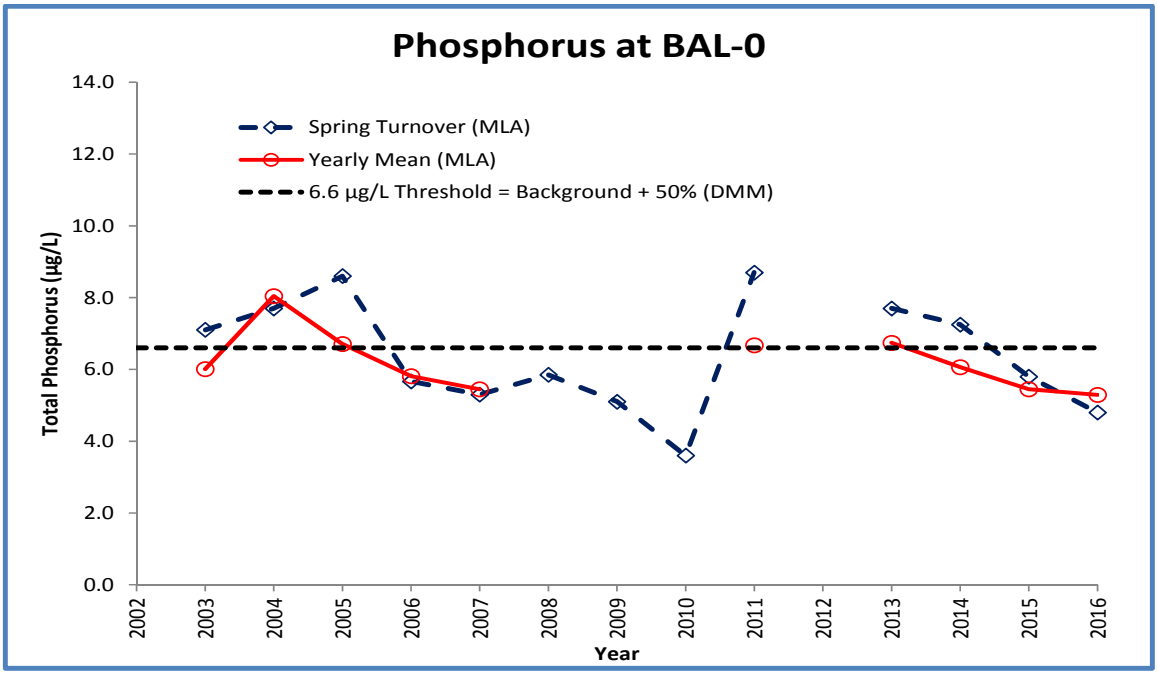
Bala Bay is a large isolated bay in the eastern part of Lake Muskoka. Most of the bay is densely developed but there is intact forest cover along most of the shoreline area. Drainage from the village of Bala does enter the bay along the western shore. The entire Muskoka River Watershed drains through Bala Bay into the Moon River System. There are also two small wetlands that drain into the bay. Monitoring started in 2003.

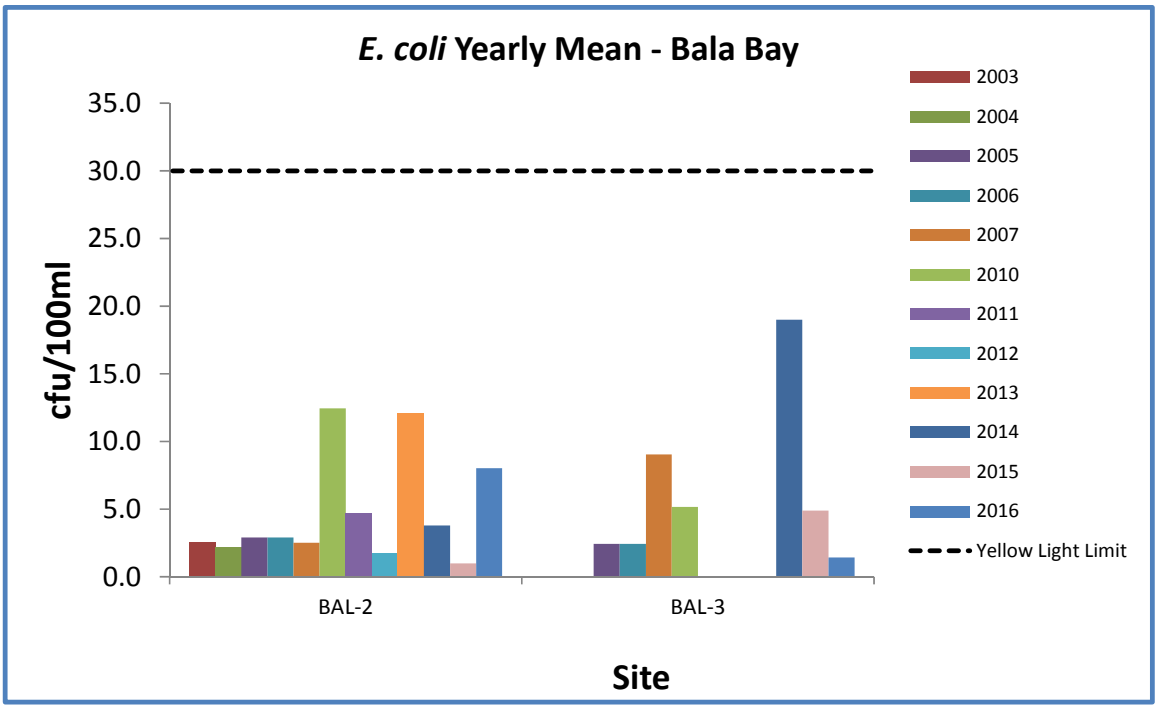
Volunteer Recognition: **Peter Joel,** Alan Hutton, and Lindsay Hutton.

Bala Bay (BAL)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
BAL-0	3.84	4.8	5.3		
BAL-2				8.0	102.6
BAL-3				1.4	97.7





Summary and Recommendations:

Phosphorus results continue to remain consistent over the sampling years and generally in the range of the DMM threshold of 6.6 µg/L. The 2016 *E.coli* results remain well below the MLA limits (details in report Section 3). Beacon recommends sampling continue to monitor long-term trends.

Area Description:

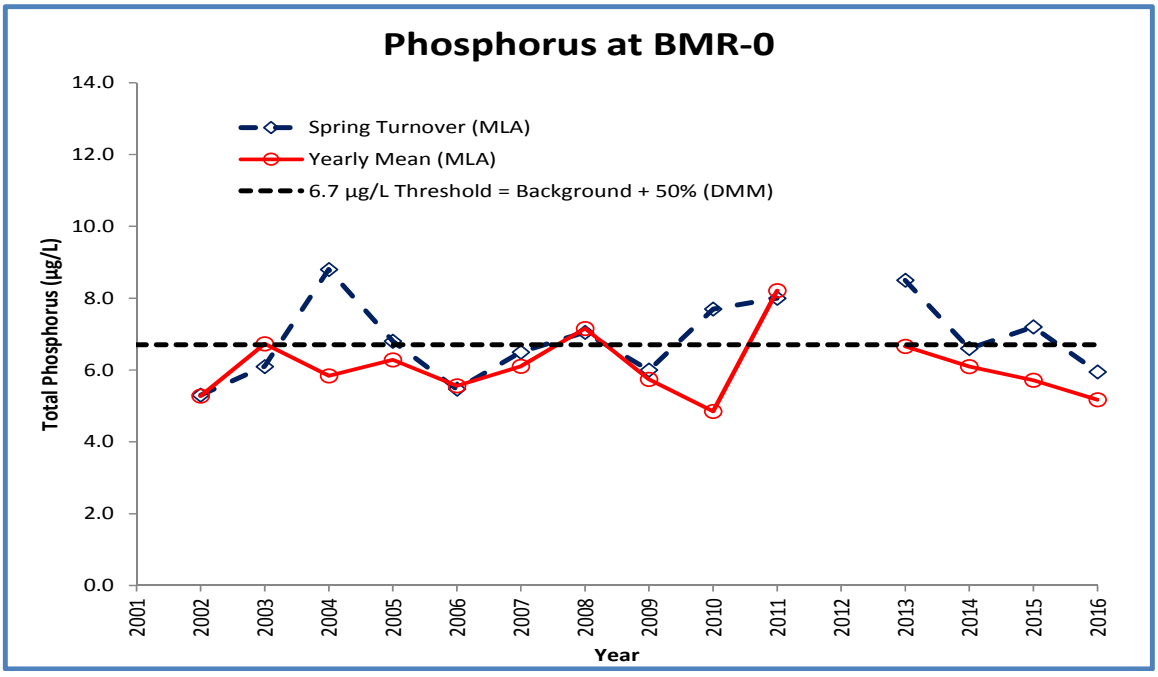
This island is in the Milford Bay area of northeastern Lake Muskoka is approximately 132 ha in size. A golf course takes up much of the island, which is associated with a small private club and marina. Most of the natural shoreline vegetation is intact, but there are many large boathouses in this area. There is a large wetland to the east where the causeway links mainland and the island. Monitoring started in 2002.

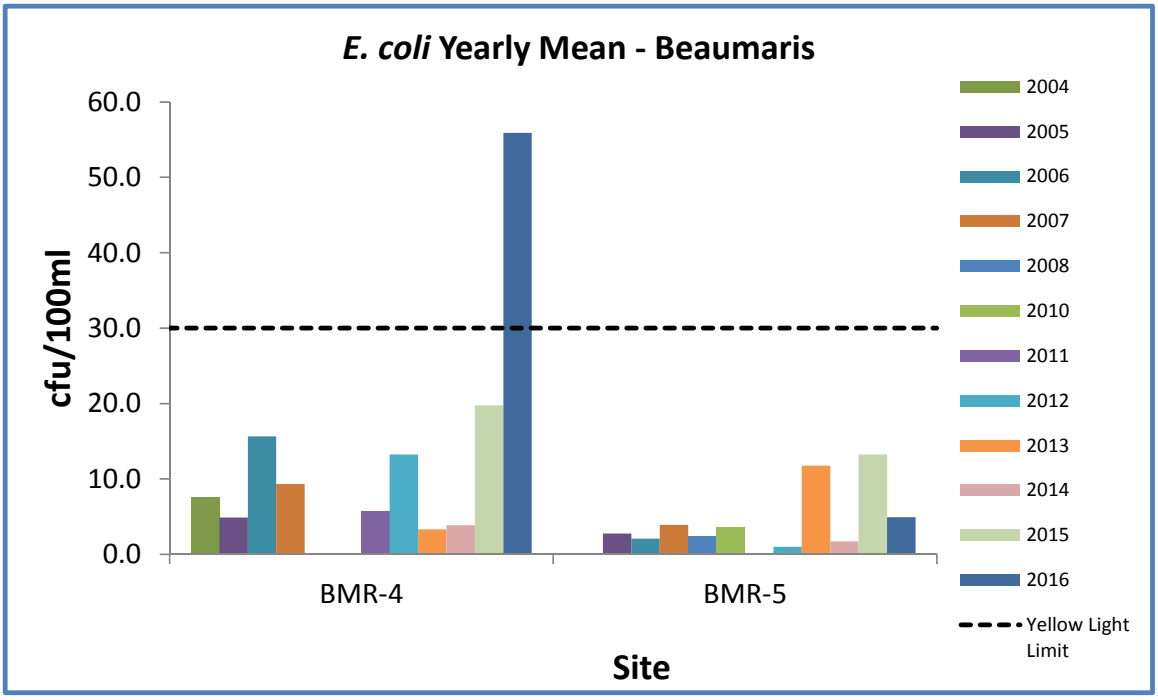
Volunteer Recognition: **Louise Cragg**, Chris Cragg, Don Furniss, Eliza Nevin and Allan Flye.

Beaumaris (BMR)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)	DOC Yearly Mean
		Spring Turnover	Yearly Mean			
BMR-0	3.48	6.0	5.2			
BMR-4		11.2	7.8	55.9	272.1	4.7
BMR-5		5.2	6.5	4.9	101.3	
BMR-6		6.3	7.4			4.7





Summary and Recommendations:

Phosphorus results at BMR-0 remain consistent over the sampling years, and similar to 2014 and 2015, the 2016 yearly mean is below the DMM threshold of 6.7 µg/L. Spring turnover phosphorus concentrations at BMR-2, BMR-4, BMR-5 and BMR-6 are consistent with 2015 results. DOC at BMR-4 and BMR-6 was sampled for in 2014, 2015 and 2016 and is discussed in Section 3.3. The *E.coli* concentrations at BMR-4 were above the yellow light limit set by the MLA (details in report Section 3), while concentrations at BMR-5 remained low. Three retests were undertaken at BMR-4, two during the 3rd sampling event and 1 during the 4th sampling event. Sampling at BMR-2 was discontinued for 2016. Construction work at BMR-4 was ongoing during the sampling season and turbid water was encountered during sampling, likely resulting in high bacteria counts. Beacon recommends sampling continue to monitor long-term trends.

Area Description:

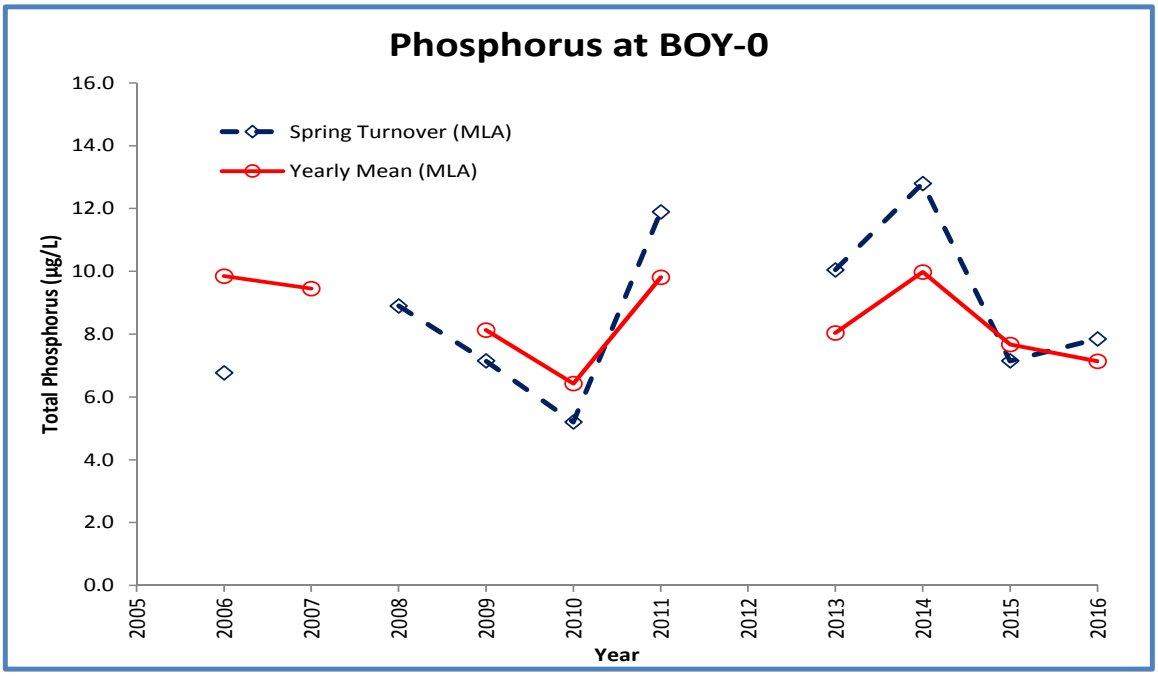
Boyd Bay is a small bay in the central part of eastern Lake Muskoka. The water quality in Boyd Bay is influenced by several natural and man-made features, including a marina in the southeast, a large wetland in the north, Highway 118 to the east and several inflowing creeks. The creeks that drain into the bay are potentially influenced by agricultural areas. Much of the shoreline is developed and many residential properties have manicured lawns along the shoreline. Monitoring started in 2006.

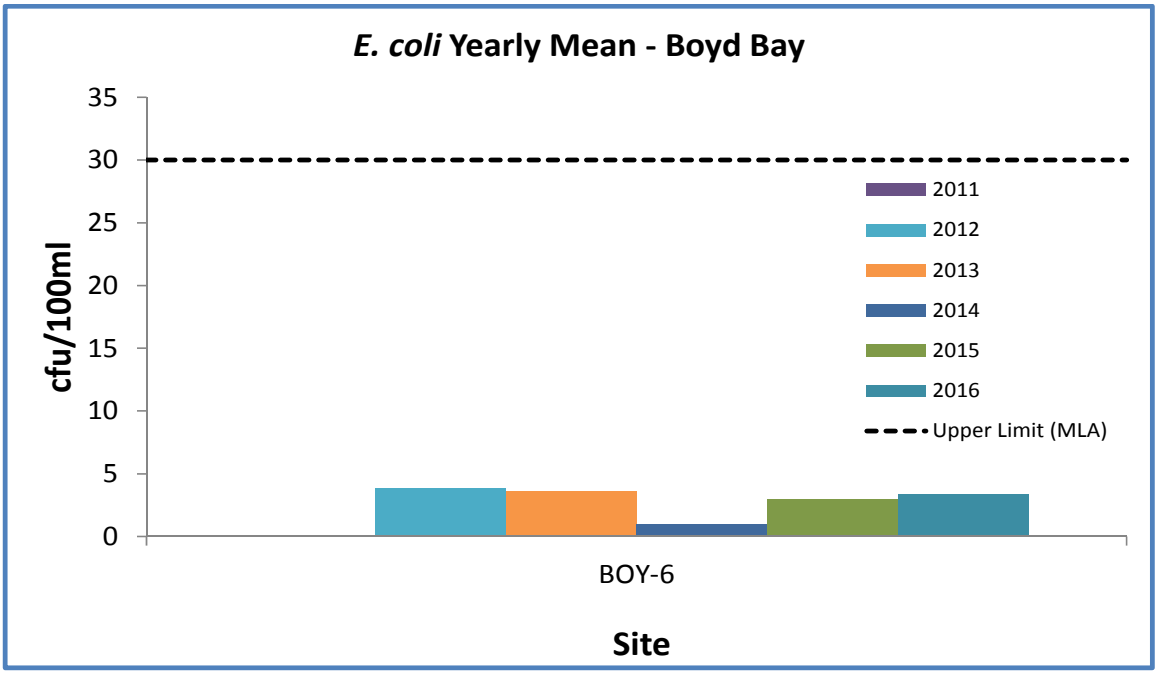
Volunteer Recognition: **John Wood,** Rayma Blaymires, Lynn Langford, Chris Blaymires, and Dave Langford

Boyd Bay (BOY)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)	DOC Yearly Mean
		Spring Turnover	Yearly Mean			
BOY-0	2.96	7.9	7.1			
BOY-3		9.7	8.3			
BOY-4		7.8	7.5			4.4
BOY-6				3.4	70.4	





Summary and Recommendations:

The spring-turnover and yearly phosphorus means at BOY-0 remained consistent with 2015 levels. Similar to results in 2015, spring phosphorus concentrations at BOY-3 and BOY-4 in 2016 were all markedly lower than values in 2014. The decreasing trend in the yearly phosphorus mean for BOY-3 and BOY-4 continued from 2014 to 2016. DOC at BOY-4 was sampled for in 2016 and is discussed in Section 3.3. *E. coli* samples were only obtained at BOY-6 in 2016 and continue to be well below the MLA stoplight limits (details in report Section 3). **Beacon recommends sampling continue to monitor long-term trends.**

Area Description:

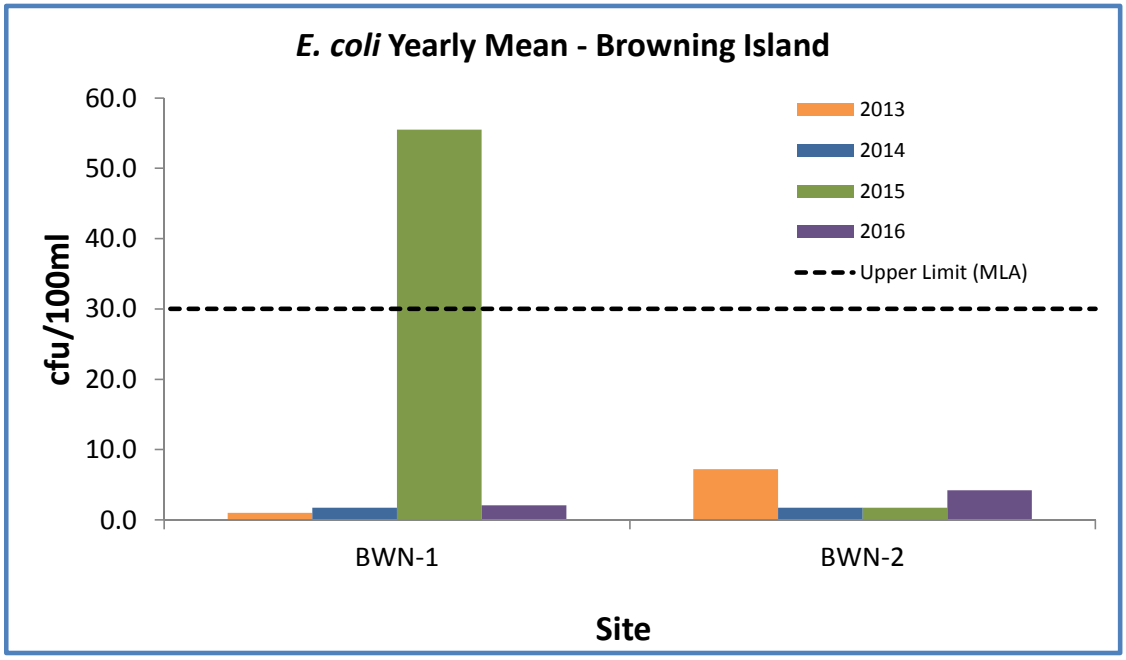
Browning Island is one of the largest islands in the Muskoka Lakes. In the late 1800s the island was stripped of its white pine. Portions of the island were then farmed (cattle, sheep and crops). The central portion of the island remains undeveloped. Through a number of donations, 338 acres of the island consists of the Browning Island Nature Reserve. Two of the sheltered bays were added to the MLA sampling program in 2013 due to concern that they may be vulnerable areas.

Volunteer Recognition: **Janet Selby**, Willie Buffet, and Kirk Swanson.

Browning Island (BWN)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
BWN-1				2.1	32.4
BWN-2				4.2	63.6



Summary and Recommendations:

E.coli results were well below the MLA stoplight limits (details in report Section 3) at both stations in 2016 and at BWN-1 were well concentrations compared to the previous year. Beacon recommends sampling continue to monitor long-term trends, with particular attention focussed on the *E. coli* results from BWN-1 in 2015.

Area Description:

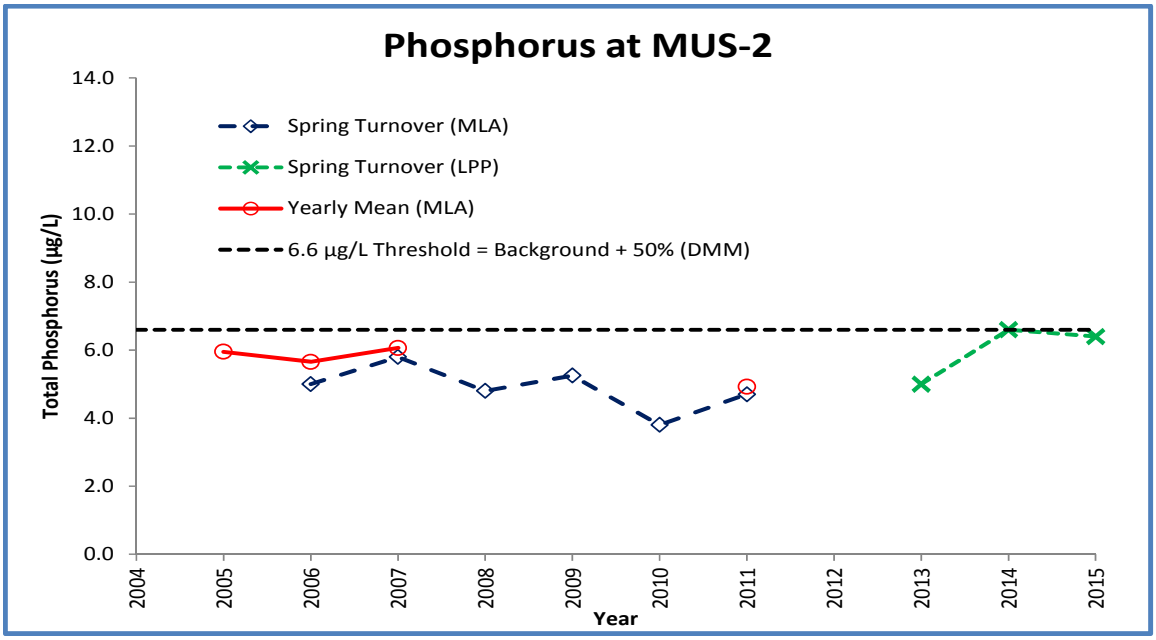
Dudley Bay is located in eastern Lake Muskoka, and is approximately 3.6 km² in size with a maximum depth of 20 m. It is considered moderately developed, with primarily residential properties and several roads, including Highway 169, that are in close proximity to the shoreline. Several creeks and wetlands drain into the bay, including that from the cranberry marsh. Dudley Bay is classified as moderately sensitive by the DMM. Monitoring started in 2005.

Volunteer Recognition: **Eleanor Lewis and Jim Lewis.**

Dudley Bay (DUD-1 & MUS-2)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
DUD-1		12.8	8.6		
MUS-2					



Summary and Recommendations:

Phosphorus results are continually at or below the 6.6 µg/L DMM threshold. The MLA relied on the Lake Partner Program for the spring phosphorus concentrations at MUS-2 in 2013-2015. Beacon recommends that the MLA rely on the Lake Partner Program data when it is available, otherwise the MLA should continue to monitor this location to analyse long-term trends.

Area Description:

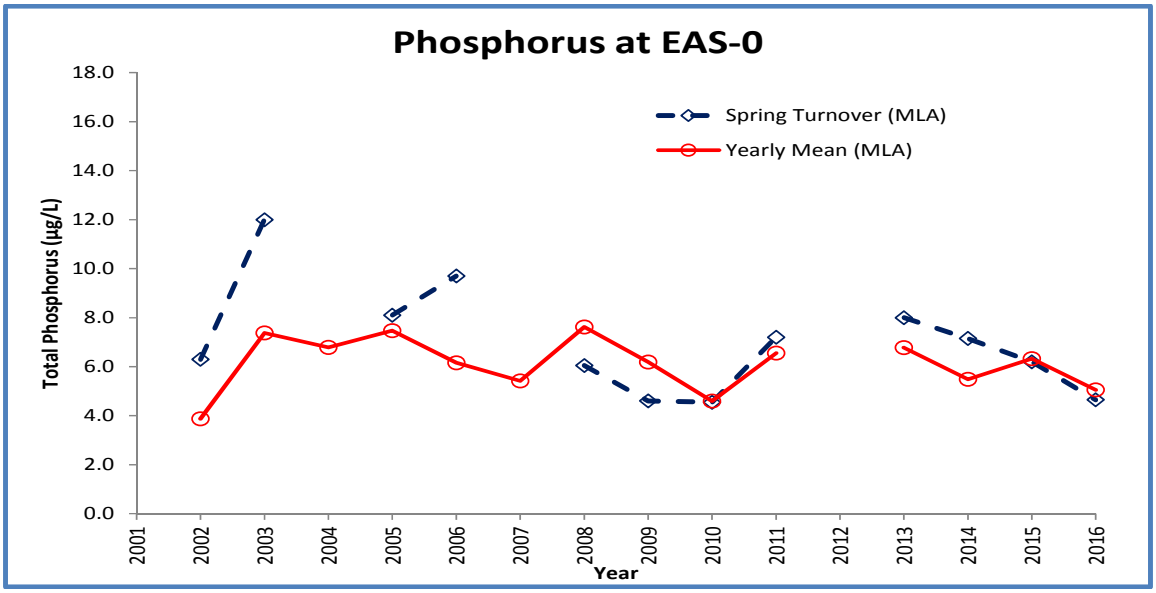
East Bay is in the western portion of Lake Muskoka and is part of Hardy Lake Provincial Park. This is a low development area with very few cottages/residences and no access roads. Several long narrow bays form the drainage area where five creeks outlet into the main bay from the park. These creeks also drain wetland areas into East Bay. Monitoring started in 2002.

Volunteer Recognition: **Louise Cragg,** Jeff Hall, Jan Getson, and Lloyd Walton.

East Bay (EAS)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
EAS-0	3.36	4.7	5.1		
EAS-2		7.6	8.5		
EAS-3		4.2			



Summary and Recommendations:

Phosphorus concentrations at EAS-0 generally remain low over the sampling years. Following the test for outliers of the spring phosphorus concentrations, the spring phosphorus data in 2004 was removed. Spring turnover phosphorus levels and yearly phosphorus means decreased in 2016 with the exception of EAS-2. Beacon recommends continued sampling to monitor long-term trends.

Area Description:

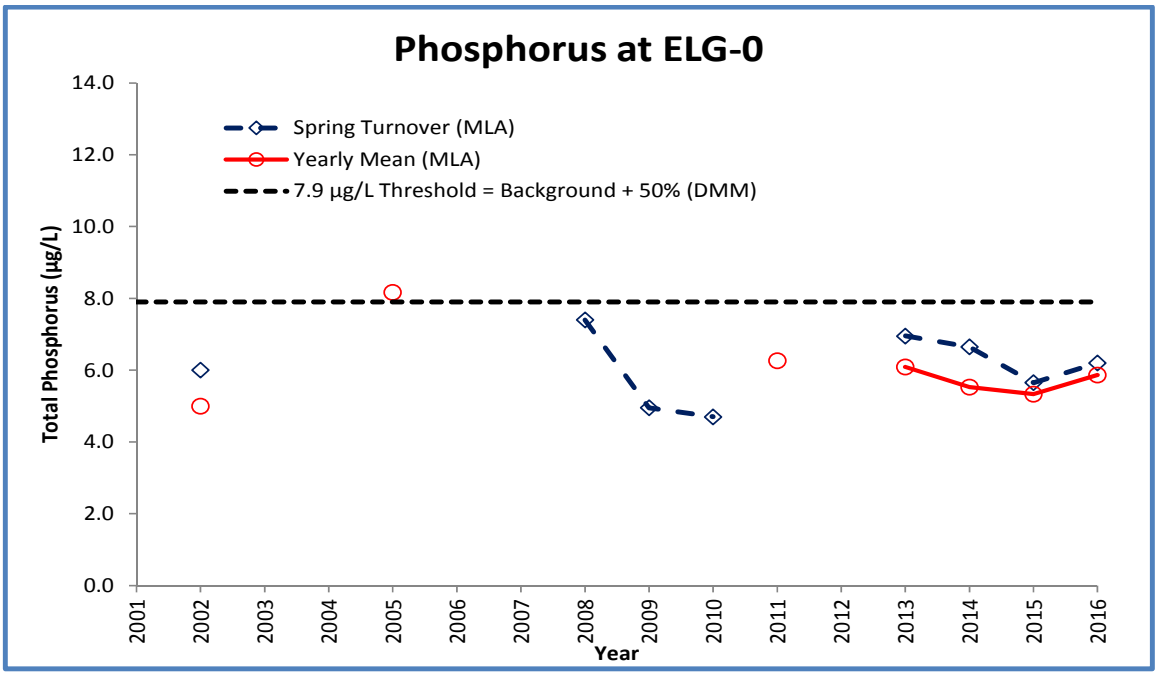
Eilean Gowan Island is located in the eastern part of Lake Muskoka and is largely developed with residential cottages. Most of these properties appear to retain a well-vegetated shoreline with the exception of a few lawns and tennis courts directly adjacent to the lake. The interior of this island is completely forested and a small stream outlets from the upland area at sampling site ELG-1. Monitoring started in 2002.

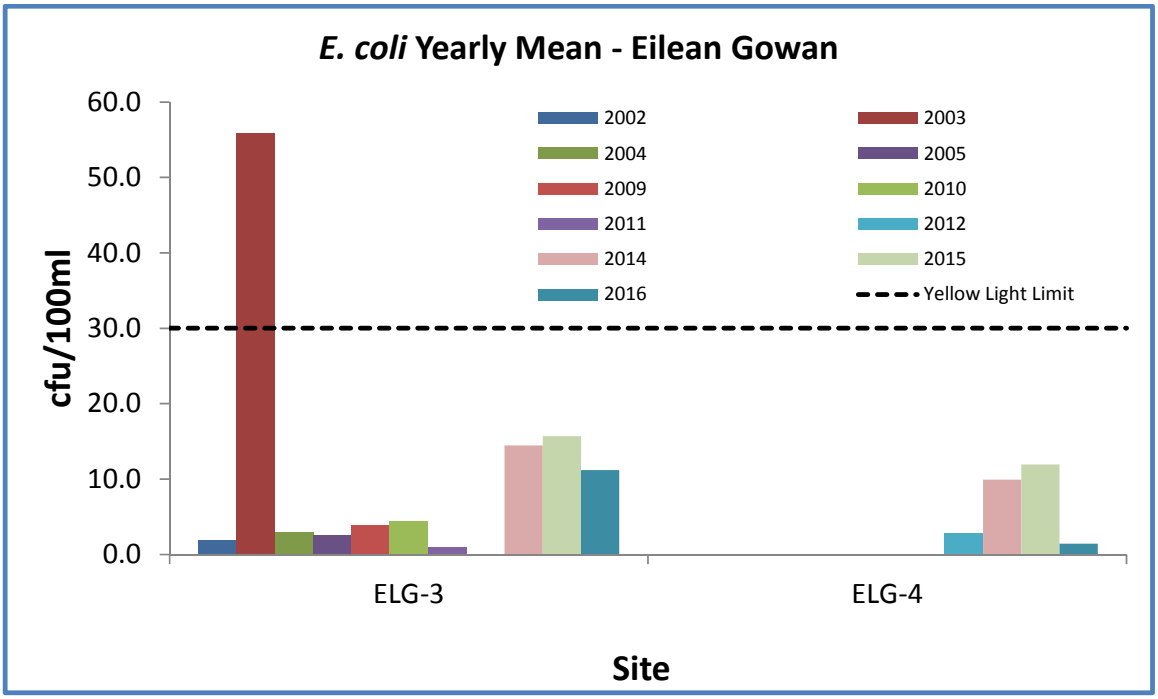
Volunteer Recognition: **Susan Murphy,** Stephen Sims, Doug Tate, Peter McMullin, Beth Tate, and Sydney Sims.

Eilean Gowan Island (ELG)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
ELG-0	3.26	6.2	5.9		
ELG-3				11.2	261.8
ELG-4				1.4	113.4





Summary and Recommendations:

Phosphorus concentrations at ELG-0 generally remain low over the sampling years. Following the test for outliers of the spring phosphorus concentrations, the 2011 spring phosphorus data remained out of the analysis. The *E.coli* yearly mean at both ELG-3 and ELG-4 in 2016 remained below the MLA stoplight limits (details in report Section 3). Beacon recommends continuing sampling to monitor trends.

Area Description:

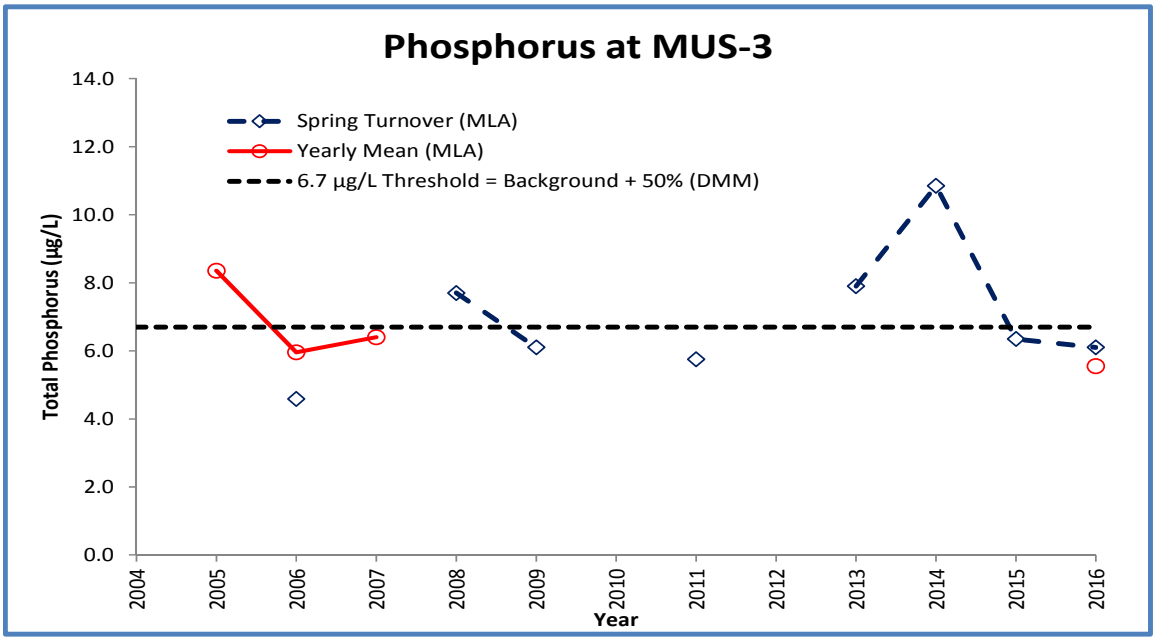
With a surface area of approximately 121 km^2 and water depths of up to 73 m, Lake Muskoka is the largest inland lake within the District of Muskoka. The Lake Muskoka watershed area is 4600 km^2 and approximately 10.5% of the watershed is covered by wetlands. The lake has various points of inflow and outflow, most notably being the outflow into the Moon River. Monitoring started in 2005.

Volunteer Recognition: **John Wood,** Rayma Blaymires, Lynn Langford, Chris Blaymires and Dave Langford.

Lake Muskoka (MUS-3)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
MUS-3	3.51	6.1	5.6		



Summary and Recommendations:

Spring phosphorus results in 2016 decreased from those recorded in the previous 3 years and remained below the DMM threshold in 2015 and 2016. Phosphorus sampling through the year resumed at MUS-3 and the yearly mean was below the DMM threshold. Beacon recommends that spring sampling continue to monitor long-term trends.

Area Description:

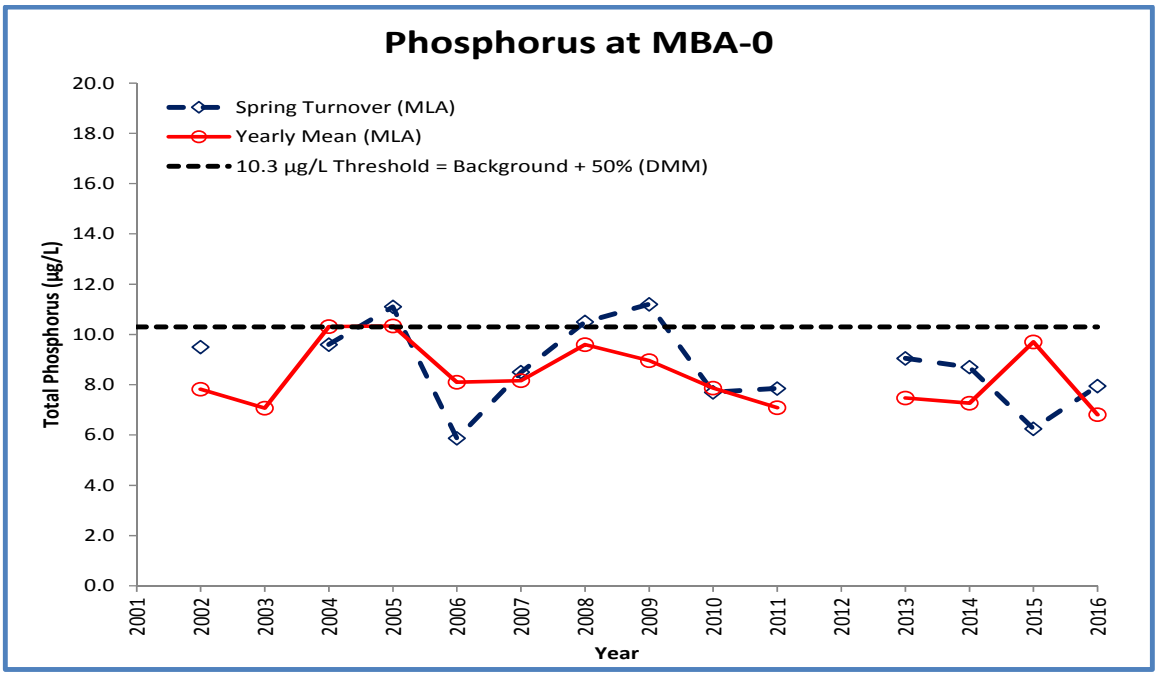
Muskoka Bay is the southernmost bay in Lake Muskoka. The bay has a long history of industrial uses and nutrient issues. While water quality in the bay has improved dramatically since the 1970s, it is still classified as moderately sensitive and over threshold by the DMM. Although the bay has a high intensity of development, 80% of the shoreline is presently in a natural state. The southern end of this bay includes a large commercial development and is the receiver of most of Gravenhurst's urban storm water. Several creeks outlet into the bay and wetlands account for 9.4% of the shoreline. Monitoring started in 2002.

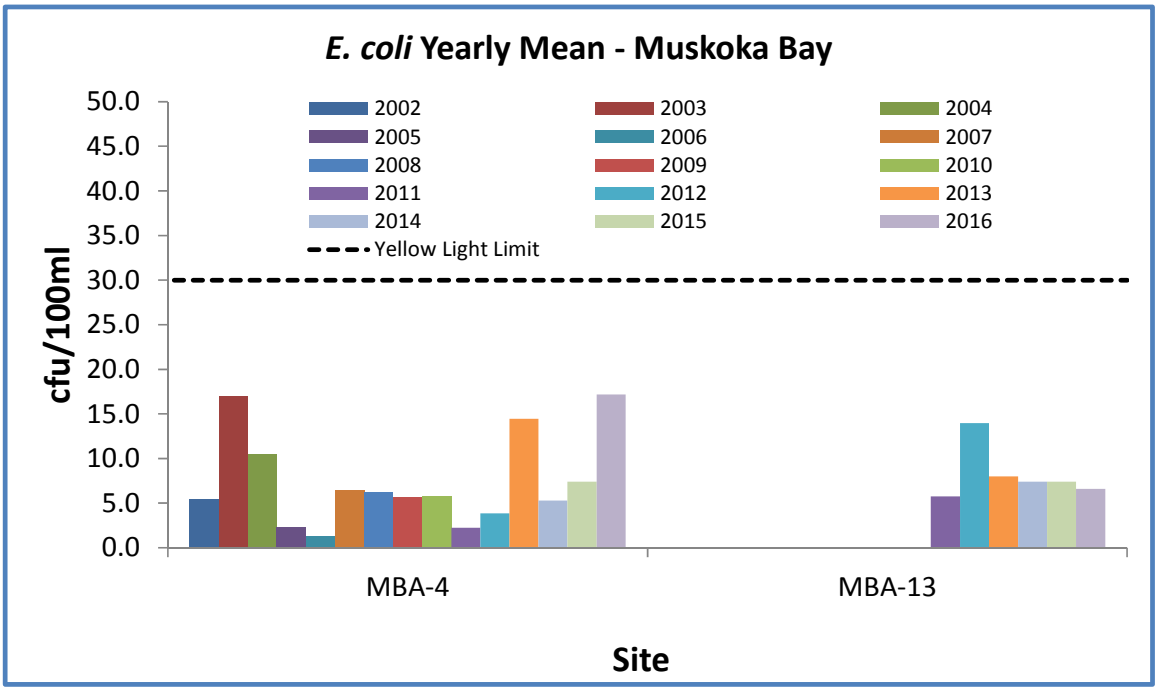
Volunteer Recognition: **Karen Abells** and Alan Goldenberg.

Muskoka Bay (MBA)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)	DOC Yearly Mean
		Spring Turnover	Yearly Mean			
MBA-0	3.91	8.0	6.8			
MBA-4				17.2	171.3	
MBA-12		22.9	81.1			1.7
MBA-13		8.1	8.5	6.6	116.4	





Summary and Recommendations:

Phosphorus concentrations continue to remain below or at the DMM threshold level at the deep station (MBA-0) through the sampling years. Using Grubb's Test for outliers, the spring 2003 phosphorus sample was identified as an outlier in 2013 and remains out of the dataset in 2016. The phosphorus sampling at MBA-12 on the third sampling date presented a very high result (202.1 µg/L), resulting in the high yearly mean. DOC at MBA-12 was sampled for in 2016 and discussed further in Section 3.3. *E.coli* levels at MBA-4 and MBA-13 were below the MLA limits (details in report Section 3). Beacon recommends that all sampling be continued to monitor long-term trends, with special attention to MBA-12 phosphorus.

Area Description:

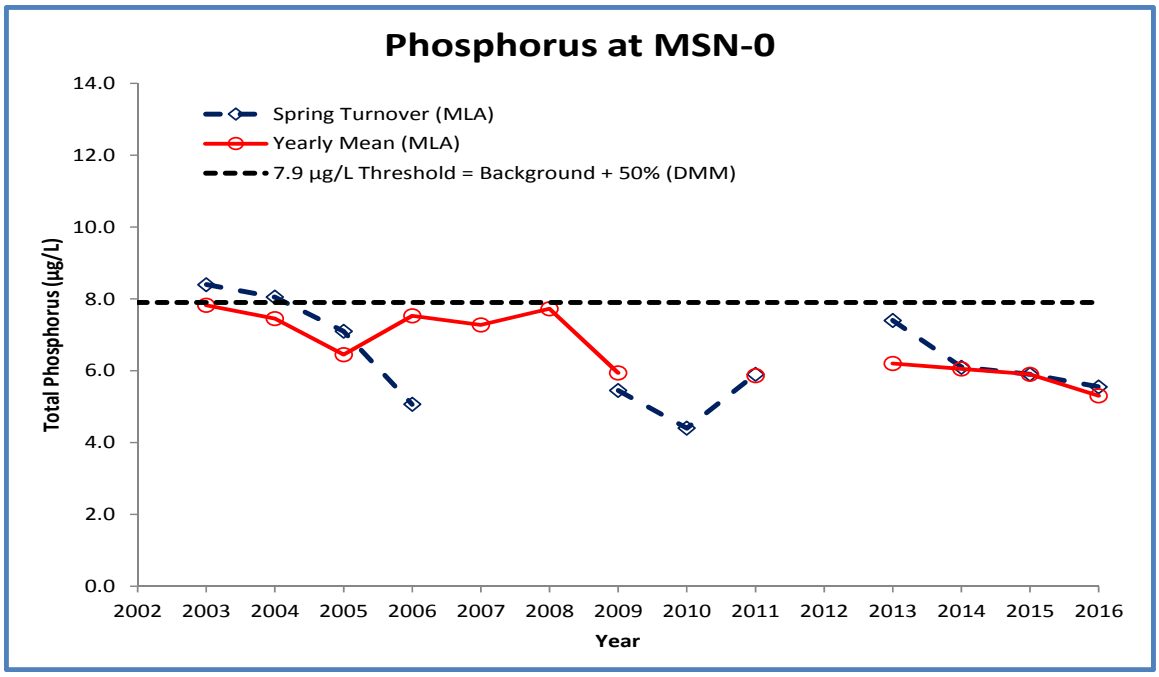
The Muskoka Sands sampling area is located in southeastern Lake Muskoka at the confluence with the Hoc Roc River. This area has a high intensity of development with a large resort and golf course, along with a high density of residential properties and roads adjacent to the lake. The Hoc Roc River flows through agricultural, industrial, residential, and natural wetland areas before it drains into a shallow bay. Dominant northwest winds and a considerable fetch would subject this area to heavy onshore wave action. Monitoring started in 2003.

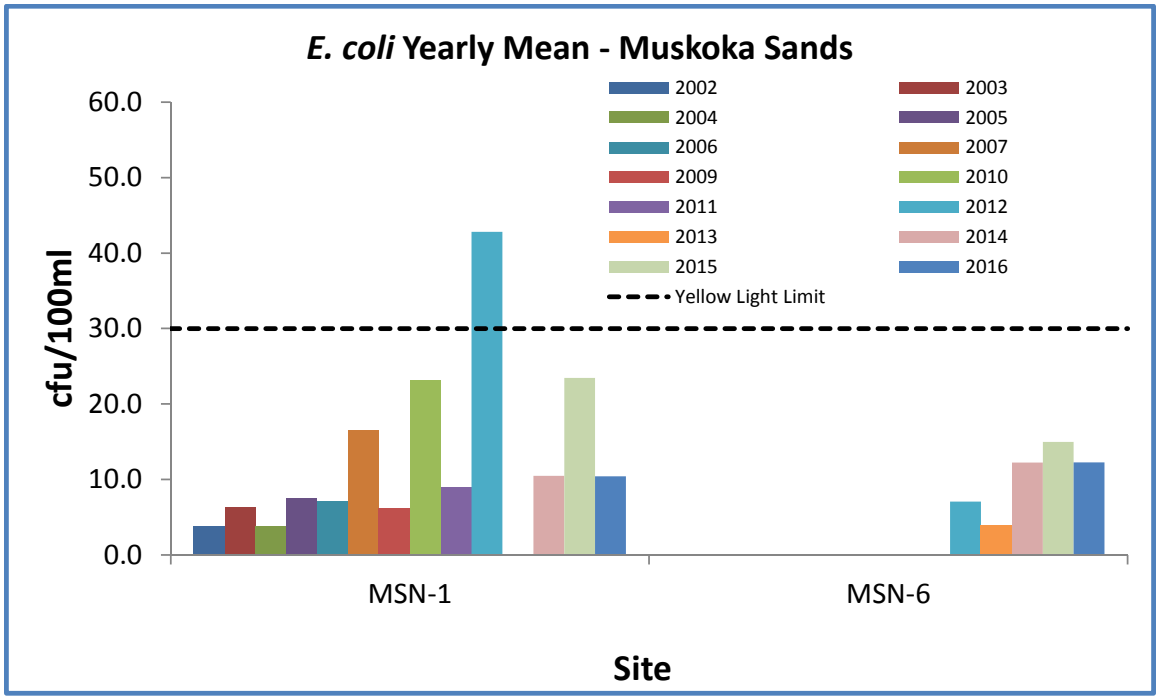
Volunteer Recognition: **Al Ward,** Mark Brosch, Rick Evans, and Carole Ward.

Muskoka Sands (MSN)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)	DOC Yearly Mean
		Spring Turnover	Yearly Mean			
MSN-0	3.60	5.6	5.3			
MSN-1				10.4	145.4	
MSN-4		24.5	26.9			8.9
MSN-5		24.8	30.4			
MSN-6				12.3	63.1	





Summary and Recommendations:

Phosphorus results at the deep-water station continue to remain at or below the DMM threshold for the past 12 years. DOC at MSN-4 was sampled for in 2013, 2015, part of 2014 and through 2016 and is discussed in Section 3.3. MSN-1 and MSN-6 *E. coli* results in 2016 were both below the MLA limits (details in report Section 3). Re-tests were required at MSN-1. **Beacon recommends that sampling continue to monitor long-term trends.**

Area Description:

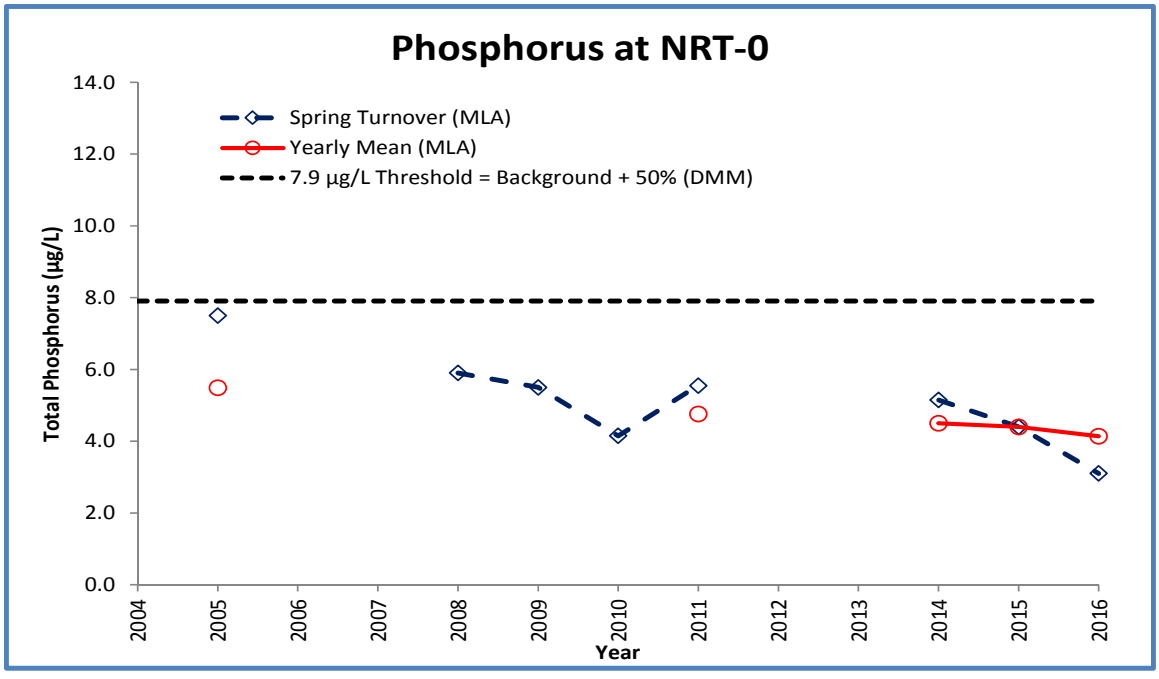
The North Bay sampling area is a large bay in northwestern Lake Muskoka. A total of eight creeks outlet into the bay, several draining wetland areas and one that passes through a District landfill site north of the lake. This is a moderately developed part of the lake, having many residential properties and several roads that are in close proximity to the shoreline. Development is mostly restricted to the areas adjacent to the lake, leaving most of the upland forested areas in a natural state.

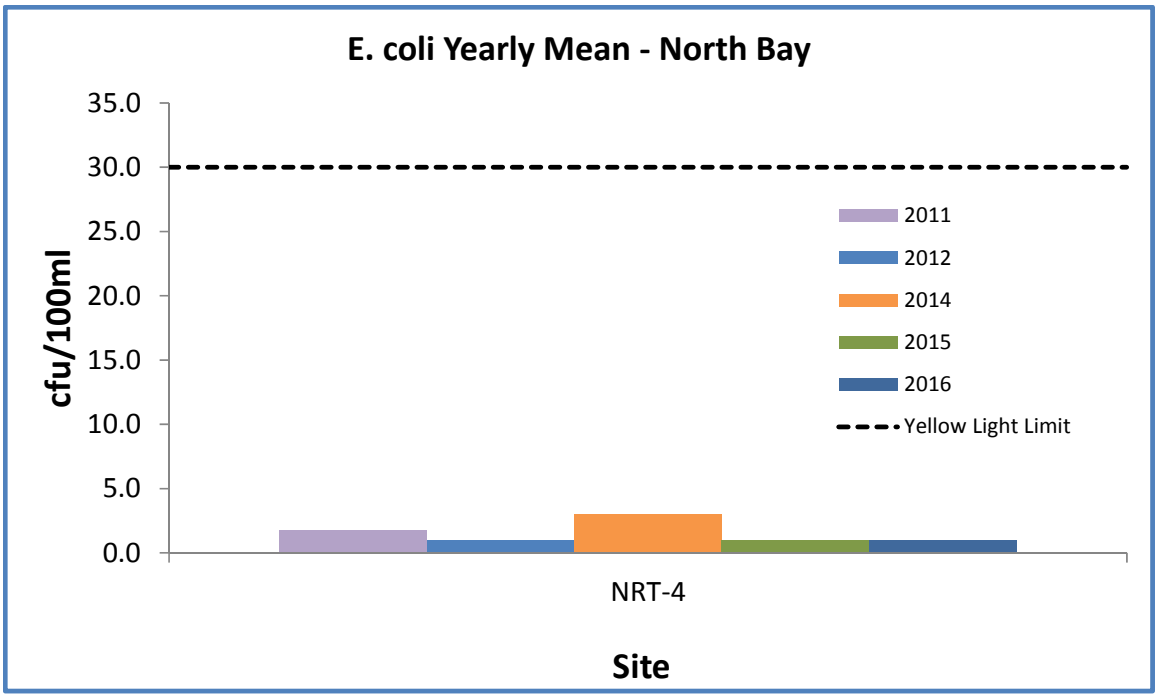
Volunteer Recognition: **Eleanor Lewis, Jim Lewis**, and Peter Joel.

North Bay (NRT)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
NRT-0	4.04	3.1	4.1		
NRT-4				1.0	17.4





Summary and Recommendations:

Spring phosphorus and yearly phosphorus mean concentrations at NRT-0 have all remained below the DMM threshold since 2005. *E.* coli levels at NRT-4 have remained well below the MLA stoplight limits (details in report Section 3). Beacon recommends sampling continue to monitor long-term trends.

Area Description:

Stephen's Bay is a small bay in the central part of eastern Lake Muskoka, south of the mouth of the Muskoka River. The water quality in Stephen's Bay is influenced by input from adjacent wetlands as well as agriculture in the east, and public beaches (Strawberry Bay and Kirby's). Much of the shoreline is developed. Monitoring started in 2013 due to concern this may be a vulnerable area.

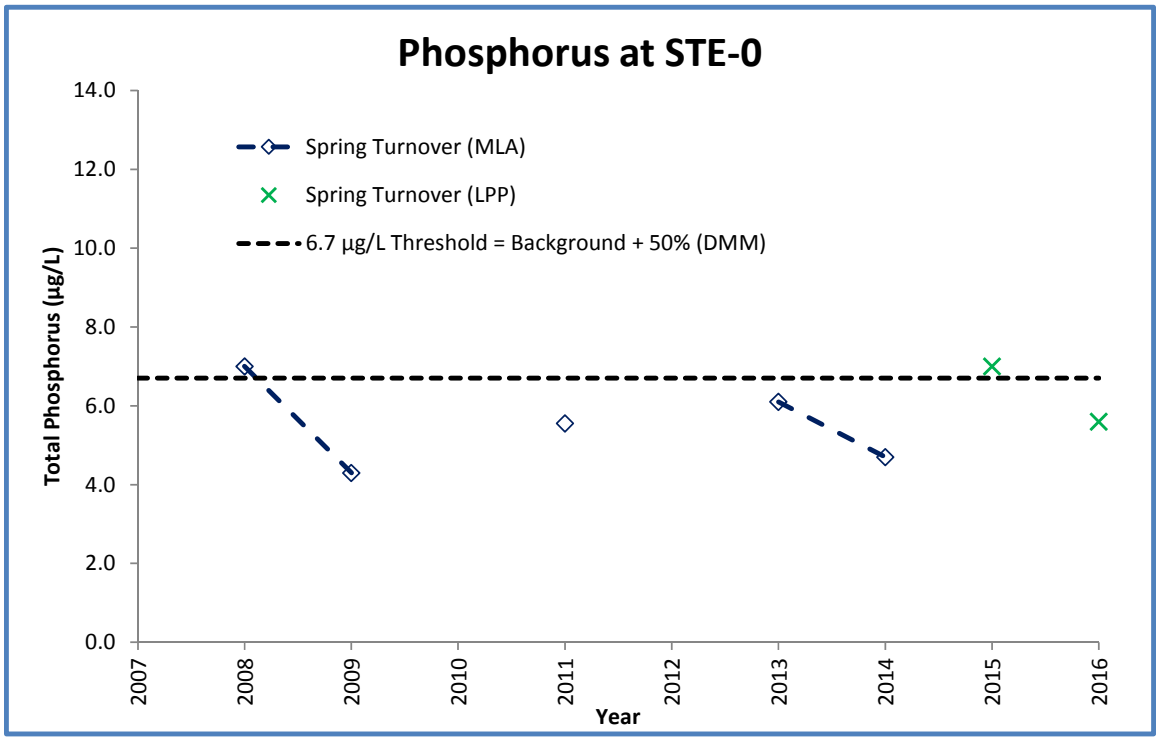
Volunteer Recognition: **John Wood,** Bob Kerton, Bari Kerton, Chloe Kerton and the Lake Partner Program.

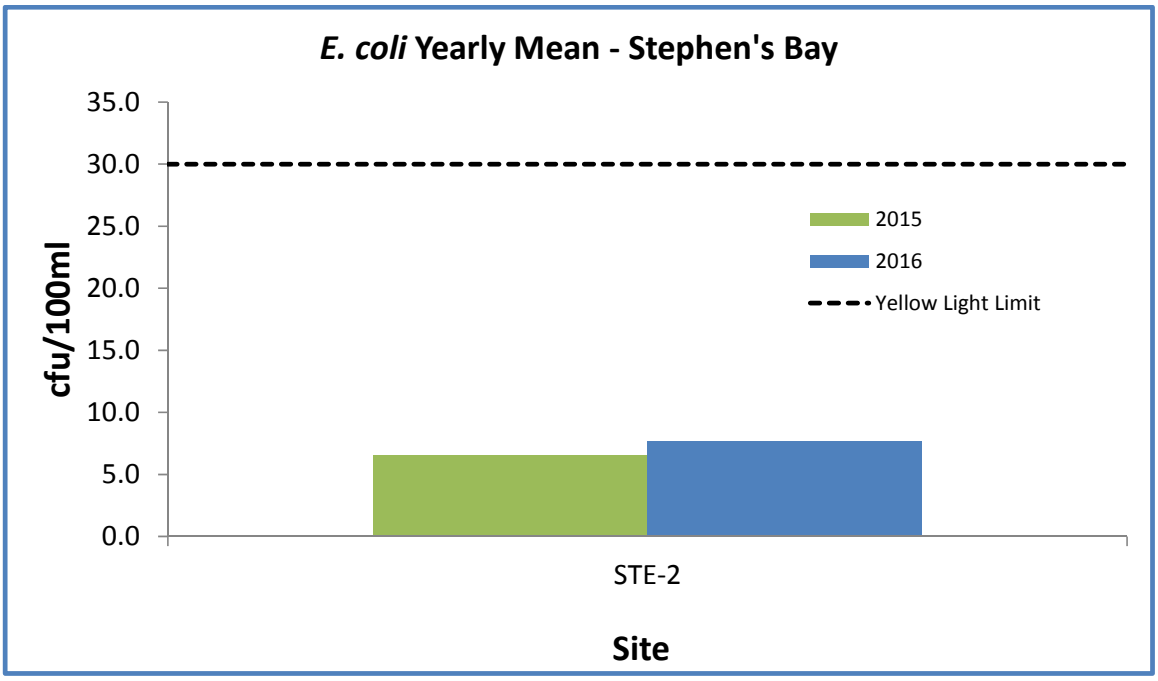
Stephens Bay (STE)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
STE-0	3.25	5.6*			
STE-2				7.7	533.1

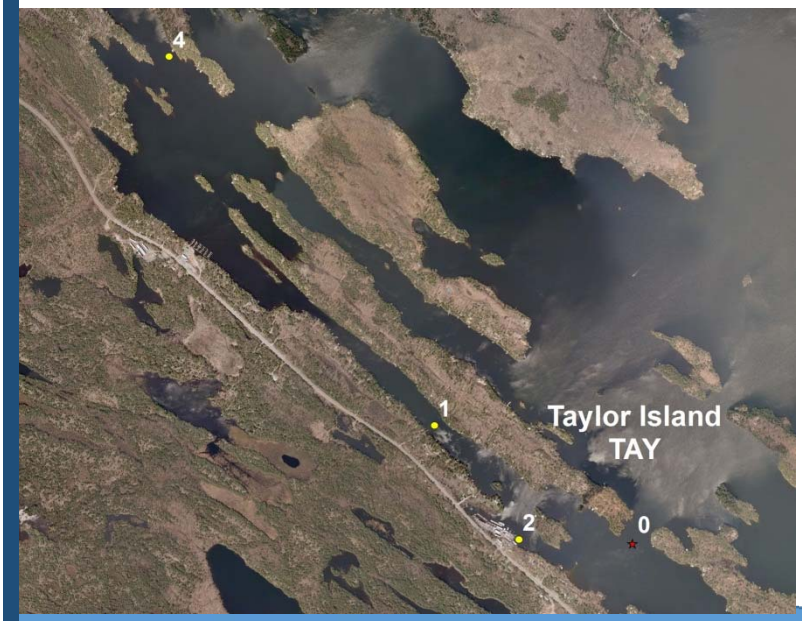
*Data from Lake Partners Program (MOECC)





Summary and Recommendations:

The MLA relied on the Lake Partner Program for the spring phosphorus concentrations at STE-0 in 2016. *E.coli* concentrations at STE-2 in 2016 remained below the MLA stoplight limits (details in report Section 3). **Beacon recommends that the MLA rely on the Lake Partner Program data when it is available, otherwise the MLA should continue to monitor this location to analyse long-term trends.**



Area Description:

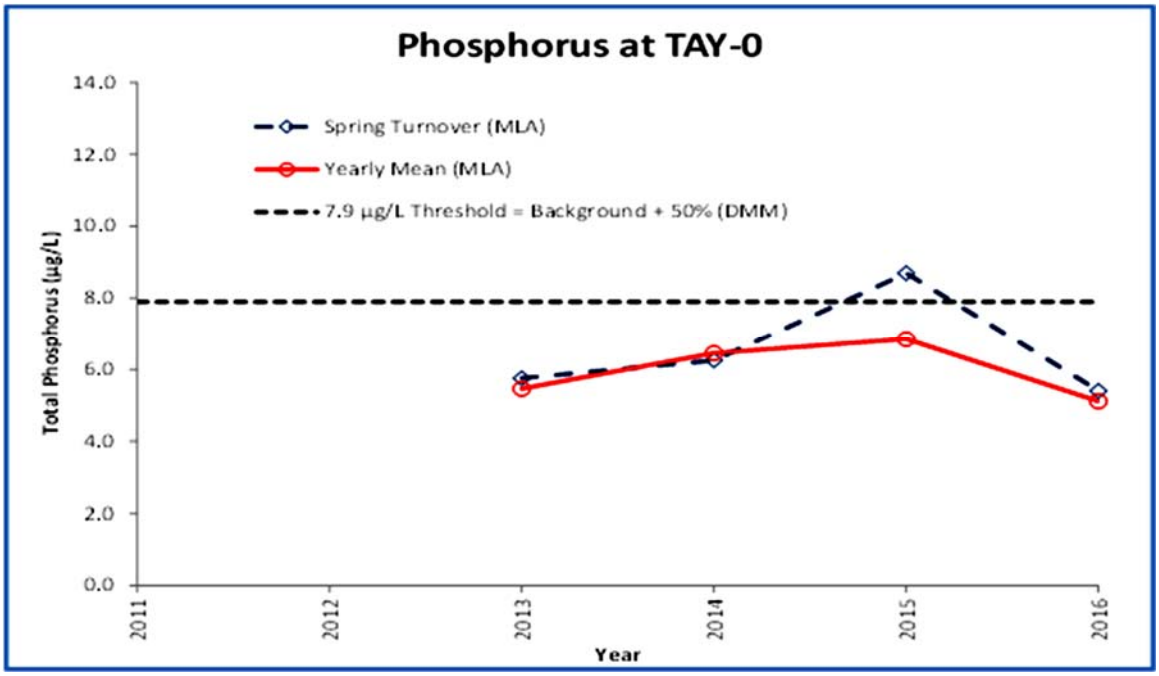
Taylor Island is in the main basin of Lake Muskoka and is approximately 76 ha in size. Development intensity in this area is considered moderate to high; however, most of the natural shoreline vegetation appears to be intact. This area has few lacustrine wetlands. Two streams originating in wetlands, outlet into the lake in this area. TAY-2 is located adjacent to a marina. Monitoring started in 2012.

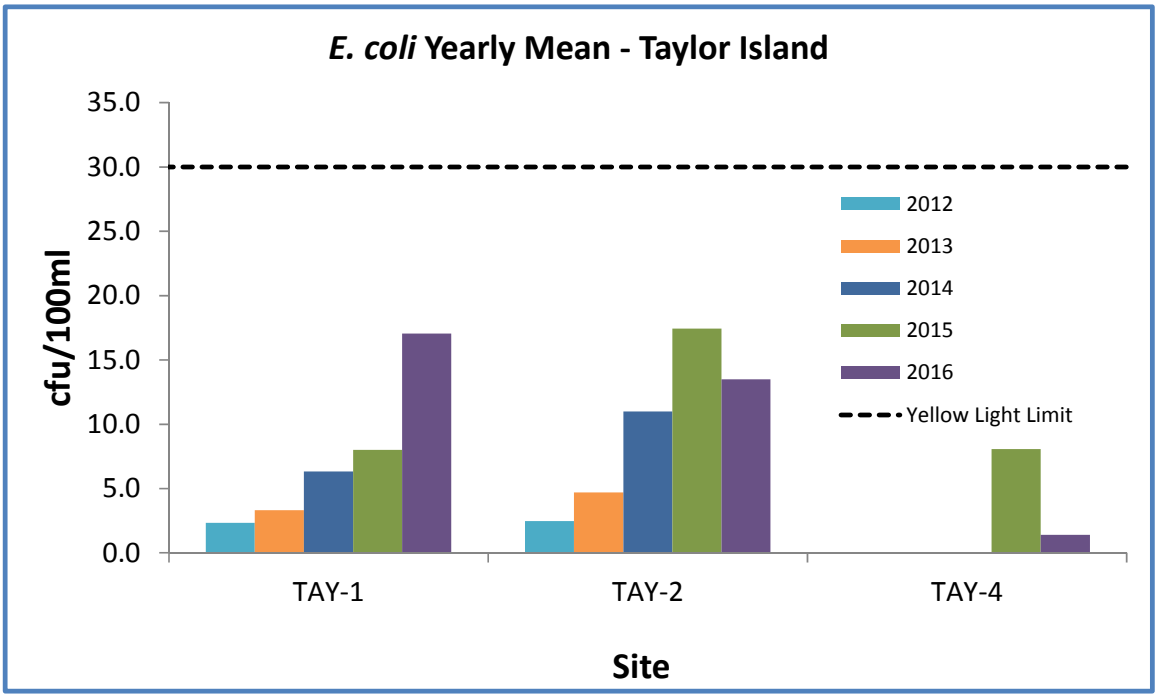
Volunteer Recognition: **Al Ward,** Rick Evans, Mark Brosch, Susan Murphy and Jennifer Evans.

Taylor Island (TAY)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
TAY-0	4.06	5.4	5.1		
TAY-1				17.0	62.9
TAY-2		6.4	6.6	13.5	80.6
TAY-4				1.4	42.6





Summary and Recommendations:

Spring phosphorus and yearly mean phosphorus concentrations were below the DMM threshold. *E.coli* concentrations at TAY-1 and TAY-2 remained below the MLA stoplight limits (details in report Section 3). Beacon recommends that sampling continue to establish a base at TAY-4 and to monitor long-term trends at all stations.

Area Description:

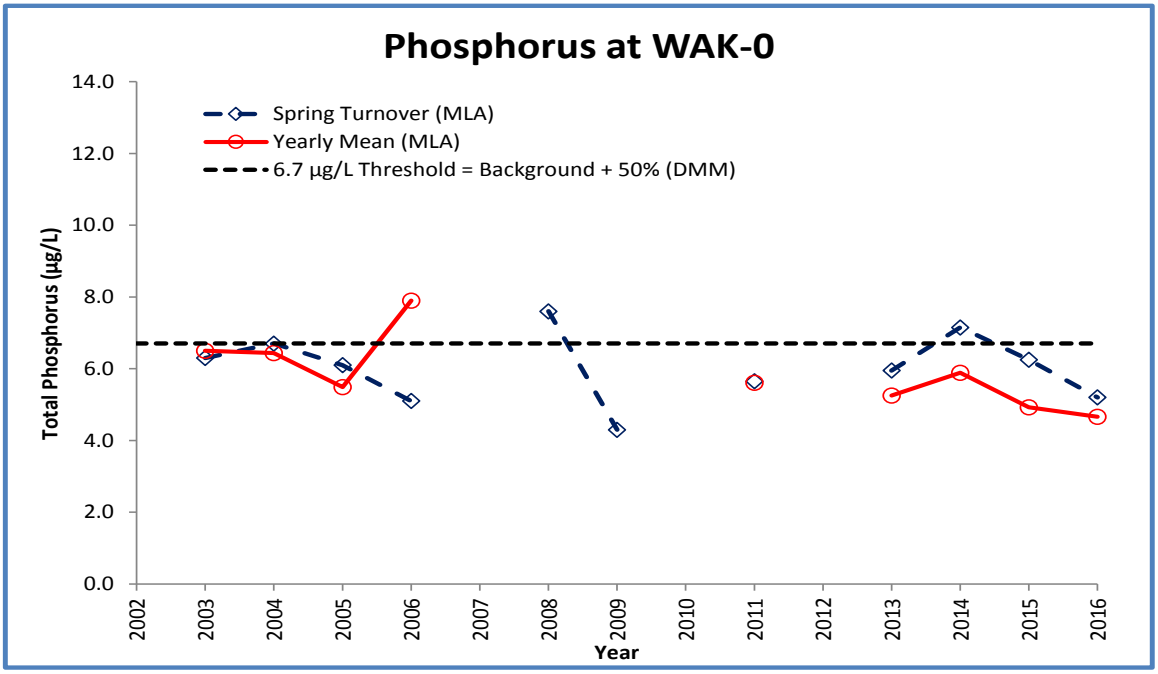
The Walker's Point sampling area is in south-central Lake Muskoka, East of Hardy Lake Provincial Park and west of Browning Island. WAK-0 is located off the tip of Walkers Point, near the mouth of Walkers Bay. A single creek outlets in Walkers Bay. The sampling area includes the bay to the north that contains the outlet of a creek which drain a series of wetlands.

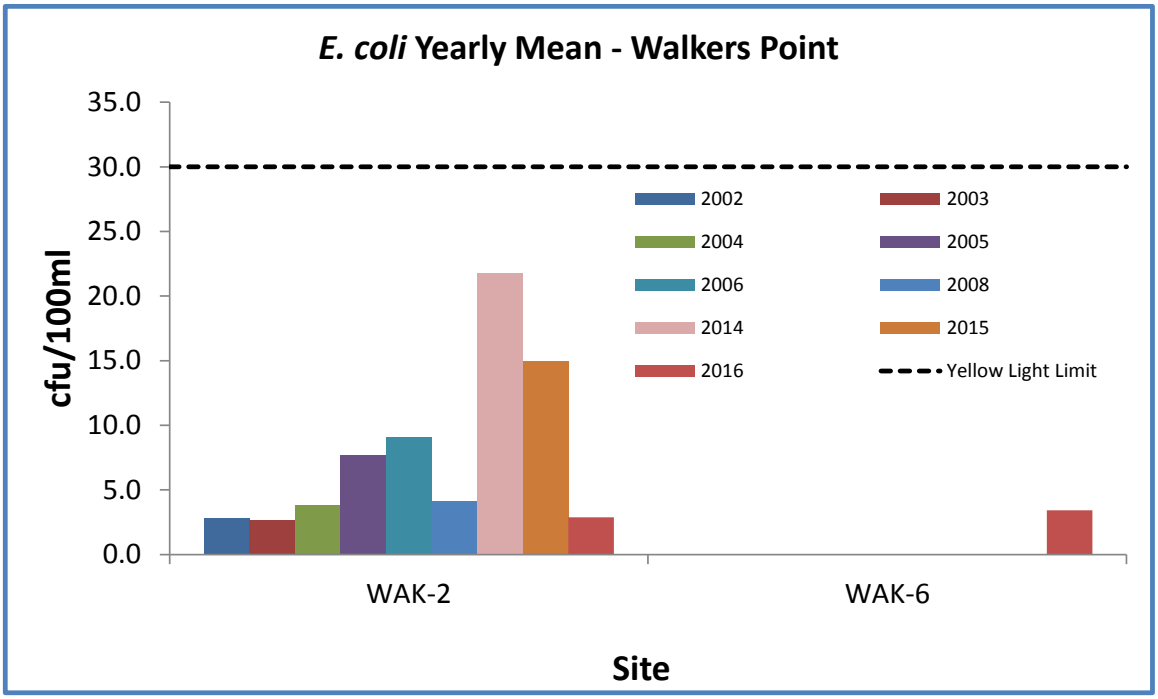
Volunteer Recognition: **Susan Murphy,** Doug Tate, Stephen Sims, Peter McMullin and Sydney Sims.

Walker's Point (WAK)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
WAK-0	3.60	5.2	4.7		
WAK-2		4.8	5.5	2.9	43.3
WAK-6		5.2	5.6	3.4	70.8





Summary and Recommendations:

Phosphorus concentrations at the deep-water station continue to remain below the DMM threshold in 2016. *E. coli* testing at WAK-2 continues to show concentrations below the MLA stoplight limits (details in report Section 3). The new station WAK-6 was started in 2016 and also shows *E. coli* concentrations below the MLA stoplight limits. **Beacon recommends that sampling continue to monitor long-term trends.**

Area Description:

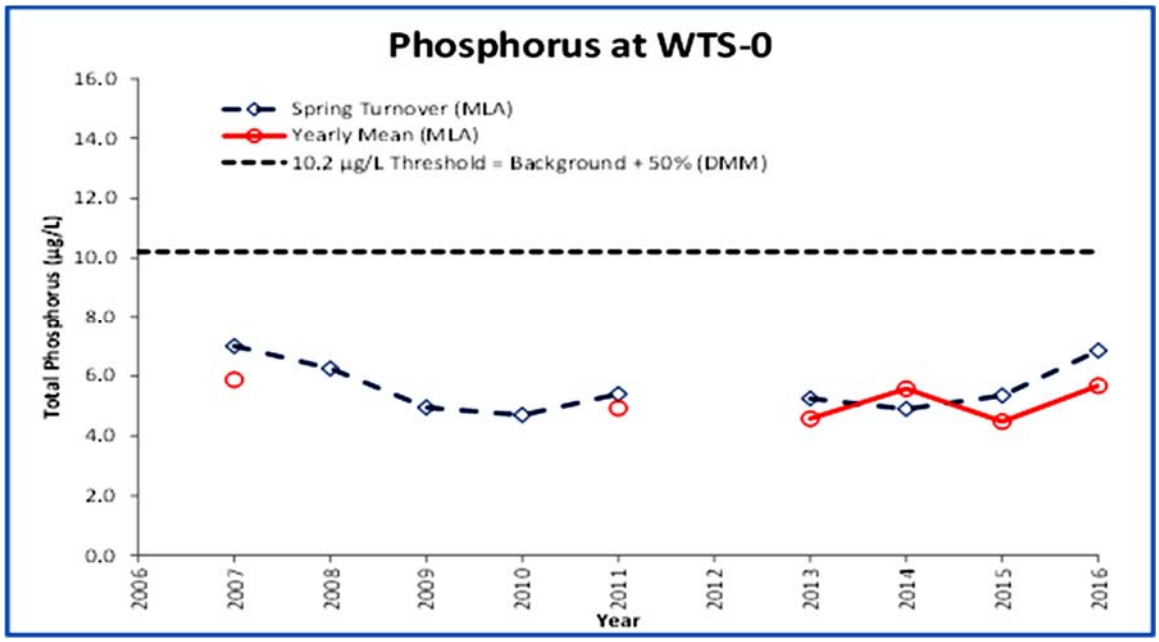
Whiteside Bay is a partially isolated bay in the northwestern portion of Lake Muskoka. It is moderately developed with cottage/residential properties and has roadways that come in close proximity to the shoreline in several areas. Inflow into the lake comes from two creeks, one of which originates in an extensive wetland complex to the north. Monitoring started in 2007.

Volunteer Recognition: **Eleanor Lewis and Jim Lewis.**

Whiteside Bay (WTS)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
WTS-0	3.53	6.9	5.7		



Summary and Recommendations:

Phosphorus results at the deep-water station remain consistently below the DMM threshold through all of the sampling years to date. **Beacon recommends that sampling continue to monitor long-term trends.**

Area Description:

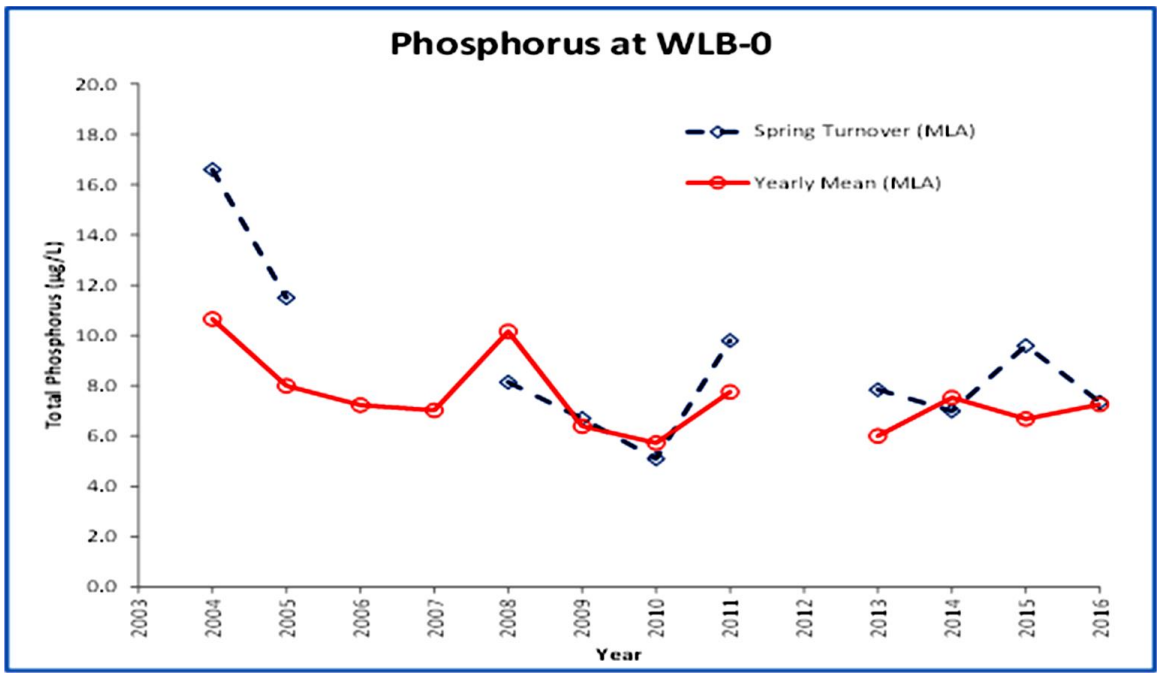
The Willow Beach sampling area encompasses a highly developed section of shoreline. There is a newly re-developed resort complex, a wetland with a creek flowing through a nine-hole golf course and several larger properties with limited retained forest cover. Highway 118 is in close proximity to the shoreline along much of this reach. Monitoring started in 2004.

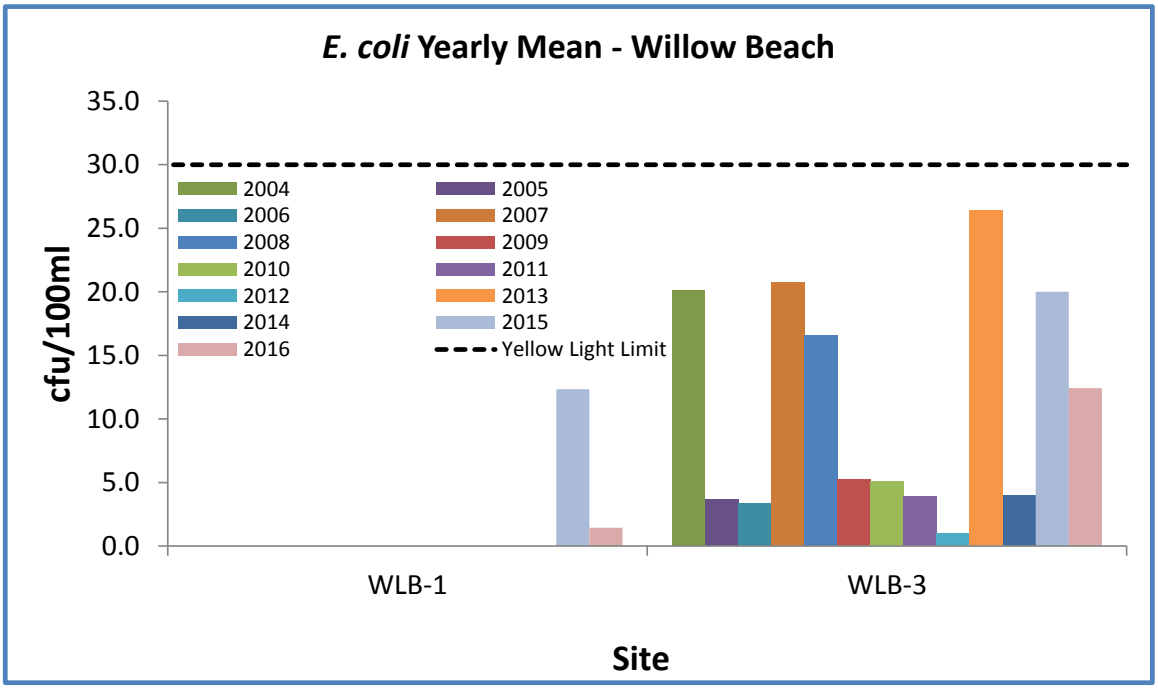
Volunteer Recognition: **Louise Cragg,** Chris Cragg, Rick Durst and Meredith Coates.

Willow Beach (WLB)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)	DOC Yearly Mean
		Spring Turnover	Yearly Mean			
WLB-0	2.55	7.4	7.3			
WLB-1		7.8	8.1	1.4	27.2	
WLB-3		7.2	9.5	12.4	183.5	5.0
WLB-4		8.3	8.0			





Summary and Recommendations:

Phosphorus concentrations at the deep-water station remain consistent throughout the sampling years. Using Grubb's Test for outliers, the spring 2006 phosphorus sample was identified as an outlier and remains out of the dataset in 2016. Sampling at WLB-4 was restarted for phosphorus. DOC at WLB-3 was sampled for in 2013, the second half of 2014, the last 3 of 4 sampling dates in 2015 and all 4 events in 2016. Results are discussed in Section 3.3. The *E. coli* levels at WLB-1 and WLB-3 remain below the MLA stoplight limits (details in report Section 3). **Beacon recommends that sampling continue to monitor long-term trends.**

Area Description:

Arthurlie Bay is in the southern basin of Lake Rosseau. The bay is quite shallow in the southern end. Development intensity is considered moderate to high, with some shoreline properties having extensive cleared areas. This bay has several lacustrine wetlands, some of which appear to be partially filled. One creek drains into the bay, flowing through agricultural land prior to entering the lake. Monitoring started in 2002.

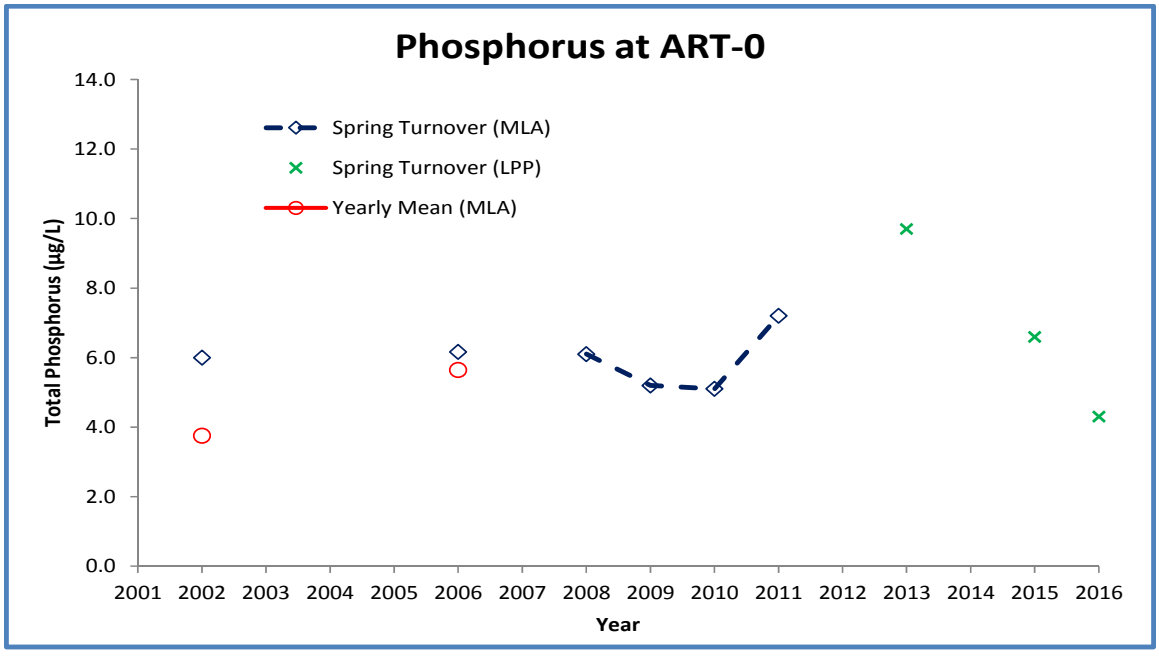
Volunteer Recognition: **Katherine Seybold,** Jayne Schipper and Andrew Schipper

Arthurlie Bay (ART)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
ART-0	3.85	4.3*			

*Data from Lake Partners Program (MOECC)



Summary and Recommendations:

Phosphorus results remain generally low with the lowest spring phosphorus measured in 2016. Beacon recommends that the MLA rely on the Lake Partner Program data when it is available, otherwise because of the increasing development pressure in the bay, the MLA should continue to monitor this location to analyse long-term trends.

Area Description:

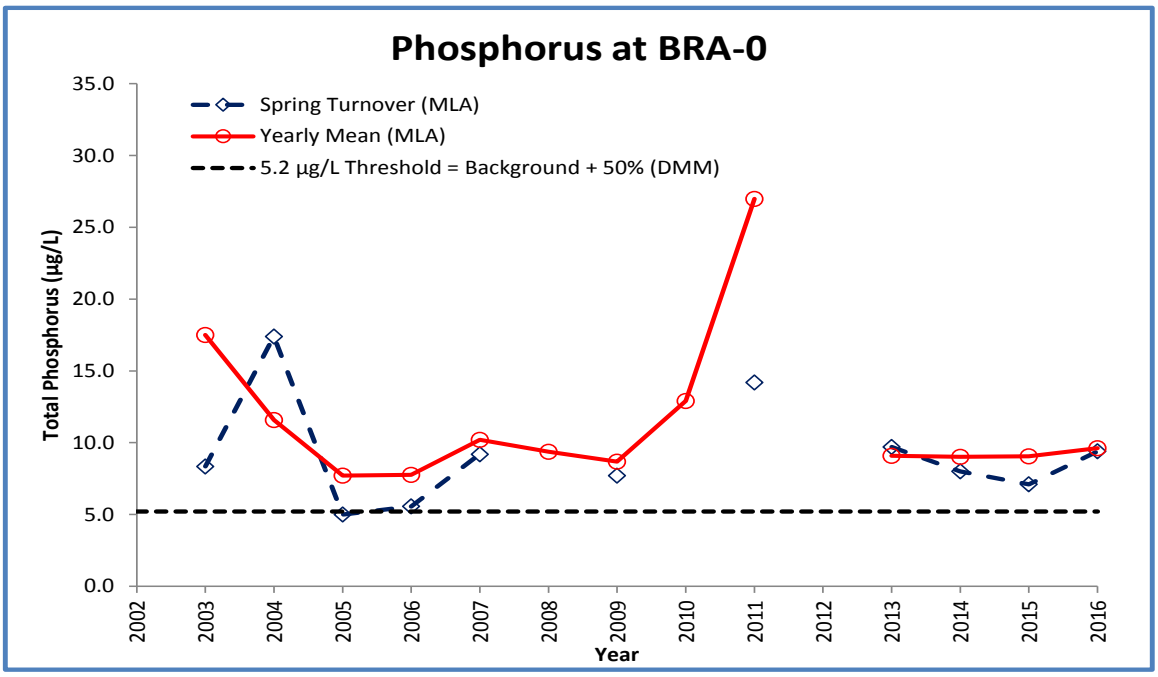
Brackenrig Bay is located in southern Lake Rosseau, is approximately 0.44 km² in area and has a maximum depth of 3 m. This isolated bay is moderately developed with residential properties. Approximately 20% of the immediate shoreline has been altered with over 60% of backlot areas cleared of natural forest. Four creeks drain into the bay, one of which flows through an agricultural area adjacent to a garden center before entering the lake. Brackenrig road comes in close proximity to the lake along the northeast shoreline. Brackenrig Bay has been classified as moderately sensitive and over-threshold by the DMM. Monitoring started in 2003.

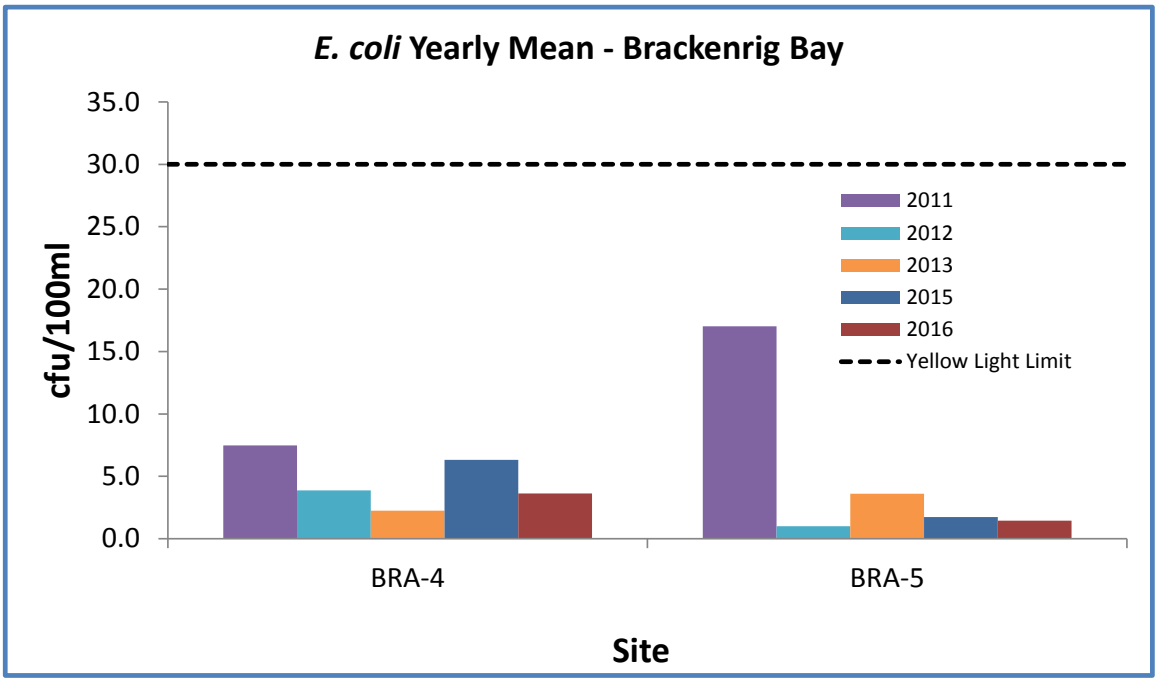
Volunteer Recognition: **Judy Stephens-Wells**, Ross Wells and Val Fleck.

Brackenrig Bay (BRA)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)	DOC Yearly Mean
		Spring Turnover	Yearly Mean			
BRA-0	2.06	9.4	9.6			
BRA-3		10.4	10.6			4.1
BRA-4				3.6	92.7	
BRA-5				1.4	77.1	
BRA-6		11.1	10.6			





Summary and Recommendations:

The overall trend of phosphorus levels remains consistent over the sampling years, and the yearly phosphorus mean continues to be above the DMM threshold of 5.2 µg/L each year. A new sampling station (BRA-6) was sampled for phosphorus in 2016. DOC at BRA-3 has been sampled for since 2013 and is discussed in Section 3.3. The *E. coli* concentrations at the two stations remain consistent with previous sampling and were below the MLA stoplight limits (details in report Section 3). Beacon recommends sampling continue to monitor long-term trends.

Area Description:

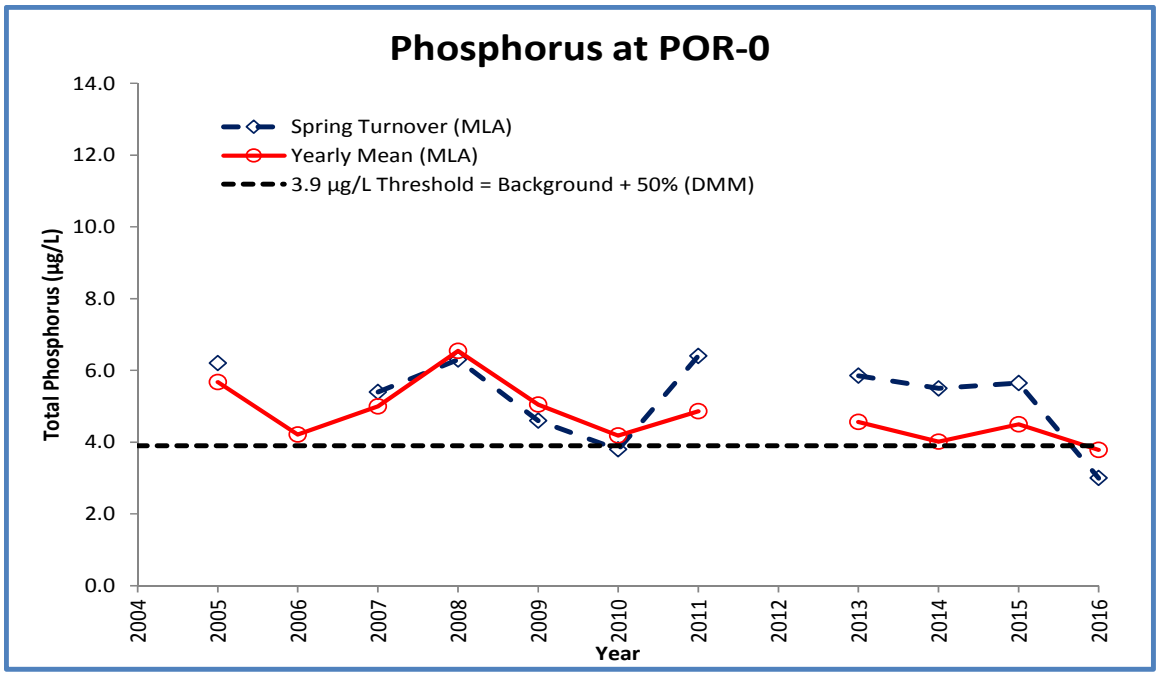
East Portage Bay is located in eastern Lake Rosseau, has an area of approximately 1.33 km², and reaches a maximum depth of 12 m. This moderately developed bay has many roads, with several areas directly adjacent to the shoreline. There is also a large agricultural area adjacent to the northern shoreline of the bay. No creeks outlet into the bay and there are no wetlands draining from the upper watershed. East Portage Bay has been classified as highly sensitive and over threshold by the DMM. Monitoring started in 2005.

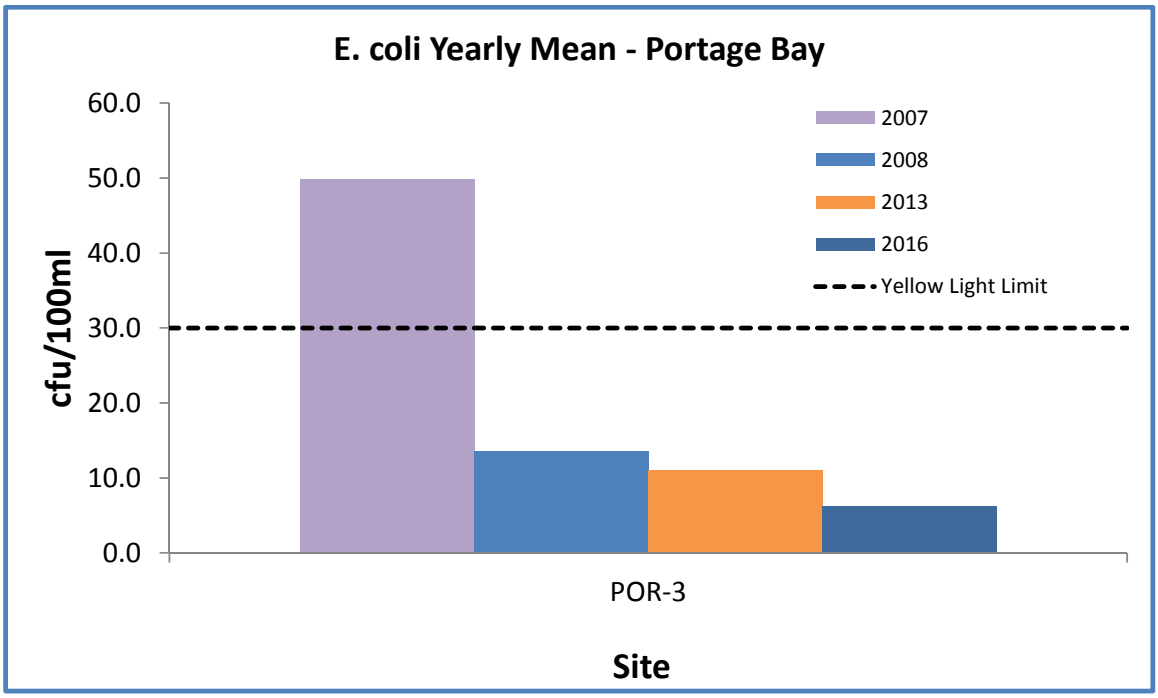
Volunteer Recognition: **Marje Henke,** Joan McKinnon, Kait Mansfield, Catherine LeBoeuf, Andy Henke and Patrick Shriner.

East Portage Bay (POR)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
POR-0	5.10	3.0	3.8		
POR-3		3.8	4.2	6.2	86.2
POR-5		3.3	3.9		





Summary and Recommendations:

Spring phosphorus concentration at the deep station was below the DMM threshold of 3.9 µg/L in 2016. Spring phosphorus concentrations at nearshore stations decreased at POR-3 and POR-5 in 2016. Phosphorus yearly mean concentrations were down slightly at the nearshore stations. *E.coli* sampling resumed in 2016 and values were below the MLA stoplight limits (details in report **Section 3**). Sampling at POR-4 was discontinued in 2016. **Beacon recommends sampling continue to monitor long-term trends.**

Area Description:

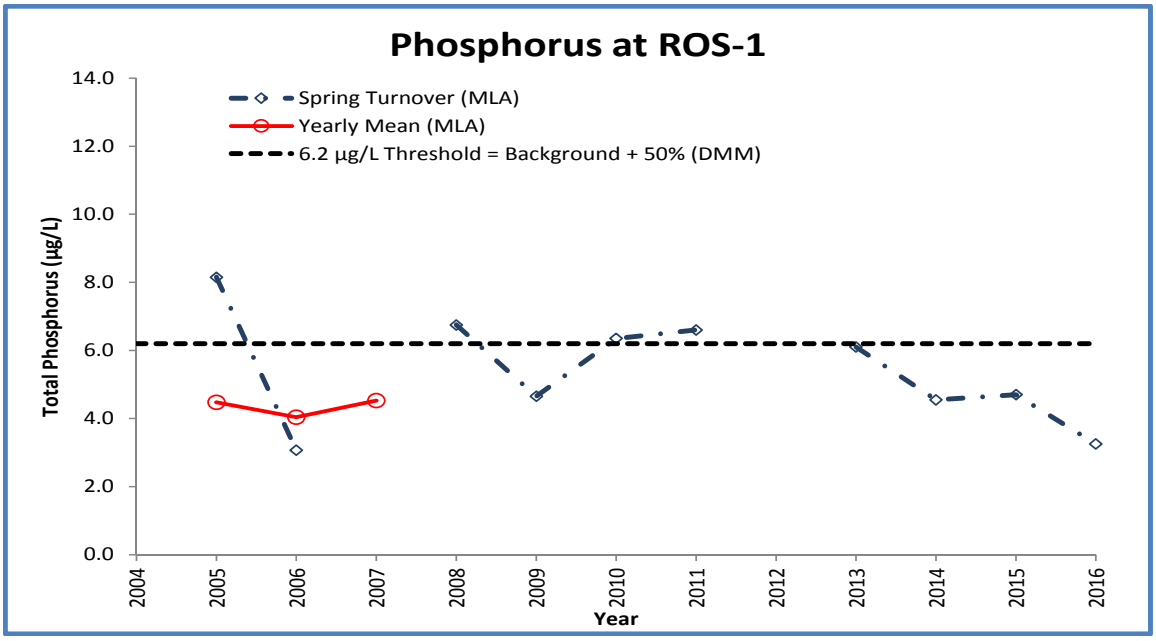
The main basin of Lake Rosseau is approximately 55.5 km² in area with a maximum depth of 60 m. The lake is classified as a coldwater lake, and supports a naturally reproducing population of Lake Trout. Wetlands account for 5% of the upper watershed. The Lake Rosseau watershed, excluding the lake itself is 204.5 km². The DMM has classified the lake as moderately sensitive. Monitoring started in 2005.

Volunteer Recognition: **Katherine Seybold,** Jayne Schipper**,** and Andrew Schipper.

Lake Rosseau (ROS)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
ROS-1	3.70	3.3			



Summary and Recommendations:

Spring phosphorus concentrations in 2016 remained lower than the DMM threshold and concentrations continue to show a decreasing trend. Only spring phosphorus samples were acquired again in 2016. Beacon recommends that spring sampling continue to monitor long-term trends.

Area Description:

The village of Minett is located in western Lake Rosseau, and has four sampling sites. Sampling sites were selected with the intention of monitoring the potential effects of high intensity development in this bay. The area contains two large resorts with golf courses, several roads, a marina, and many private residential properties. There is one wetland adjacent to the lake and several other small ones in the area of the bay. Monitoring started with the original program in 2003.

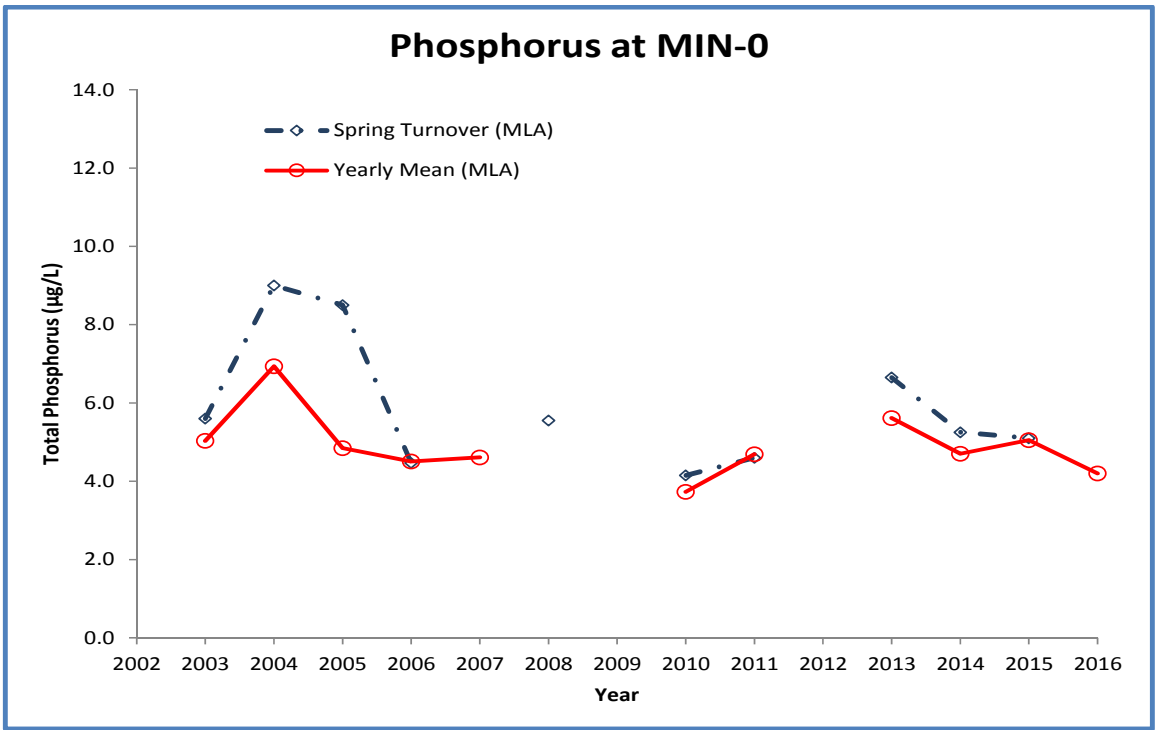
Volunteer Recognition: **Laurie Thomson**, **Greg Thomson** and Taylor Thomson.

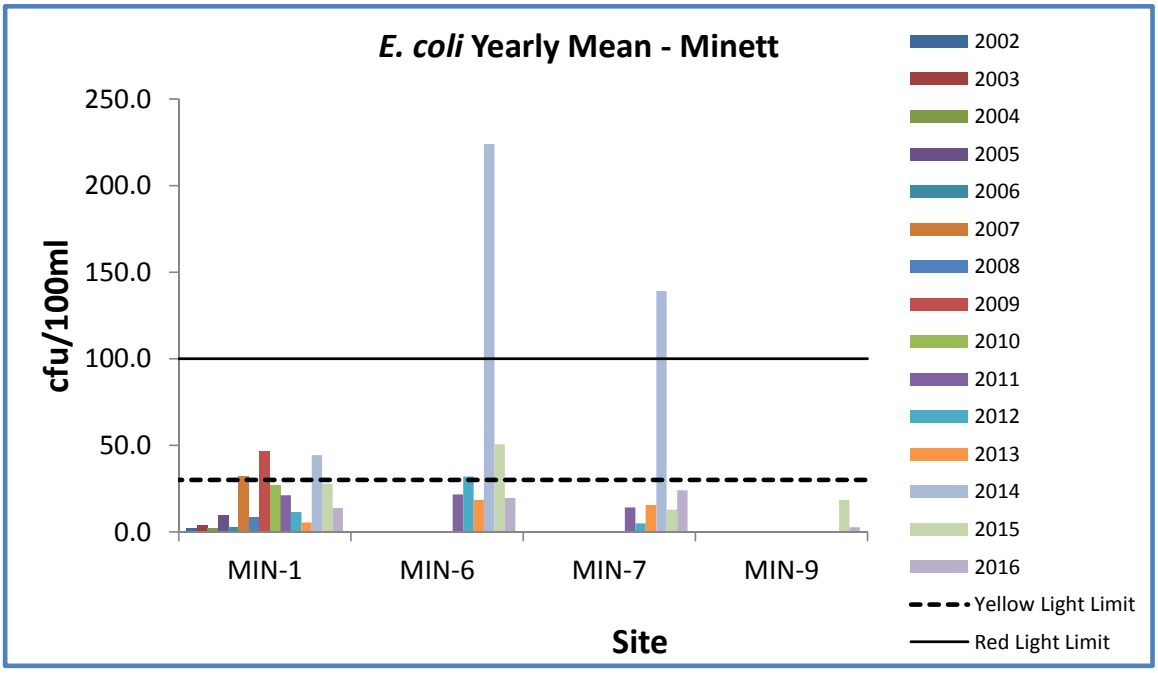
Minett (MIN)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)	DOC Yearly Mean
		Spring Turnover	Yearly Mean			
MIN-0	4.67	15.7*	4.2			
MIN-1		5.5	5.6	13.8	52.5	
MIN-6		8.4	9.9	19.6	76.6	4.4
MIN-7		4.5	5.1	24.1	134.1	
MIN-9		6.3	5.2	2.8	26.6	

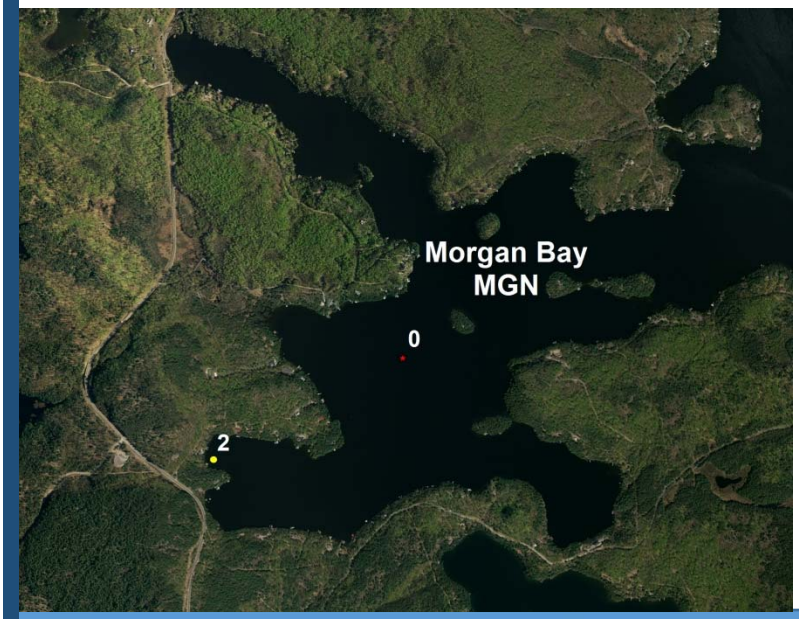
*outlier according to Grubbs Test





Summary and Recommendations:

Phosphorus concentrations continue to remain consistent through the sampling years at the central deep station. Spring phosphorus concentrations as well as yearly mean phosphorus concentrations at each of the nearshore stations in 2016 were all lower than those recorded in 2015, with the exception of the spring turnover at MIN-9. Using Grubb's Test for outliers, the spring 2016 phosphorus sample at MIN-0 was identified as an outlier and was removed from the graph and yearly average for 2016. DOC at MIN-6 was sampled for in 2014, 2015 and 2016 and is discussed in Section 3.3. The yearly mean *E.coli* results at stations MIN-1, MIN-6 and MIN-7 were all below the MLA stoplight limits (details in report Section 3). Re-tests for *E. coli* were required at MIN-1, MIN-6, MIN-7 and MIN-9. **Beacon recommends that the 2017 sampling program continue to monitor long-term trends.**



Area Description:

Morgan Bay is in the northernmost part of Lake Rosseau, and a series of small bays make up this large sampling area. Several creeks outlet into this bay close to the nearshore sampling sites and there is a wetland adjacent to the lake at MGN-3. Most of the shoreline area is developed with residential properties, but many retain natural riparian vegetation. Nearly the entire area has road access and several of these roadways come very close to the water. Monitoring started in 2008.

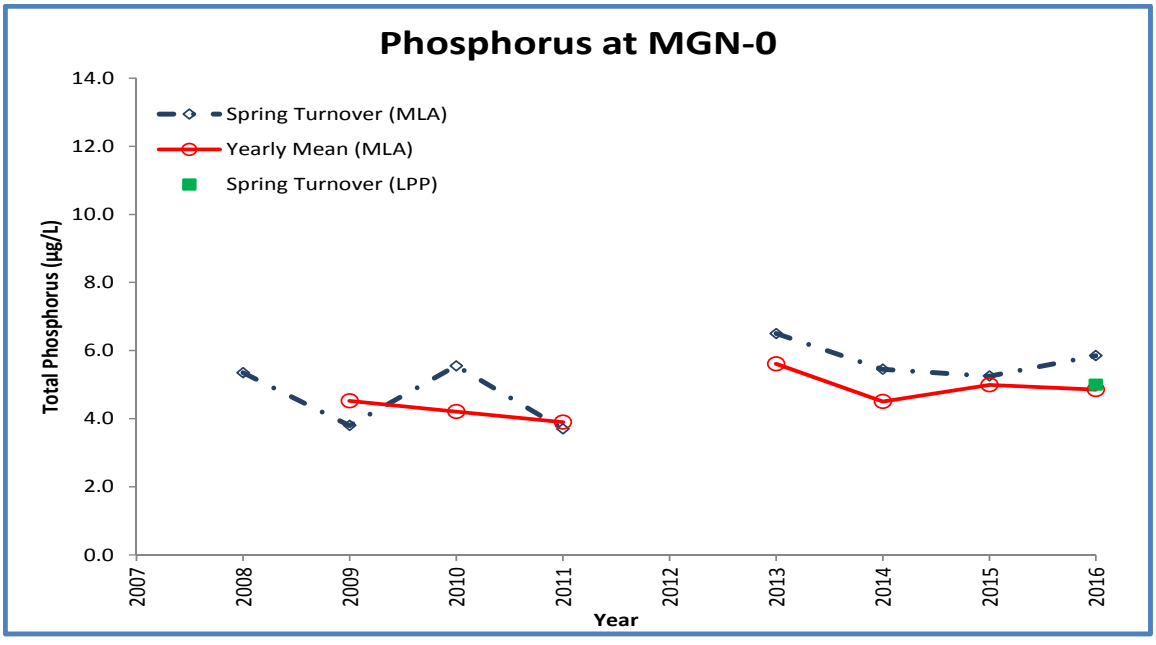
Volunteer Recognition: **David Peacock** and Mary Anne Peacock.

Morgan Bay (MGN)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

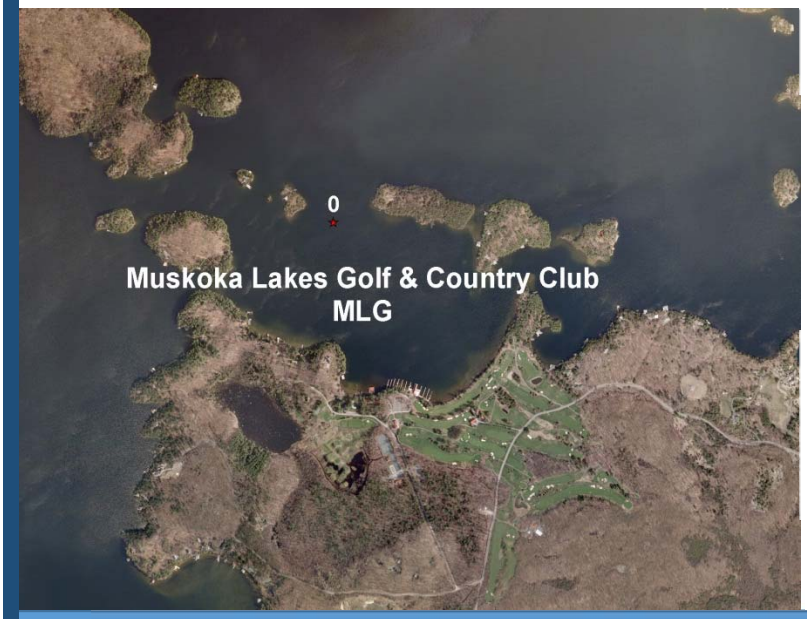
Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
MGN-0	4.00	5.0*	4.9		
MGN-2		5.9	4.5		

*Data from Lake Partners Program (MOECC)



Summary and Recommendations:

All phosphorus results remain consistent over the sampling years. **Beacon recommends that the MLA rely on the Lake Partner Program data when it is available, sampling continue to monitor long-term trends.**



Area Description:

The Muskoka Lakes Golf & Country Club sampling site is located along the southern shore of Lake Rosseau's main basin, near the Town of Port Carling. This bay collects run-off from a golf course area with associated clubhouse and marina. The bay also contains a large wetland that drains into the lake. Dominant northwest winds and a large fetch results in considerable wave action along the southern shoreline of the bay.

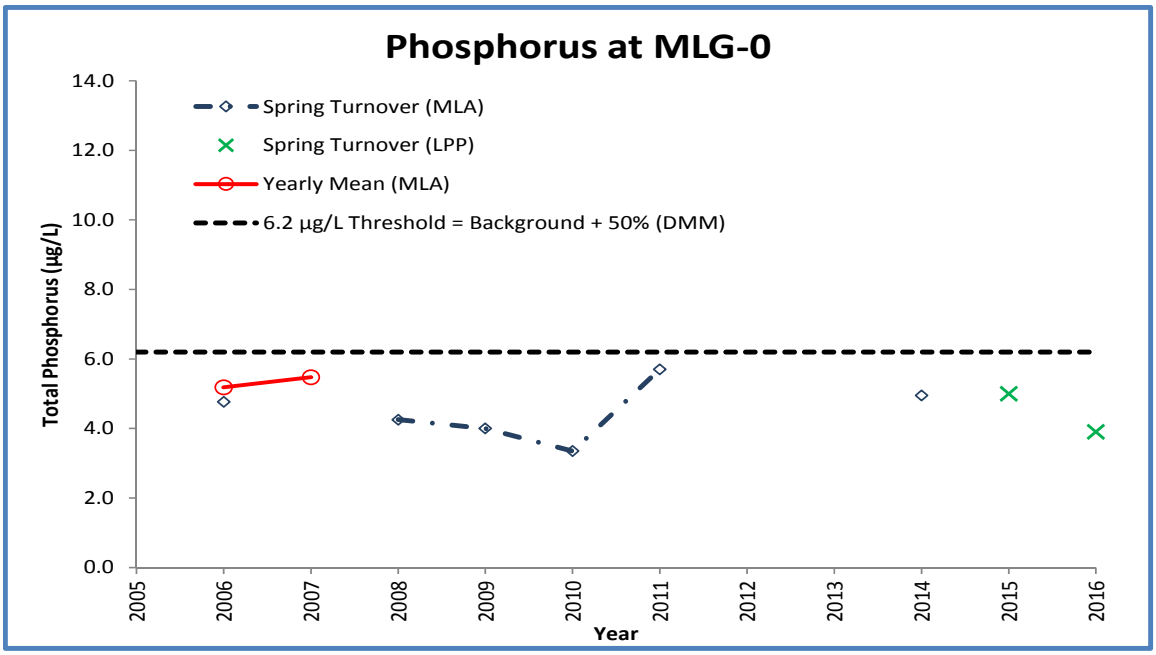
Volunteer Recognition: **Katherine Seybold,** Jayne Schipper, and Andrew Schipper.

Muskoka Lakes Golf (MLG)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
MLG-0*	4.35	3.9*			

*Data from Lake Partners Program (MOECC)



Summary and Recommendations:

Phosphorus concentrations remain consistent across the sampling years and below the DMM threshold. **Beacon recommends that the MLA rely on the Lake Partner Program data when it is available, otherwise the MLA should continue to monitor this location to analyse long-term trends.**

Area Description:

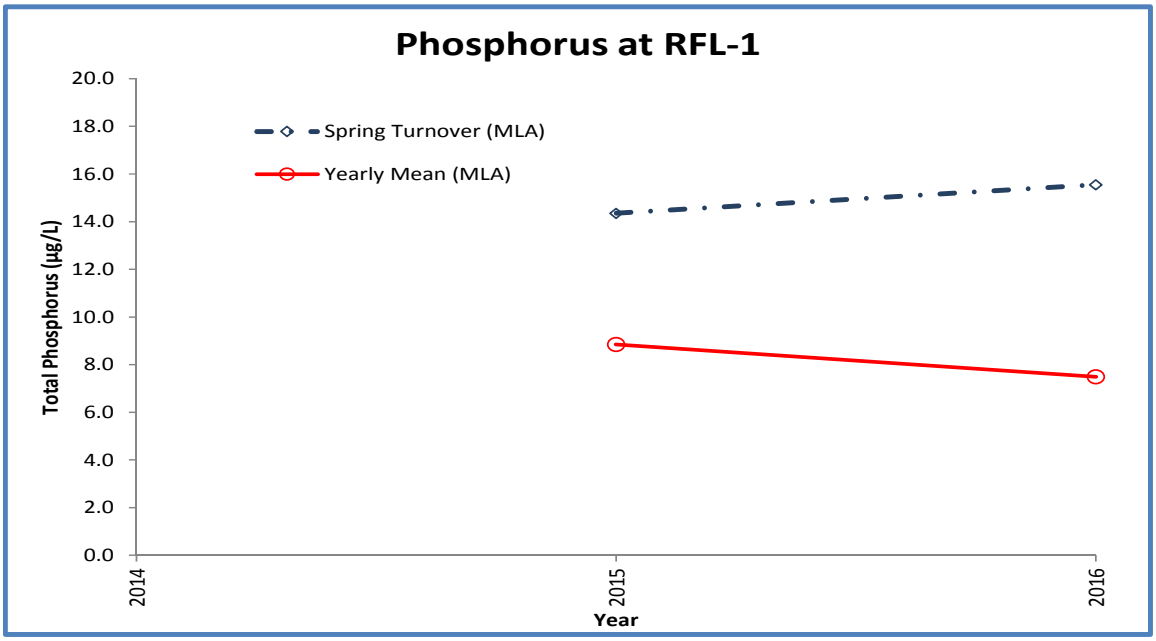
The Rosseau Falls site is located at the point where the Rosseau River enters Rosseau Lake. The Rosseau River Subwatershed flows through the Rosseau River into Lake Rosseau at RFL-1. The Subwatershed is 12,969 hectares in area with 98% identified as natural habitat. Cardwell Lake is the only major water body in the subwatershed and is approximately 2.0 km^2 in size.

Volunteer Recognition: **David Peacock,** Sue Wessenger, John Wessenger and Mary Anne Peacock.

Rosseau Falls (RFL)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
RFL-1		15.6	7.5		



Summary and Recommendations:

This nearshore station was established in 2015. Beacon recommends that sampling continue to monitor long-term trends.

Area Description:

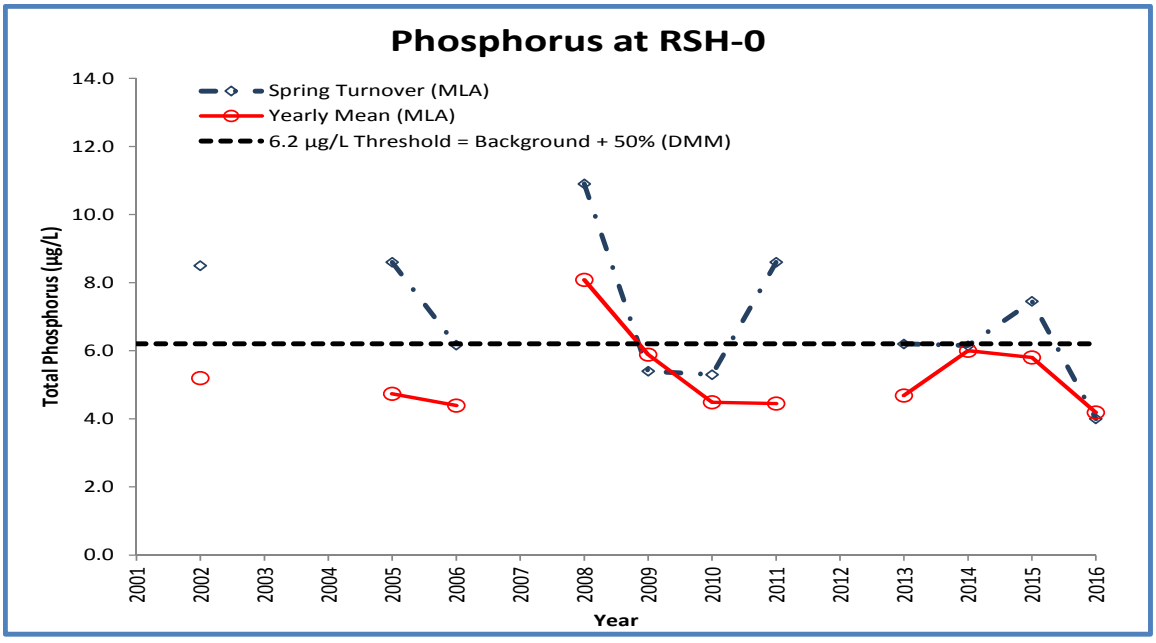
The Rosseau North sampling area is within the limits of the village of Rosseau, at the northern end of Lake Rosseau. Drainage from the village enters the lake at the sampling sites, as well as at the mouth of the Shadow River. Two creeks drain into the bay, one through a lacustrine wetland along the western shoreline and the other near Highway 141 to the east. There is a high level of development not only along the shoreline of the lake and Shadow River, but in much of the watershed area in the form of residential and agricultural properties. Monitoring started in 2002.

Volunteer Recognition: **David Peacock** and Mary Anne Peacock.

Rosseau North (RSH)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
RSH-0	3.80	4.0	4.2		
RSH-2		5.4	4.7		
RSH-4		3.8	4.6		



Summary and Recommendations:

Spring phosphorus and yearly mean phosphorus levels at the deep station were both below the DMM threshold in 2016 and the lowest recorded to date. Spring phosphorus as well as yearly mean phosphorus concentrations at each of the nearshore stations in 2016 were all lower than those recorded in 2015. **Beacon recommends that sampling continue to monitor long-term trends.**

Area Description:

Royal Muskoka Island has one deep-water sampling site located in the central portion of Lake Rosseau. This is a highly developed residential island with many roads and cottages along the shoreline. A large proportion of the interior of the island is cleared or otherwise altered. The eastern shore, opposite RMI-0, is less developed with residences spread out along the shore. Northwest winds and a long fetch would result in significant wave action.

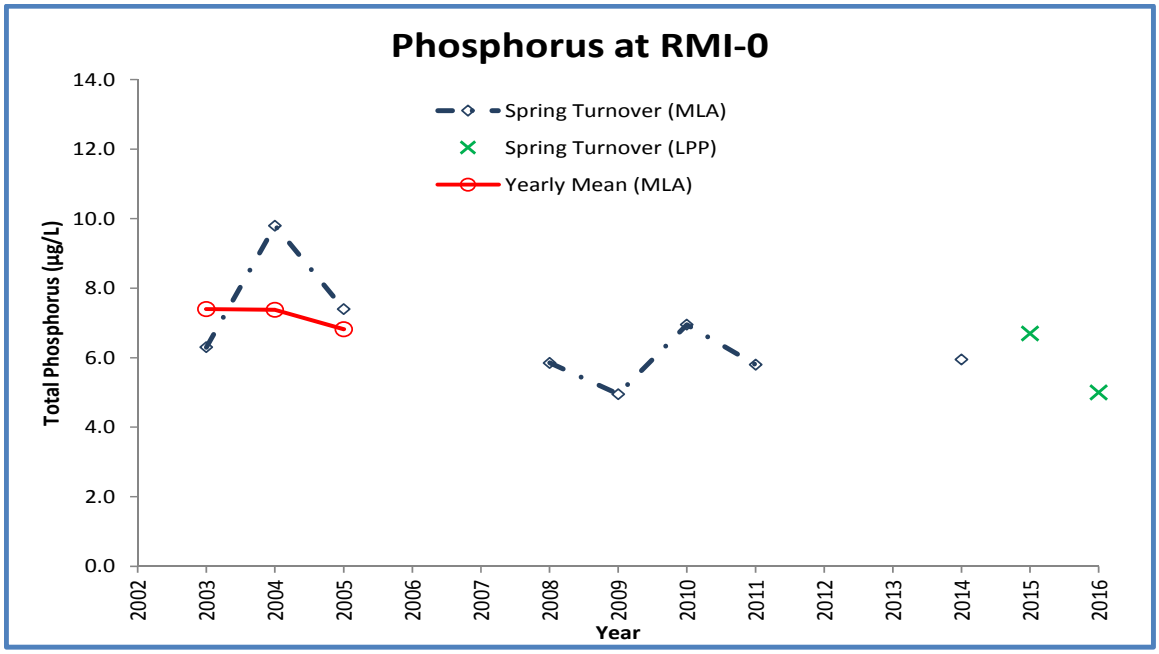
Volunteer Recognition: **Katherine Seybold,** Jayne Schipper and Andrew Schipper.

Royal Muskoka Island (RMI)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

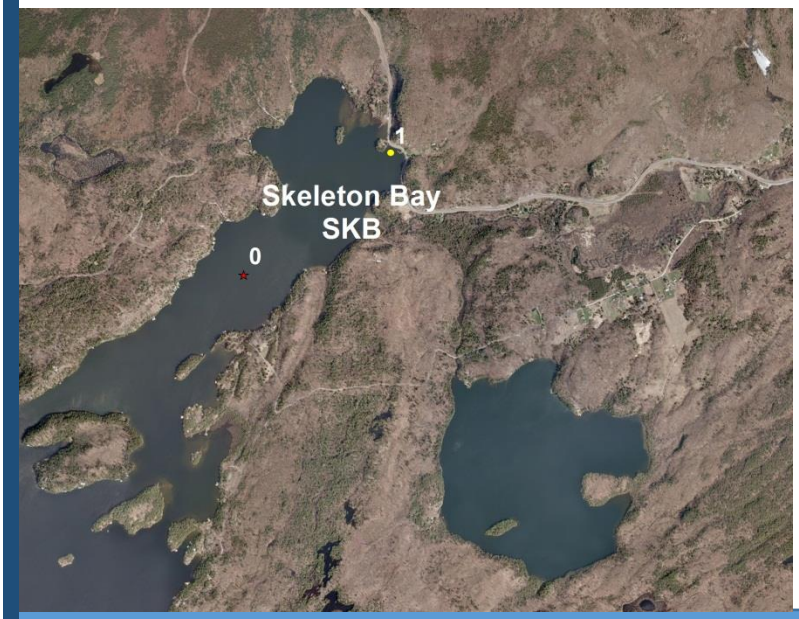
Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
RMI-0	3.45	5.0*			

*Data from Lake Partners Program (MOECC)



Summary and Recommendations:

Phosphorus concentrations remain consistent across the sampling years. **Beacon recommends that the MLA rely on the Lake Partner Program data when it is available, and the MLA should continue to monitor this location to analyse long-term trends.**



Area Description:

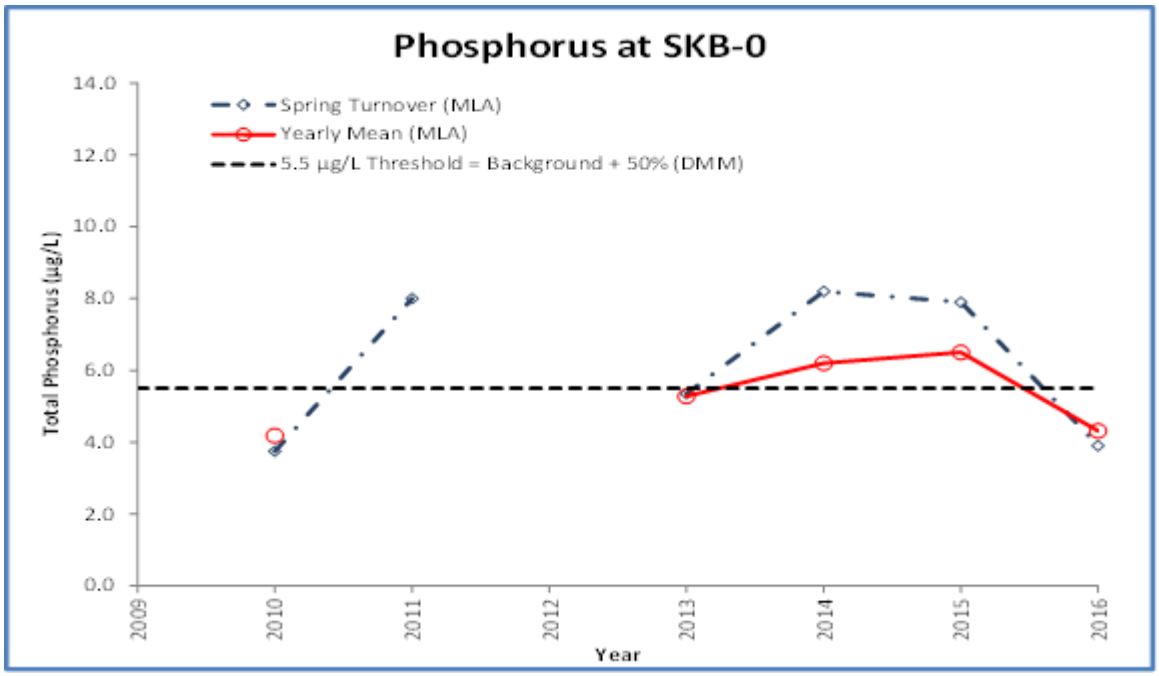
Skeleton Bay is located in the eastern portion of Lake Rosseau's north basin. It is approximately 1.7 km² in size with a maximum depth of 20 m. Highway 141 follows the shoreline in the northeast section of the bay, below a steep, cliffed area. This bay is fed by six watercourses including the Bent River which drains agricultural lands. Skeleton Bay is classified as moderately sensitive by the DMM. Monitoring started in 2010.

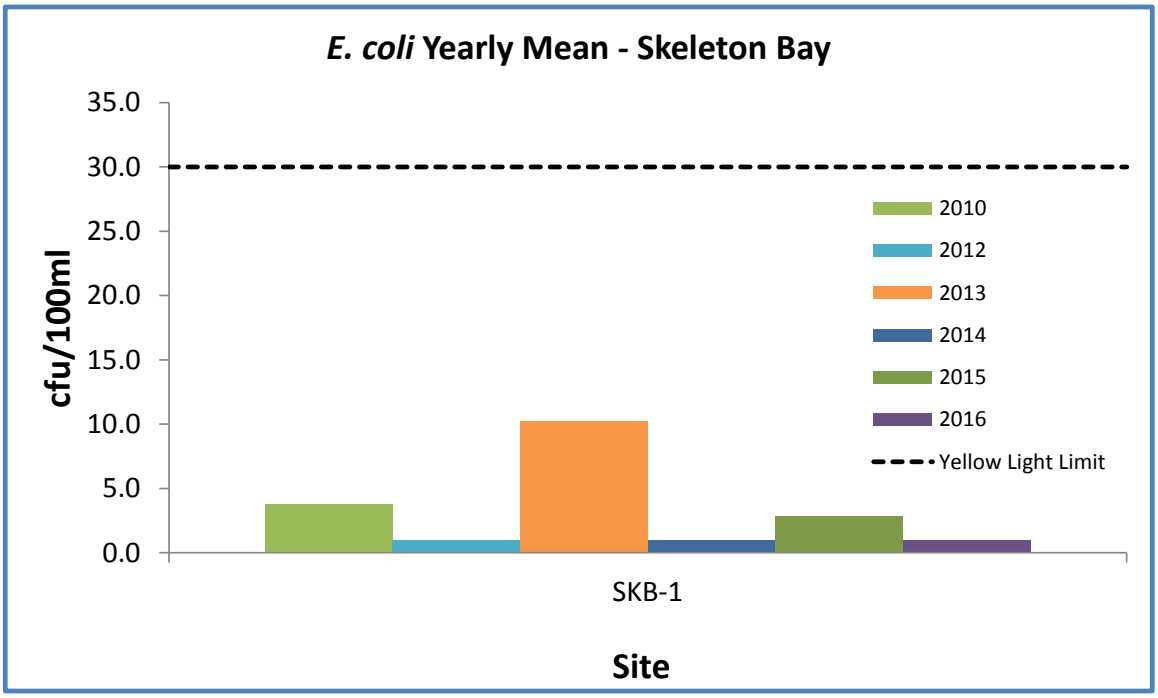
Volunteer Recognition: **Jill Lavine.**

Skeleton Bay (SKB)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
SKB-0	3.78	3.9	4.3		
SKB-1		9.8	6.5	1.0	15.4





Summary and Recommendations:

As indicated in the graph, both spring phosphorus and yearly mean phosphorus concentrations at the deep station in 2016 were below the DMM threshold. Both spring turnover phosphorus and yearly mean phosphorus at SKB-1 were higher than the concentrations recorded in 2015. *E.coli levels* were again minimal in 2016 and well below the MLA stoplight limits (details in report Section 3). **Beacon recommends continuing the monitoring program.**

Area Description:

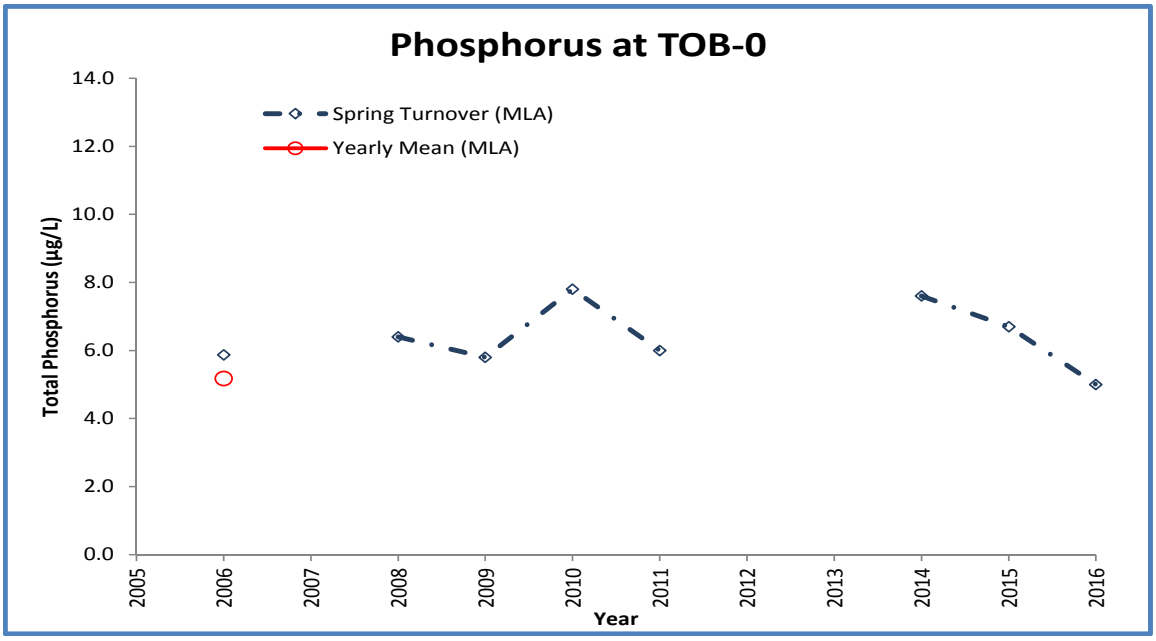
Tobin's Island is an open bay area in the central part of Lake Rosseau. The surrounding area is moderately developed with cottage/residential properties along the shoreline and much of the inland forest area remaining in a natural state. Two creeks from adjacent wetland areas drain into the lake within this sampling area.

Volunteer Recognition: **Katherine Seybold,** Jayne Schipper and Andrew Schipper.

Tobin's Island (TOB)

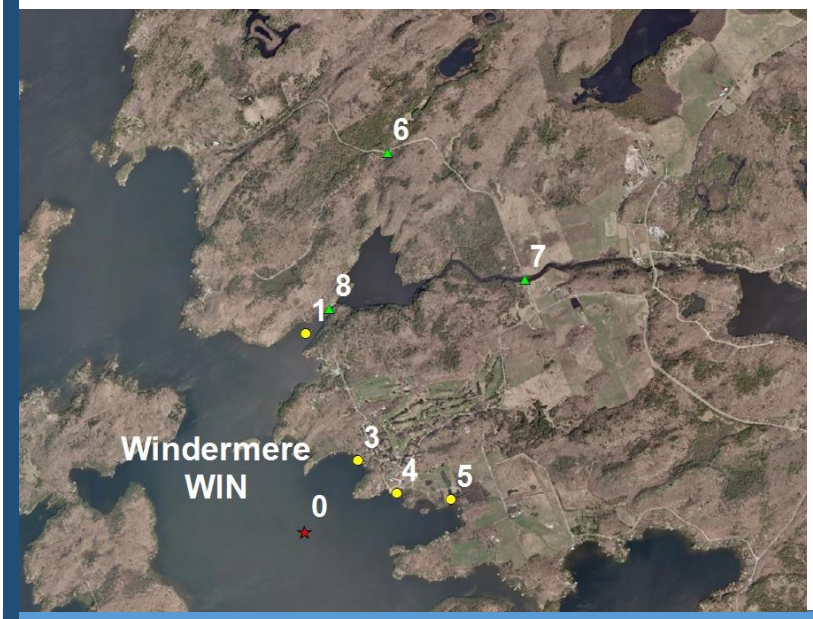
2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (ug/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
TOB-0	3.10	5.0			



Summary and Recommendations:

Phosphorus levels are consistent through the sampling years. **Beacon recommends that sampling continue to monitor long-term trends.**



Area Description:

The Windermere village area in northern Lake Rosseau is a highly developed resort and residential area. There is a large resort complex, golf course, marina, and many residential properties. In addition, there is a significant amount of agricultural land near the sampling area. Several creeks outlet into this area, one of which flows through farms fields and wetlands and enters the lake at the marina. Monitoring started with the original program in 2003.

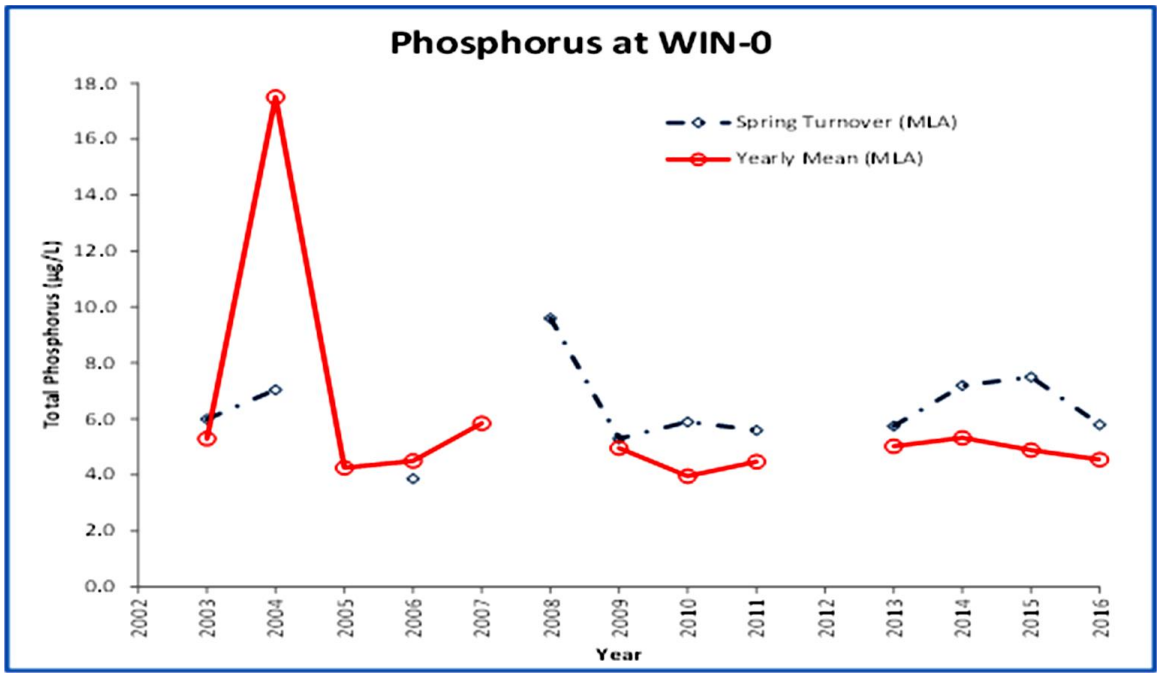
Volunteer Recognition: **Katherine Seybold,** Jayne Schipper and Andrew Schipper.

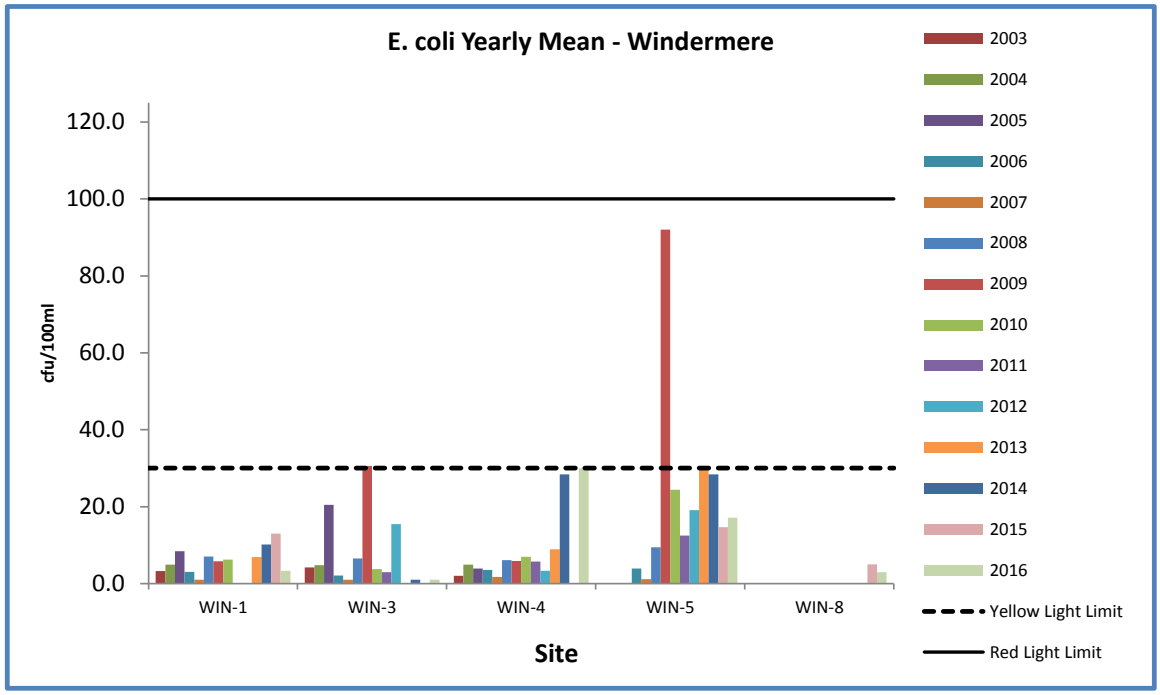
Windermere (WIN)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)	DOC Yearly Mean
		Spring Turnover	Yearly Mean			
WIN-0	4.19	5.8	4.6			
WIN-1		16.5	14.9	3.3	96.7	4.7
WIN-3		4.8	4.6	1.0	41.7	
WIN-4		4.5	4.6	30.0	388.3	
WIN-5		5.7	9.9	17.1	143.5	
WIN-6			27.4*			5.0*
WIN-7		45.5	39.1			5.8
WIN-8		17.2	15.1	3.0*	2425.0*	

*Only 1 sample collected





Summary and Recommendations:

Phosphorus concentrations at the deep station (WIN-0) remain generally consistent through all of the sampling years. Spring turnover phosphorus increased at WIN-1, WIN-7 and WIN-8 and decreased at WIN-4 and WIN-5 from results obtained in 2015. Only one phosphorus sample was obtained at Win-6 in 2016 (2nd sampling date). Although spring phosphorus concentrations at WIN-7 and WIN-8 were higher in 2016, the yearly mean at both stations was lower. DOC was sampled for and is discussed in Section 3.3. *E. coli* counts remain low although reached the MLA Yellow Light Limit (details in report Section 3), at WIN-4. An *E. coli* re-test was required at WIN-4 during the 2nd sampling event. **Beacon recommends that all sampling be continued to monitor long-term trends.**

Area Description:

Bass Lake is a small, shallow, moderately developed lake located immediately southwest of Lake Joseph. It is 0.96 km^2 in area with a maximum depth of 8 m. Hwy 169 separates this lake from Lake Joseph at the north end. Bass Lake drains wetlands located to the south and water flows into Stills Bay via Stills Falls. Bass Lake has been classified as moderately sensitive by the DMM. Monitoring started in 2005.

Volunteer Recognition: **Chris Bodanis**, Chris Turney, John Turney and Bev Turney.

Bass Lake (BAS)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
BAS-2		6.3	6.6		
BAS-3				1.0	21.2
BAS-5	3.20	4.4	5.3		
BAS-6				4.2	34.7
BAS-7		2.6	9.9		

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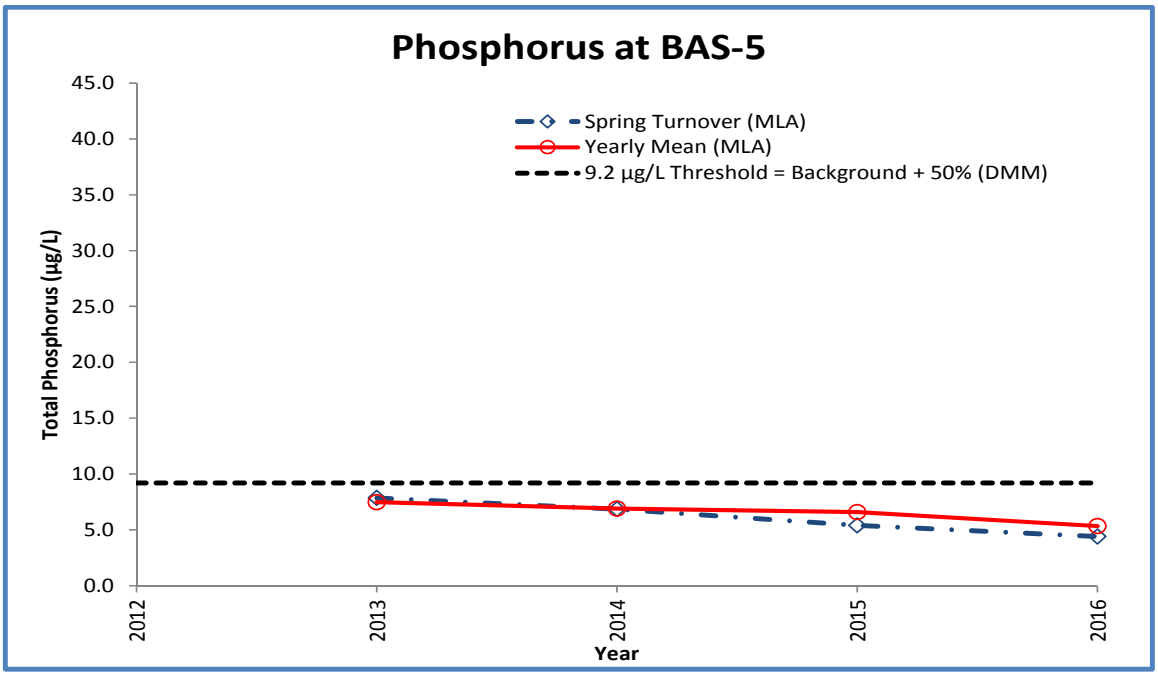
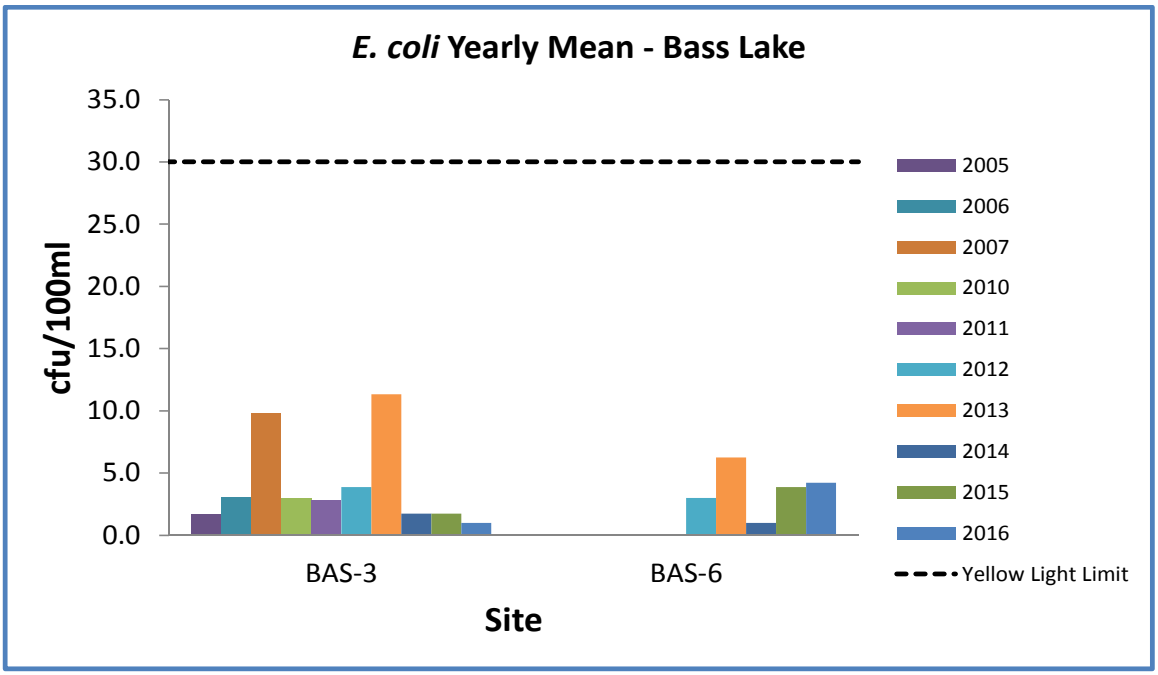




Summary and Recommendations:

Spring turnover phosphorus as well as the yearly mean phosphorus concentrations continue to be below the DMM threshold of 9.2 µg/L. Phosphorus results at BAS-2 in 2016 were similar to those recorded in 2014 and a high phosphorus value recorded at this station in 2015 was not realized in 2016. The 2016 *E.coli* results remain well below the MLA stoplight limits (details in report Section 3). **Beacon recommends all sampling be continued to monitor long-term trends in 2016**.

Area Description:

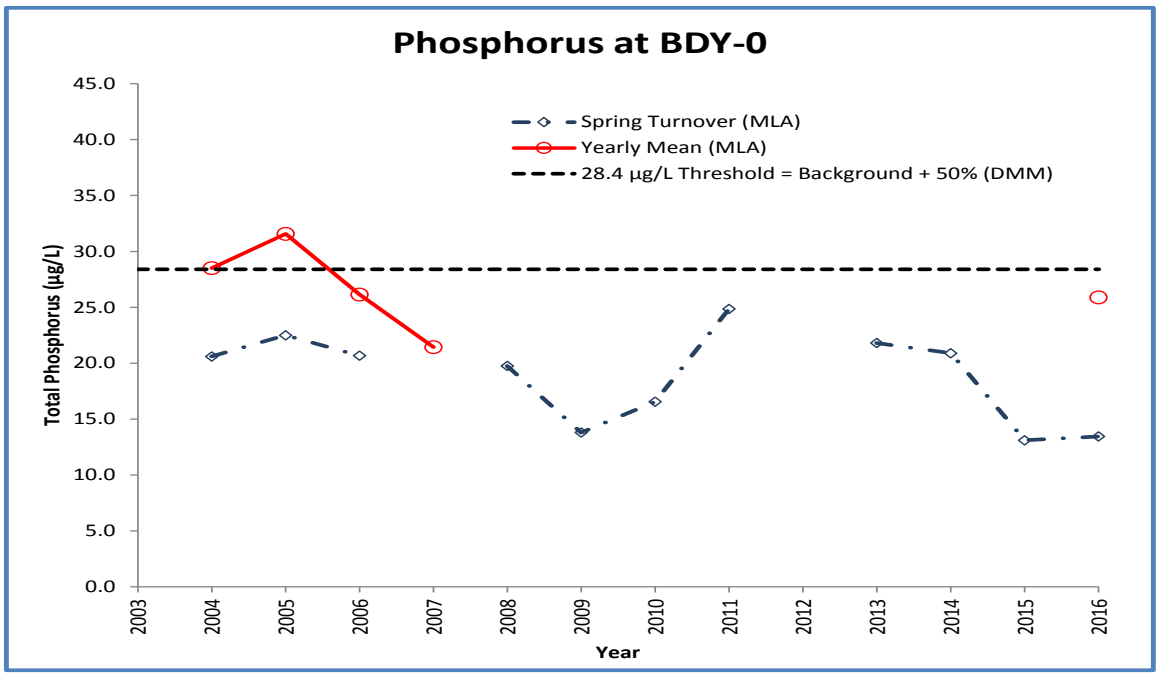
The shoreline of Brandy Lake is moderately developed with many residences and access roads. A large number of the properties maintain a natural shoreline but, there is close to 10% un-buffered lawn. Approximately 40% of the lake shoreline is natural wetland. In the eastern portion of the lake, there is a large wetland with a creek outlet. A second creek is located to the southeast. Brandy Lake is a dystrophic, or "tea-coloured" lake, which is naturally rich in carbon. Monitoring started in 2004.

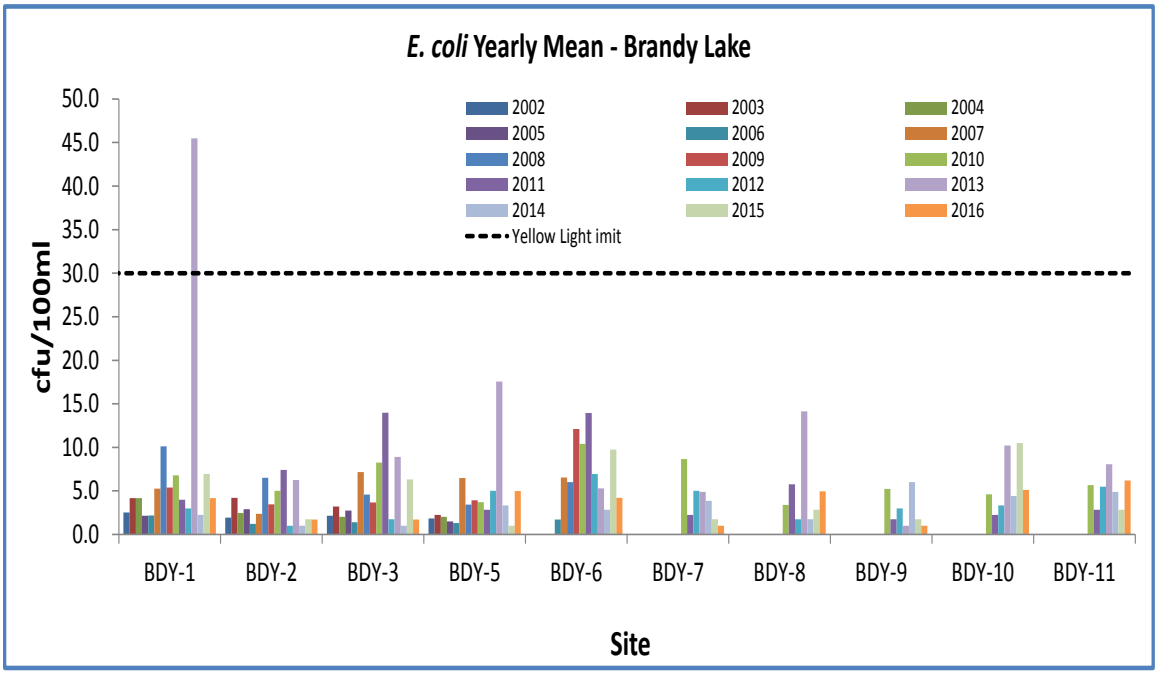
Volunteer Recognition: **Robert Hogg**, Jon de Veth, Peter Sale, and Fred Kelsey.

Brandy Lake (BDY)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

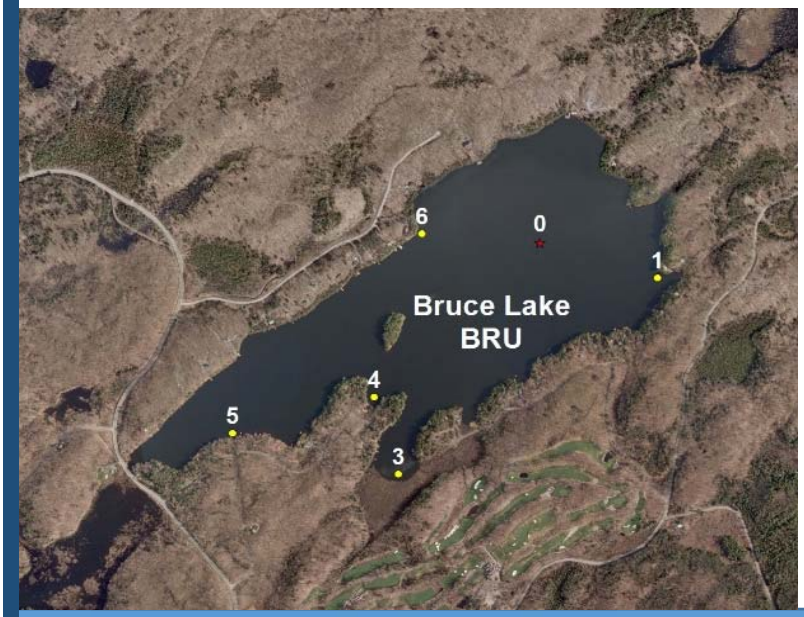
Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
BDY-0	1.21	13.5	25.9		
BDY-1				4.2	19.4
BDY-2				1.7	23.1
BDY-3				1.7	9.2
BDY-5				5.0	14.2
BDY-6				4.2	10.1
BDY-7				1.0	11.1
BDY-8				5.0	28.5
BDY-9				1.0	15.5
BDY-10				5.1	22.2
BDY-11				6.2	43.3





Summary and Recommendations:

Spring phosphorus concentrations remain consistently below the DMM threshold of 28.4 µg/L through all sampling years and the 2015 spring phosphorus concentration (13.1 µg/L) at BDY-0 remains the lowest recorded to date. All of the 2016 *E. coli* yearly means at each of the nearshore stations were below the MLA stoplight limits (details in report Section 3). That said, retests for the bacterial counts were required once each at BDY-5, BDY-8, BDY-10 and BDY-11 in 2016. Retest results were included in the yearly mean values shown above. **Beacon recommends continued sampling to monitor long-term trends.**



Area Description:

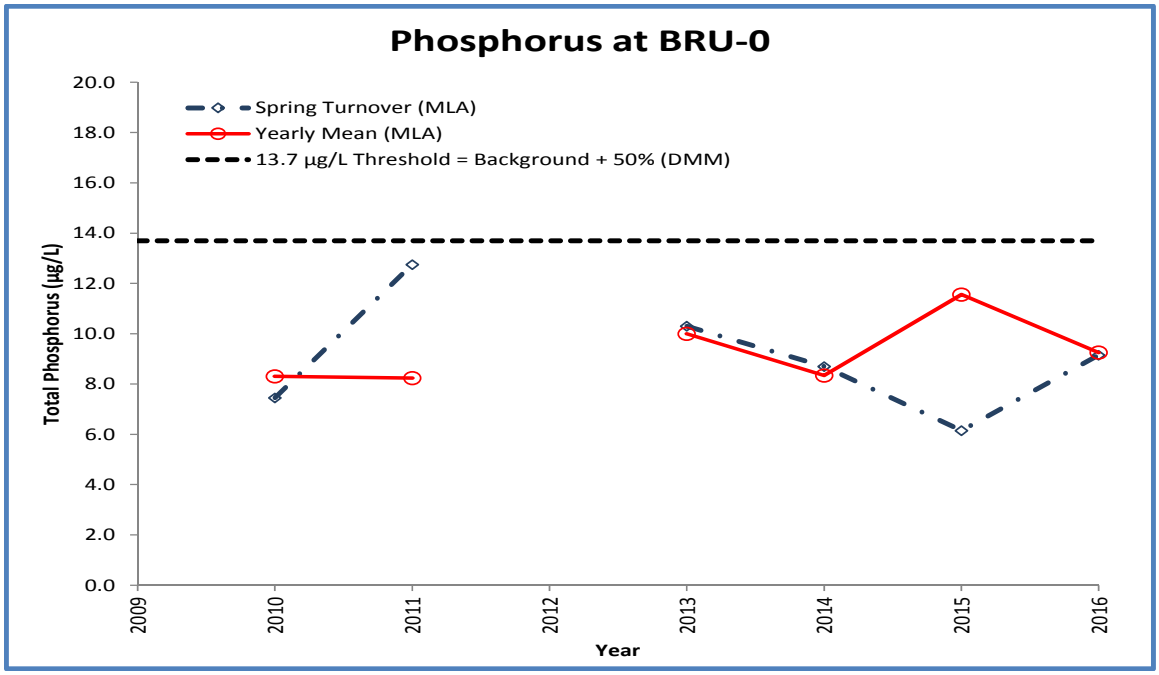
Bruce Lake is located east of Hwy 632, between Lake Joseph and Lake Rosseau. It is relatively small in size at 1.0km^2 and has a maximum depth of 6 m. Approximately 25% of the catchment area for this lake is made up of wetlands. The lake is moderately developed and there is a golf course located immediately to the south. Bruce Lake is classified as moderately sensitive by the DMM. Monitoring started in 2010.

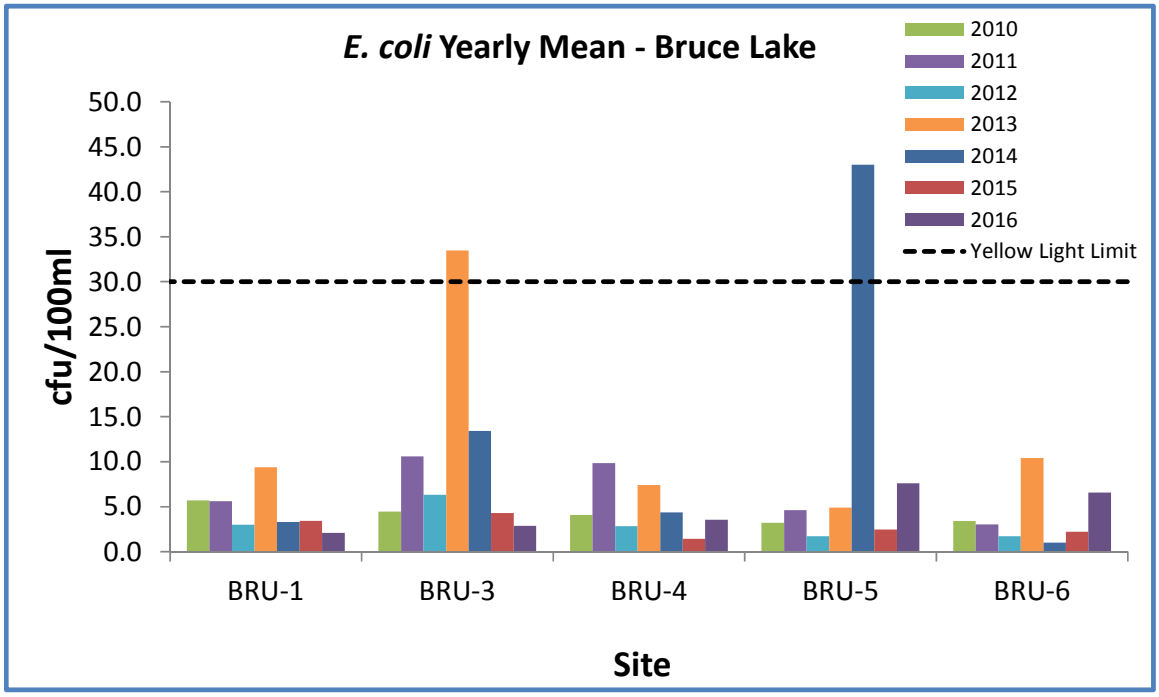
Volunteer Recognition: **Paul Hutchinson**, Richard Eaves, Joanna Eaves and Brian Beatty.

Bruce Lake (BRU)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
BRU-0	3.27	9.2	9.3		
BRU-1		9.5	8.8	2.1	33.1
BRU-3		9.0	13.6	2.9	47.9
BRU-4		8.7	8.3	3.6	33.0
BRU-5		9.8	8.5	7.6	37.5
BRU-6		10.8	9.6	6.6	33.2





Summary and Recommendations:

Phosphorus concentrations remain consistently below the DMM threshold of 13.7 µg/L through all sampling years and the 2015 spring turnover phosphorus concentration (6.2 µg/L) at the deep station remains the lowest recorded to date. All spring turnover phosphorus concentrations at the nearshore stations, except BRU-4, were above the 2015 concentrations. The yearly phosphorus mean results were generally consistent at the nearshore stations in 2016 with the exception of BRU-3 due to high concentrations (28.1 µg/L) at the third sampling date. All of the 2016 *E. coli* yearly means at each of the nearshore stations were well below the MLA stoplight limits (details in report Section 3). **Beacon recommends that sampling continue to monitor long-term trends.**

Area Description:

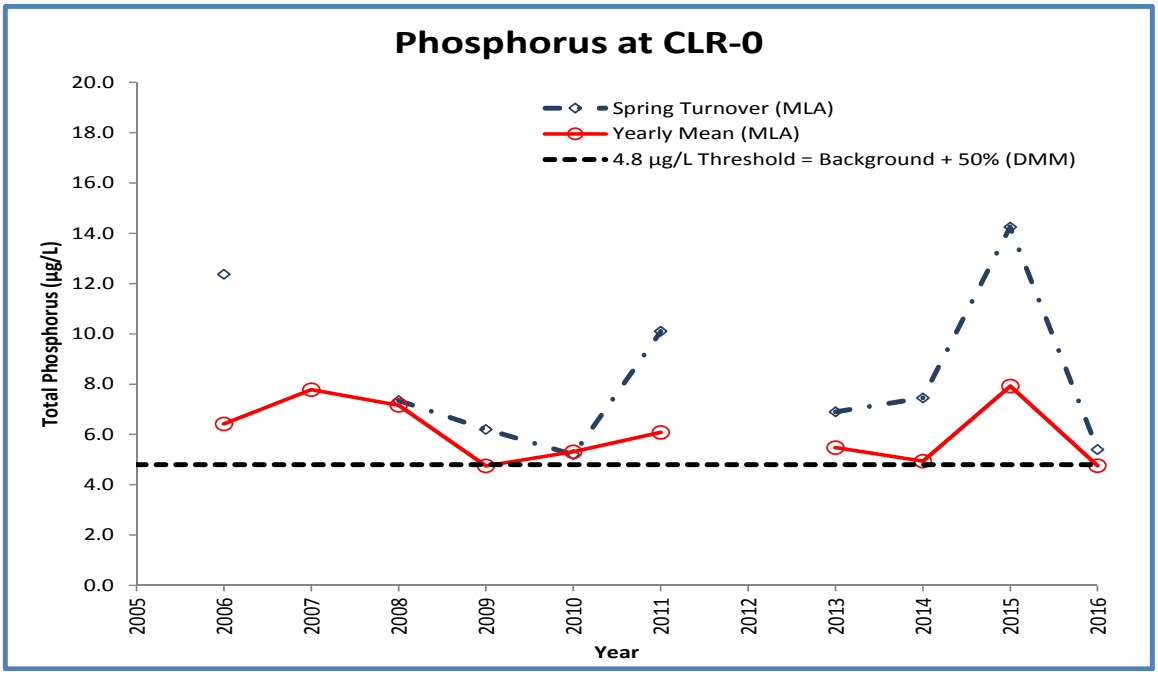
Clear Lake, also called Torrance Lake, is a moderately developed lake with much of the shoreline area converted into residential lots. It is also adjacent to highway 169. This lake is 152 ha in size, has a maximum depth of 16 m and has a very small watershed. There is limited inflow and outflow of water on this lake. Clear Lake has been classified as moderately sensitive and over threshold by the DMM. Monitoring started in 2006.

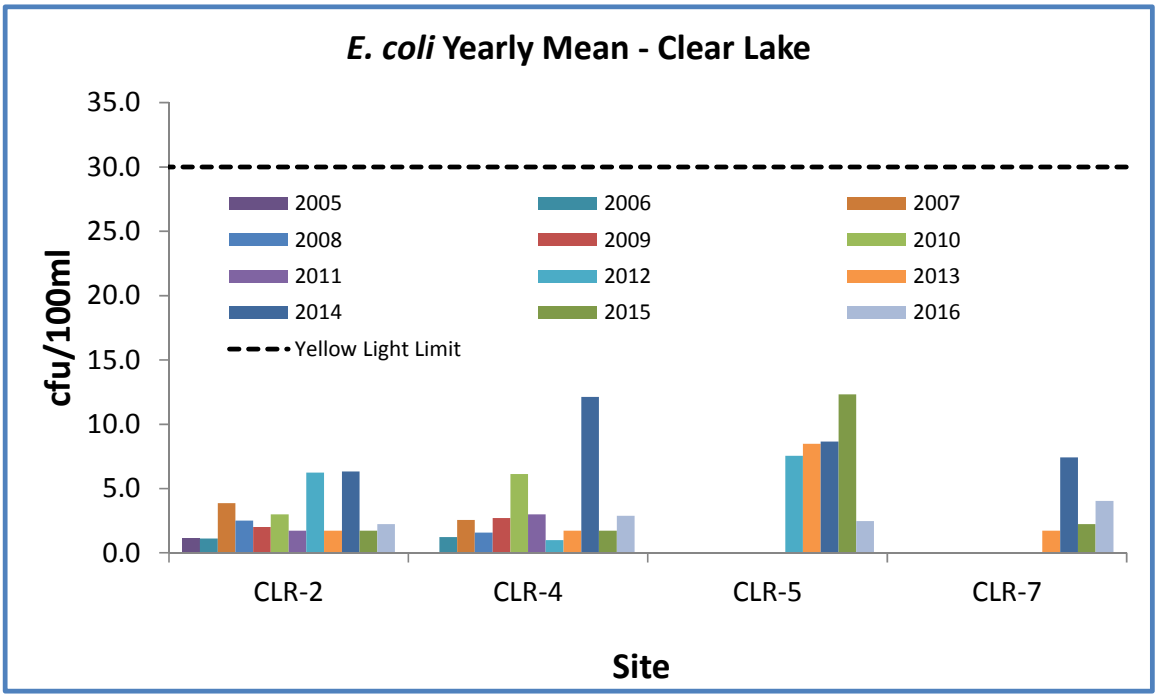
Volunteer Recognition: **Bob and Sharon Cleverdon**

Clear Lake (CLR)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
CLR-0	5.99	5.4	4.8		
CLR-2		5.9	5.6	2.2	42.2
CLR-4		6.1	4.8	2.9	56.6
CLR-5		5.4	5.6	2.5	77.7
CLR-7				4.0	35.6





Summary and Recommendations:

Phosphorus concentrations at the deep station (CLR-0) remain consistently at or above the DMM threshold of 4.8 µg/L each year and the spring turnover phosphorus concentration in 2016 was well below the highest recorded to date (14.3 µg/L) in 2015. The *E.coli* levels at all four nearshore sites sampled in 2016 were well below the MLA stoplight limits (details in report Section 3). The *E. coli* yearly mean concentration at CLR-5 (2.5 cfu/100ml) is the lowest recorded value to date at that station. **Beacon recommends that sampling continue to monitor long-term trends.**

Area Description:

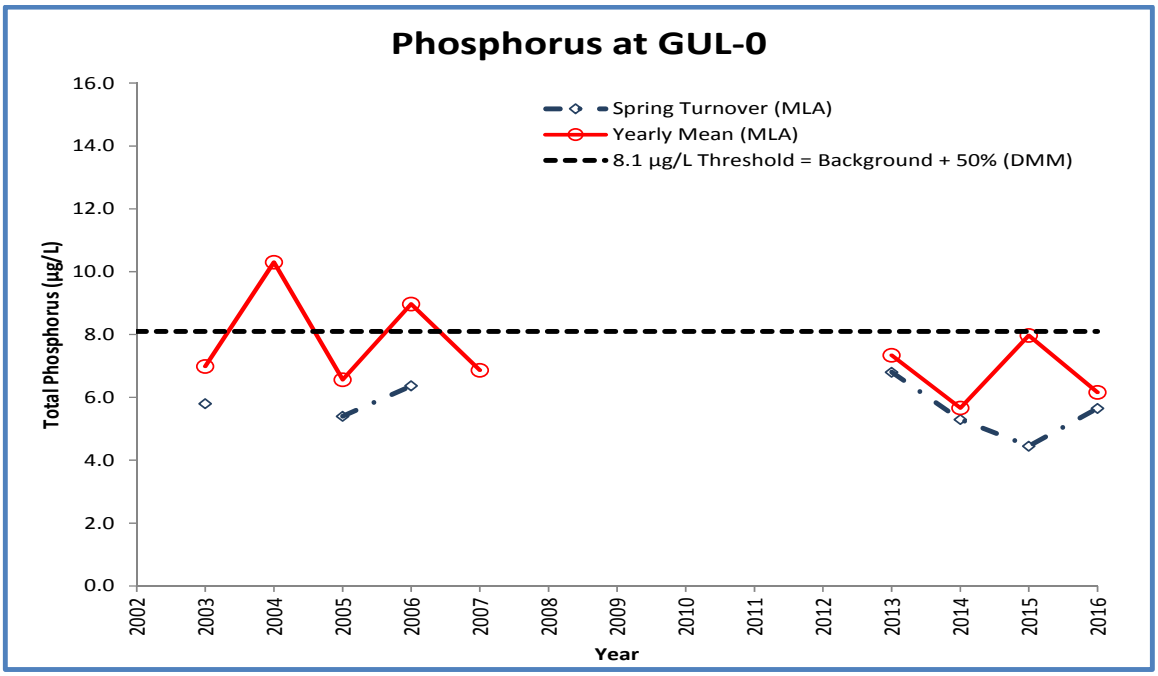
Gull Lake is located in the Town of Gravenhurst. Highway 11 crosses Gull Lake at its midpoint. The lake is approximately 1.35 km² in area, with a maximum depth of 7 m. Gull Lake is fed directly from Silver Lake at its south end with an additional nine creeks outletting into the lake. The Gull Lake watershed is approximately 3.6 km² in size. Gull Lake is classified as moderately sensitive by the DMM. Monitoring started with the original program in 2003.

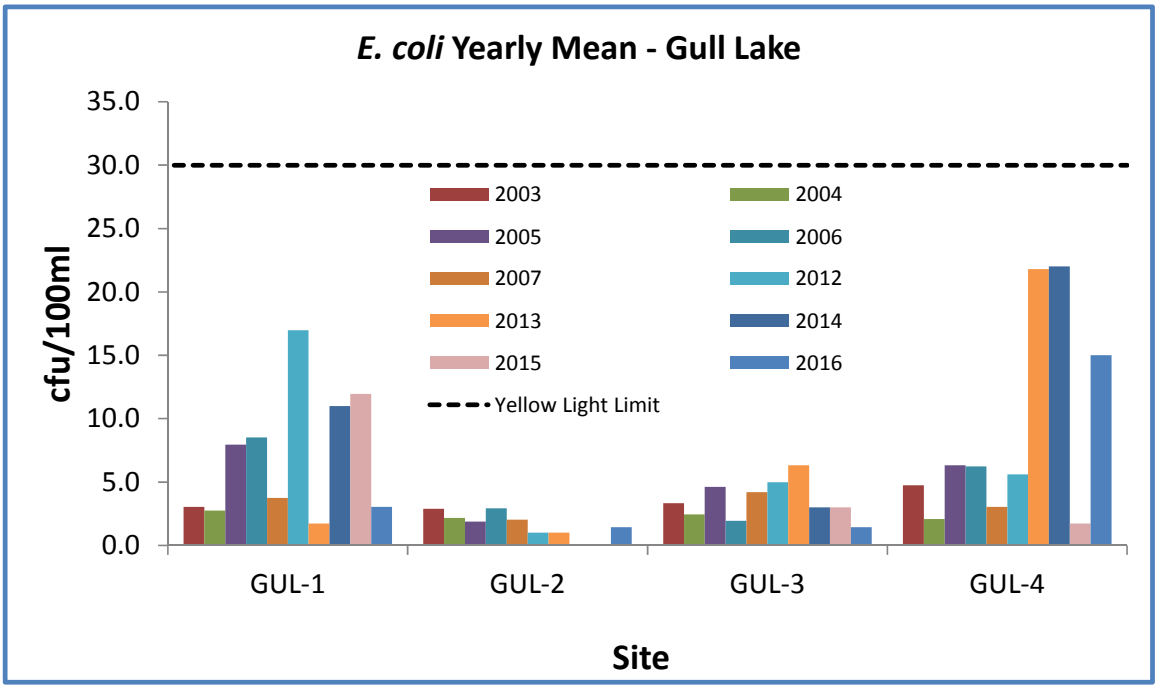
Volunteer Recognition: Gregory Bertrand, Roger Bertrand, and Alexander Bertrand.

Gull Lake (GUL)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
GUL-0	3.92	5.7	6.2		
GUL-1				3.0	43.8
GUL-2				1.4	348.7
GUL-3				1.4	66.6
GUL-4				15.0	271.8





Summary and Recommendations:

The spring turnover and yearly phosphorus means at the deep station (GUL-0) are generally consistent and remain below or at the DMM threshold of 8.1 µg/L in 2016. Using Grubb's Test for outliers, the spring 2004 phosphorus sample at GUL-0 was identified as an outlier and remains out of the dataset in 2016. GUL-2 was restarted in 2016. *E. coli* counts were below the MLA stoplight limits (details in report Section 3) at all four nearshore sites. A retest was required at GUL-4 during the 3rd sampling event and yearly mean *E. coli* concentrations at GUL-4 in 2016 remained similar to those recorded in 2013 and 2014. **Beacon recommends sampling be continued to monitor long-term trends at all sites.**

Area Description:

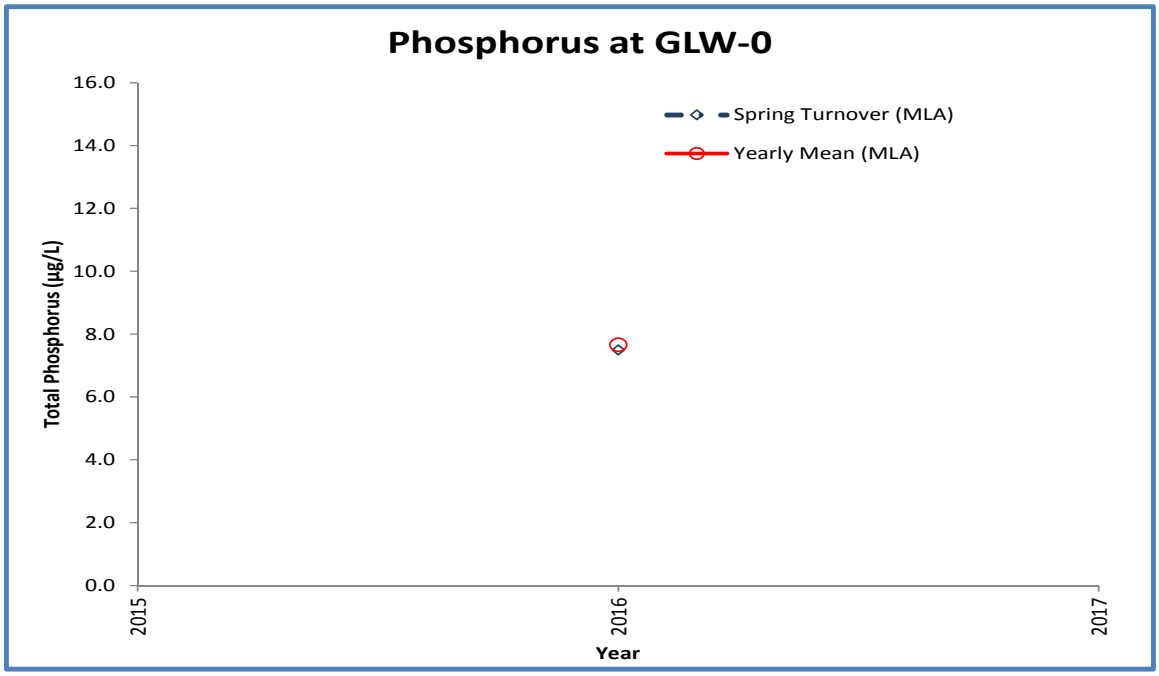
Gullwing Lake is a lake of moderate size (82 hectares) located just south of Torrance. The maximum depth is 9 m and the mean depth is 4m. The watershed for the lake is 5.71 km^2 and is listed as having moderate sensitivity by the District Municipality of Muskoka. Development around the shoreline varies from none on Crown Land (25%) to shoreline residential and a seasonal vacation park located in the most northwestern section.

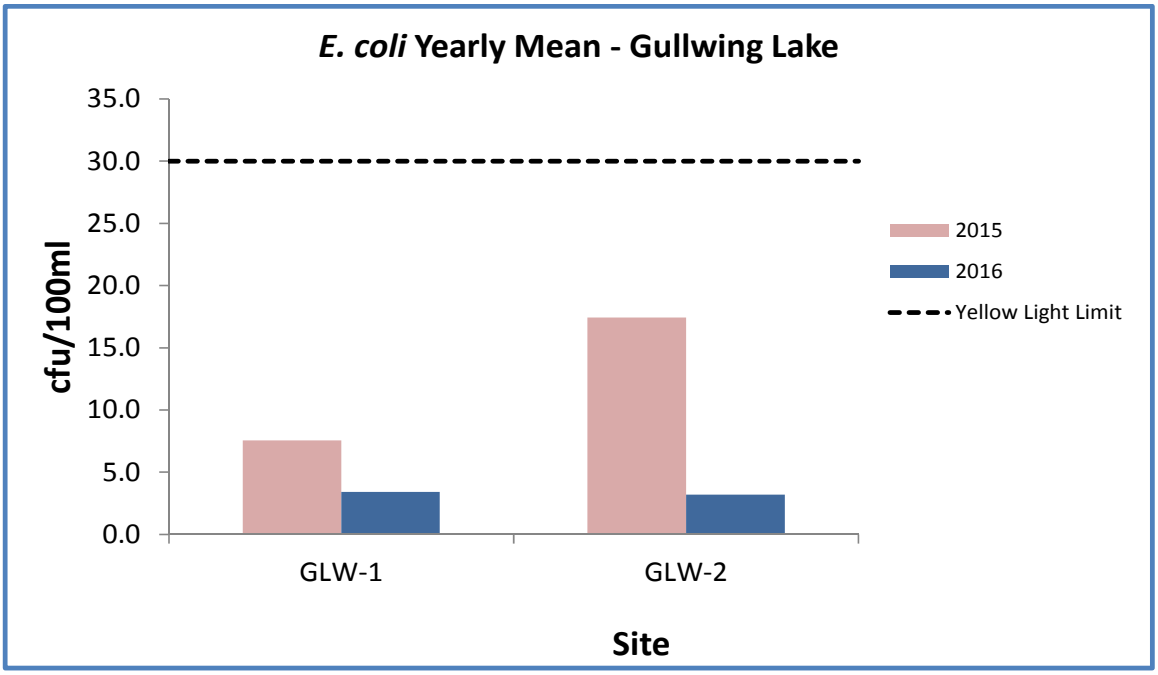
Volunteer Recognition: **Kellie Dobson,** Kim Enns and Donna Di Lello.

Gullwing Lake (GLW)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
GLW-0	2.60	7.5	7.7		
GLW-1		8.3	7.6	3.4	58.4
GLW-2		8.5	7.3	3.2	70.1





Summary and Recommendations:

This sampling area was established in 2015. *E. coli* yearly means at GLW-1 and GLW-2 in 2016 were well below values observed in 2015. **Beacon recommends that sampling continue to monitor long-term trends.**

Area Description:

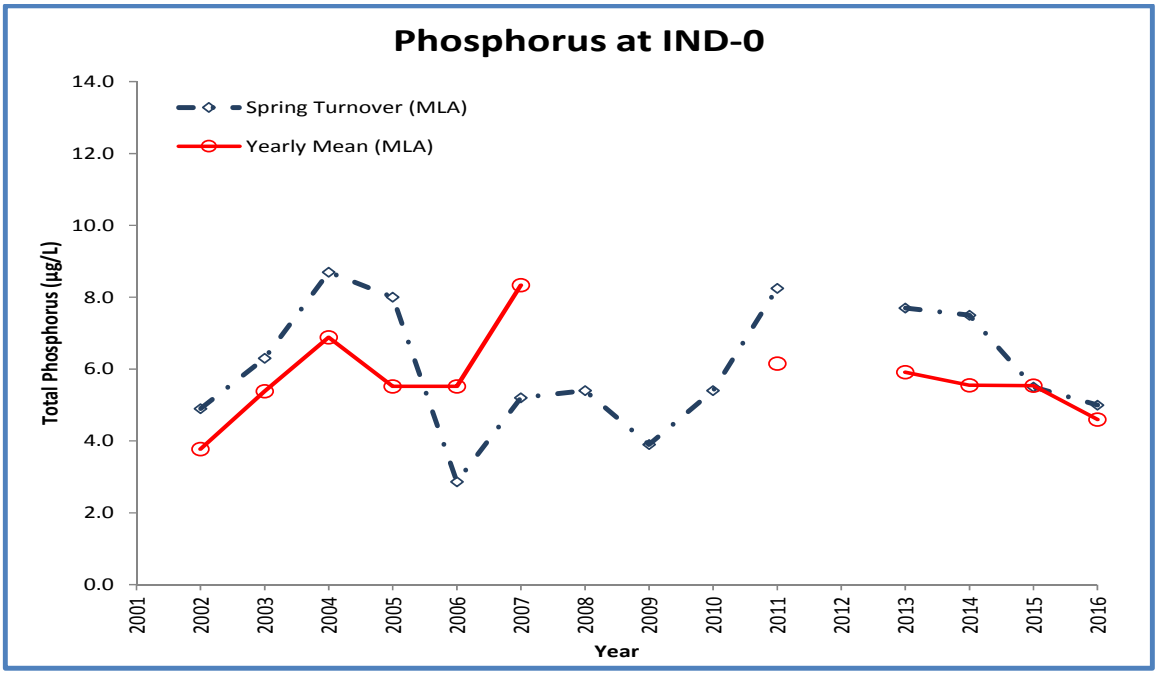
The Indian River flows from Lake Rosseau, through Port Carling and into Mirror Lake and Lake Muskoka. This highly developed area receives stormwater from the Port Carling urban centre. It also has high boat traffic, a locks system, marinas and many commercial and residential properties. A large lacustrine wetland is located adjacent to the river. Monitoring started in 2002.

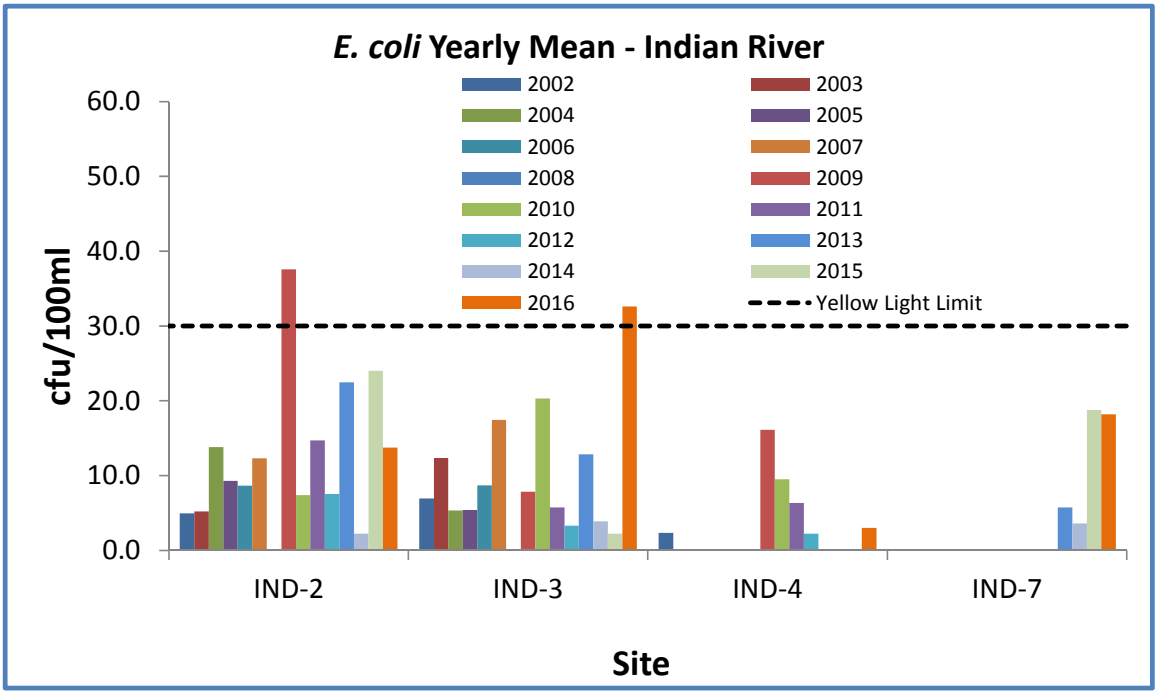
Volunteer Recognition: **Susan Carson,** Ian Turnbull, Paul Raymond, Dianne Turnbull, and Randy Carson.

Indian River (IND)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)	DOC Yearly Mean
		Spring Turnover	Yearly Mean			
IND-0	4.75	5.0	4.6			
IND-2				13.8	149.1	
IND-3				32.6	94.7	
IND-4				3.0	69.9	
IND-7		8.9	8.3	18.2	103.5	4.2





Summary and Recommendations:

Spring phosphorus concentrations at the deep station (IND-0) continue to remain consistent through 2016. Phosphorus spring turnover and yearly mean results in 2016 at IND-7 were slightly higher than those measured in 2015, however they remained lower than those recorded in 2014 and much closer to results obtained in 2013. Sampling for bacteria at IND-4 was restarted in 2016. *E. coli* concentrations observed in 2016 are well below the MLA stoplight limits (details in report Section 3) at all stations except IND-3. Re-tests were required at IND-3 during the second and third round of sampling. **Beacon recommends that all sampling be continued to monitor long-term trends and *E.coli* levels.**

Area Description:

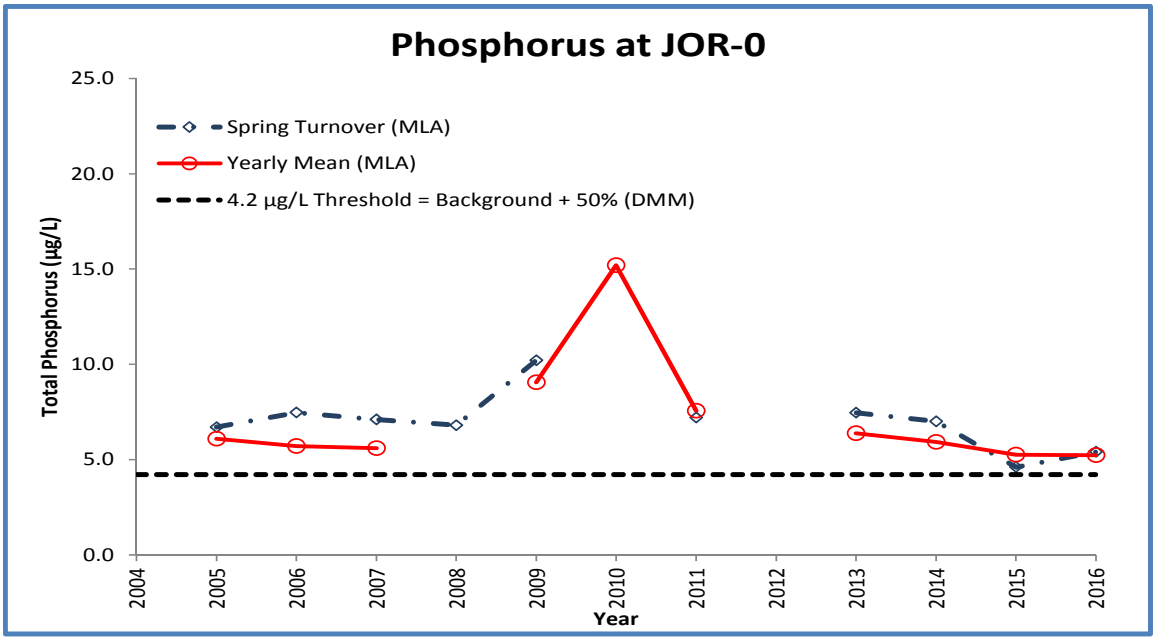
The Joseph River is the water body connecting Lake Joseph and Lake Rosseau. The river is 1.37 km² in size and up to 8 m deep. Direction of flow is from Lake Joseph into Lake Rosseau. A marina, a bridge crossing for Peninsula Road and two wetlands are located adjacent to the channel. This area receives significant boat traffic as the main navigable waterway between the two large lakes. The Joseph River is classified as moderately sensitive by the DMM. Monitoring started in 2005.

Volunteer Recognition: **Beth Guy,** Laurie Leiser, and Paul Crokey.

Joseph River (JOR)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
JOR-0	4.13	5.4	5.2		
JOR-2		3.6	4.6		
JOR-3		4.5	5.2		



Summary and Recommendations:

Phosphorus results remain consistent over the sampling years, and slightly over the DMM threshold. JOR-1 was discontinued for 2016, while JOR-2 was restarted. **Beacon recommends sampling continue to monitor long-term trends.**

Area Description:

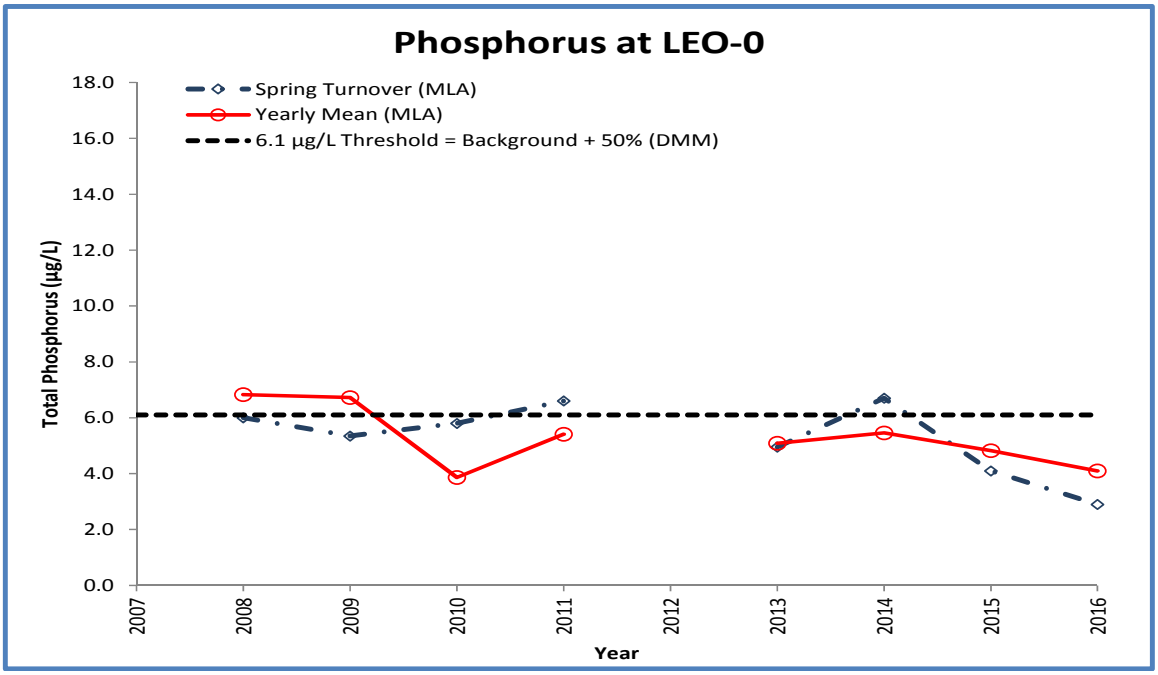
Leonard Lake is a medium sized lake at 1.52 km² in size and has a maximum depth of 16 m. This lake is moderately developed with primarily residential properties. Immediate shoreline alteration is limited to 9% but backlot clearing and forest thinning is found in 77% of properties. There is limited inflow and outflow of water on this lake, and few wetlands in the vicinity. Leonard Lake is classified as moderately sensitive and over-threshold by the DMM. Monitoring started in 2008.

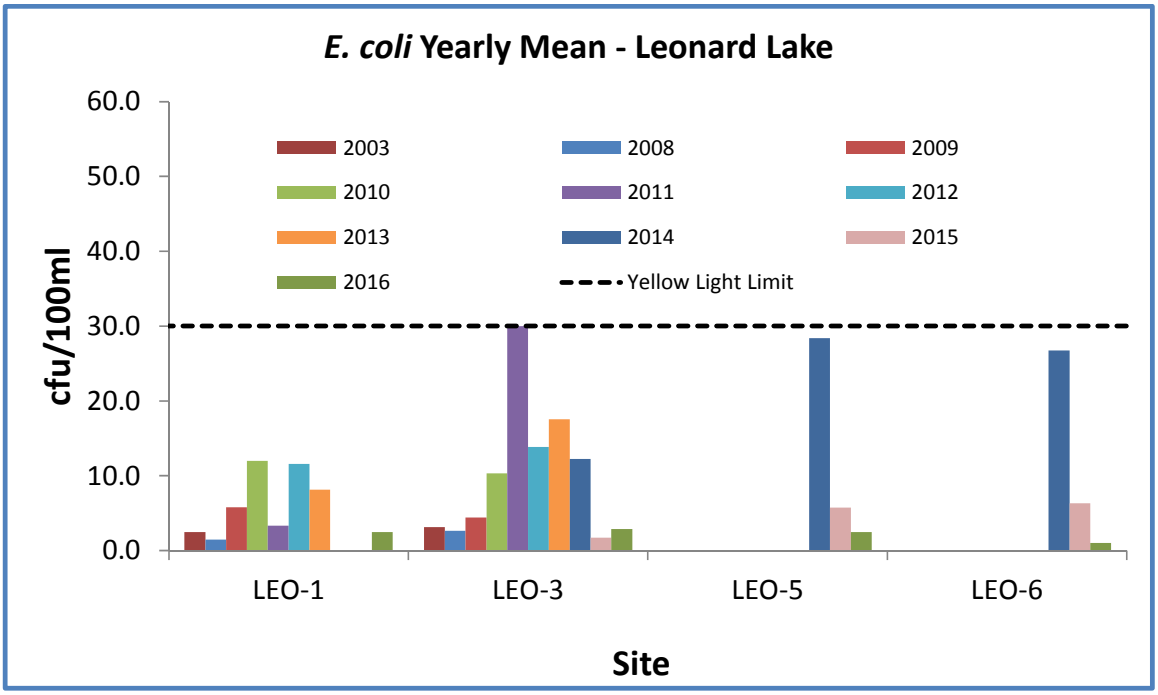
Volunteer Recognition: **Gordon Roberts, Betty Isbister,** Ester Giesbrecht, Hayden Hankey, Cole Roberts, and Jacob Roberts.

Leonard Lake (LEO)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
LEO-0	4.56	2.9	4.1		
LEO-1		3.4	4.5	2.5	38.1
LEO-3		4.6	4.8	2.9	128.7
LEO-5				2.5	27.2
LEO-6				1.0	94.2





Summary and Recommendations:

The spring turnover and yearly phosphorus mean concentrations in 2016 remained below the DMM threshold of 6.1 µg/L. *E. coli* sampling at LEO-1 was restarted in 2016. *E. coli* counts were similar to values observed in 2015 and all yearly *E. coli* means at each of the nearshore stations were well below the MLA stoplight limits (details in report Section 3). **Beacon recommends that all sampling be continued to monitor long-term trends.**

Area Description:

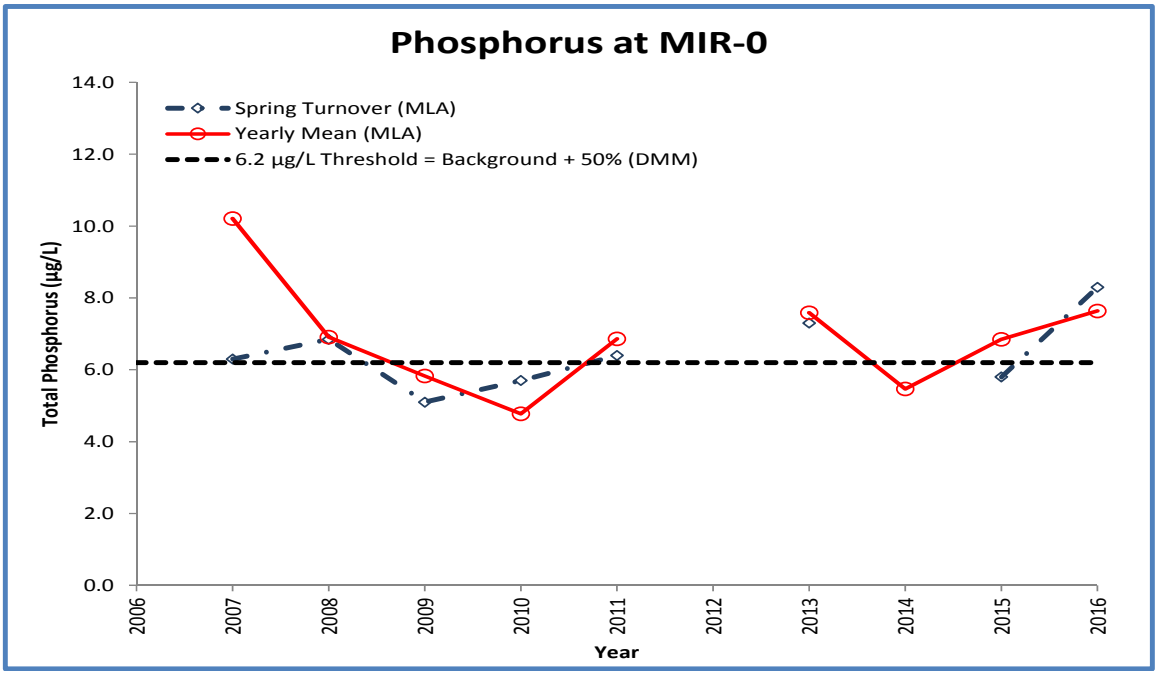
Mirror Lake is essentially a widening of the Indian River as it flows between Lake Rosseau to the north and Lake Muskoka to the south. The lake is approximately 0.46 km² in area, with a maximum depth of 8 m. Two small creeks outlet into the lake near sampling sites MIR-1 and MIR-2. Much of the lake is within the Town of Port Carling and receives drainage from the urban area. Mirror Lake has a small watershed, approximately 0.97 km², and is classified as moderately sensitive and over-threshold by the DMM. Monitoring started in 2007.

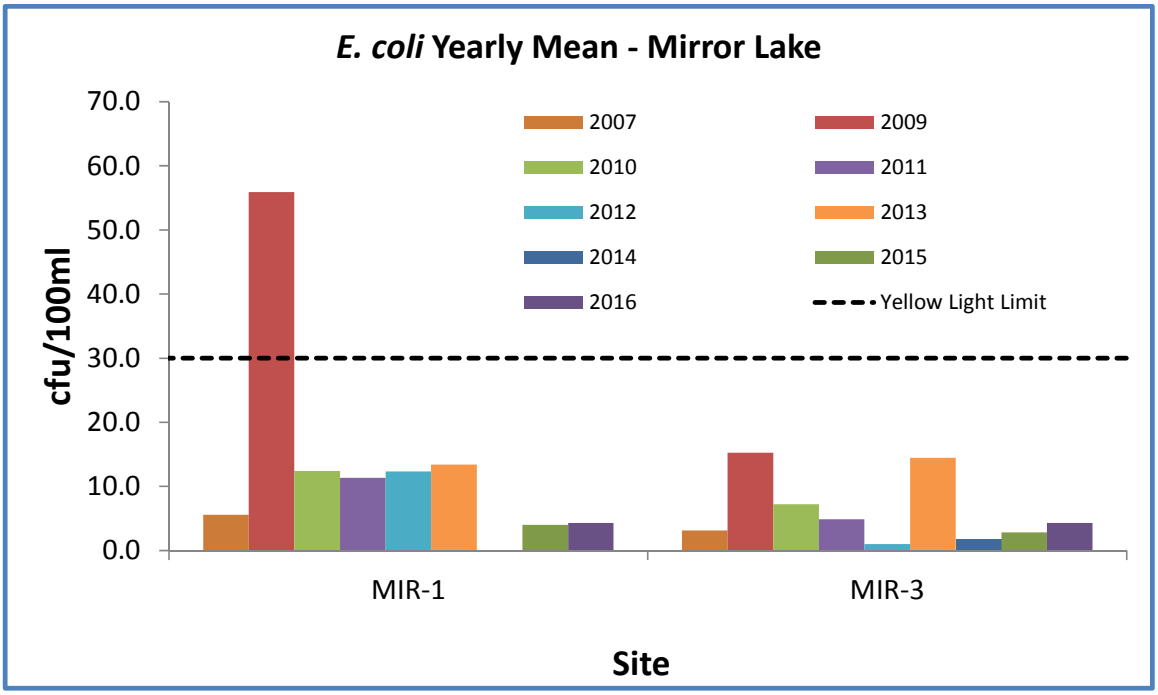
Volunteer Recognition: **Paul Raymond, Susan Carson,** Randy Carson & Tyler Ham, Aiden Schottler, Claire Danes, and Julie Laclautre.

Mirror Lake (MIR)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

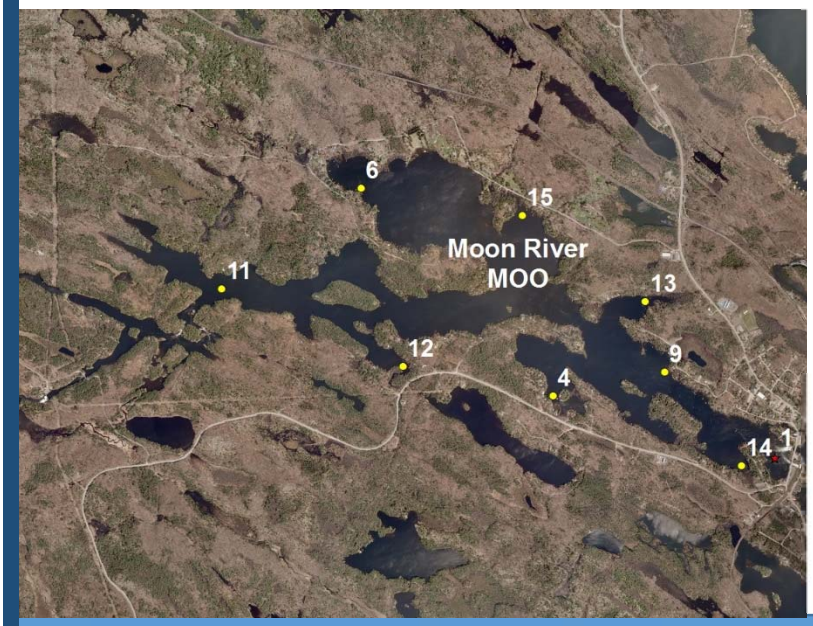
Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
MIR-0	2.74	8.3	7.6		
MIR-1				4.3	138.2
MIR-3		4.6	6.5	4.3	28.9





Summary and Recommendations:

Similar to 2015, the yearly phosphorus mean is slightly above the DMM threshold of 6.2 µg/L. The 2011 spring turnover phosphorus result at the deep station (MIR-0) remains removed from the analysis following the 2016 Grubb's Test for outliers. *E. coli* counts remain below the MLA stoplight limits (details in report Section 3) at both nearshore stations sampled in 2016. **Beacon recommends that all sampling be continued to monitor long-term trends.**



Area Description:

The Moon River is the main outlet of the Muskoka Watershed, flowing from Lake Muskoka to Georgian Bay. The river receives overland drainage from the Town of Bala and its urban area, including many roads and the developed shoreline. Approximately 12 creeks outlet into this sampling area, several of which drain wetlands.

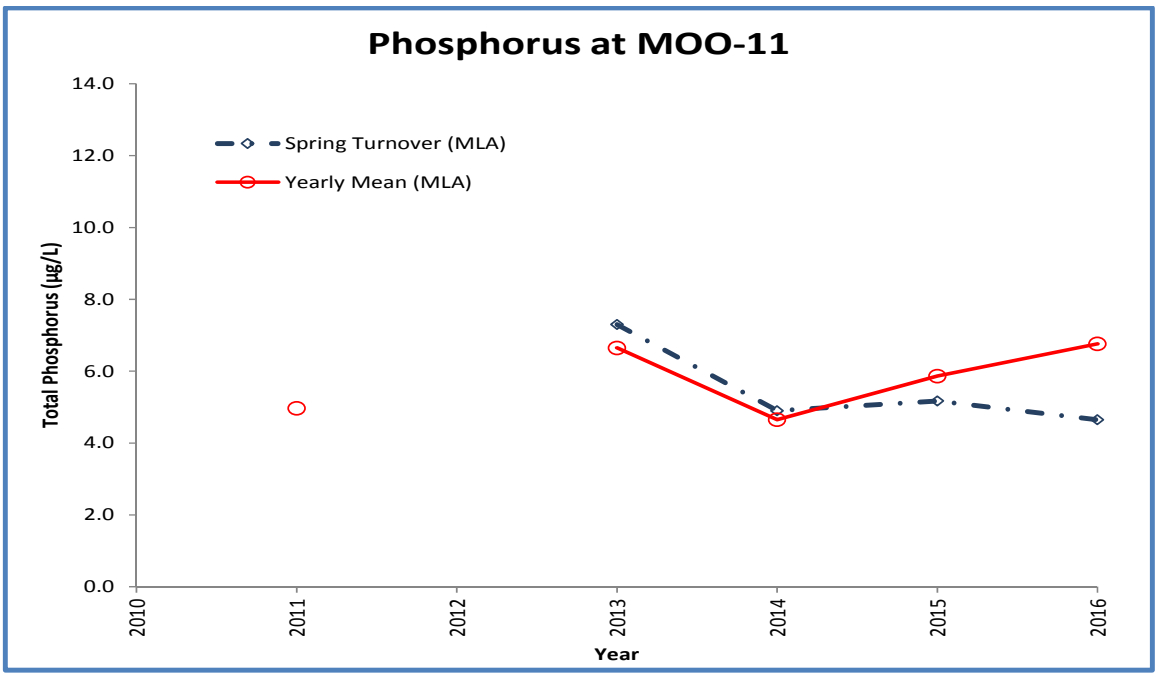
Volunteer Recognition: **Bruno Polewski,** Cathy Malcomson, Frida Ardal, Jessica Ylanko, Hannu Ylanko, Joa Roth, and Allan Turnbull.

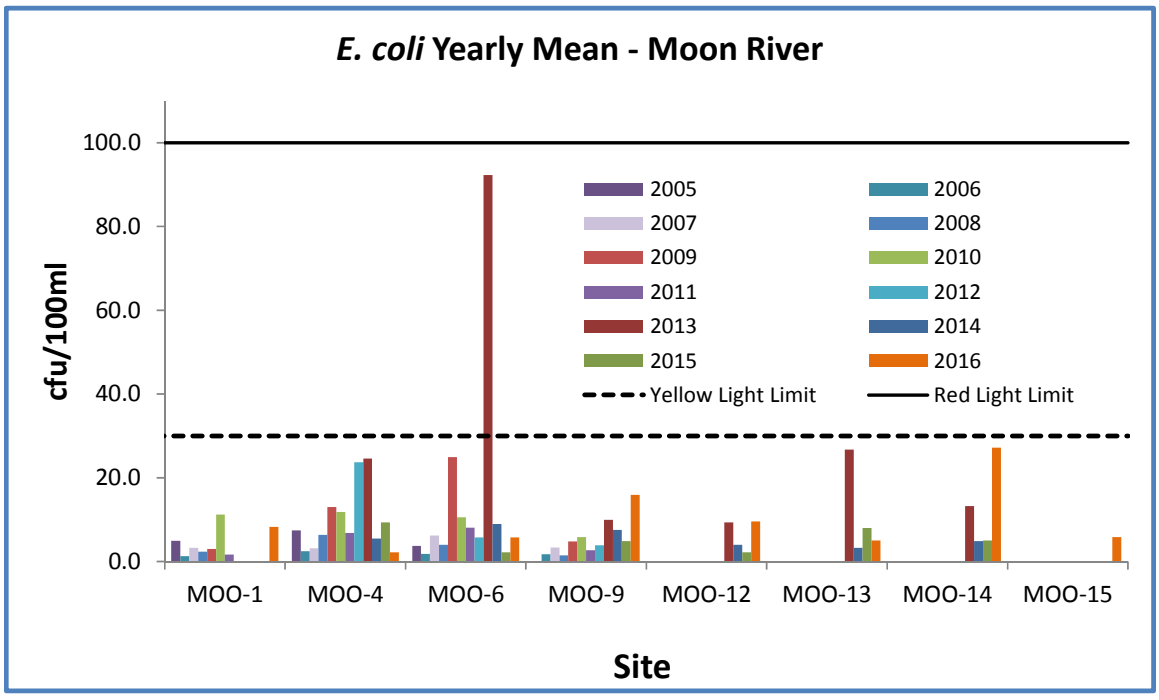
Moon River (MOO)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
MOO-1		5.7	6.5	8.3	7.9
MOO-4		7.3	7.4	2.2	54.9
MOO-6	4.50*	4.7	5.8	5.8	43.3
MOO-9		3.7	5.4	15.9	63.7
MOO-11	3.48	4.7	6.8		
MOO-12		8.6	7.7	9.6	55.3
MOO-13		7.2	7.7	5.0	70.2
MOO-14		4.7	5.5	27.2	50.5
MOO-15		6.3	6.0	5.8	51.9

*only 1 depth collected





Summary and Recommendations:

Yearly mean phosphorus concentrations at MOO-11 in 2016 were the highest recorded to date. A new station MOO-15 was sampled for phosphorus and bacteria. Spring turnover phosphorus concentrations in 2016 were down at MOO-1, MOO-6, MOO-9, MOO-11, MOO-13 and MOO-14 and increased at MOO-4, MOO-12 and MOO-15 compared with 2015 results. Sampling at MOO-10 was discontinued for 2016 and one new station was sampled for bacteria in 2016 (MOO-15). *E. coli* levels were all below the MLA stoplight limits (details in report Section 3) in 2016. **Beacon recommends that all sampling be continued to monitor long-term trends.**

Area Description:

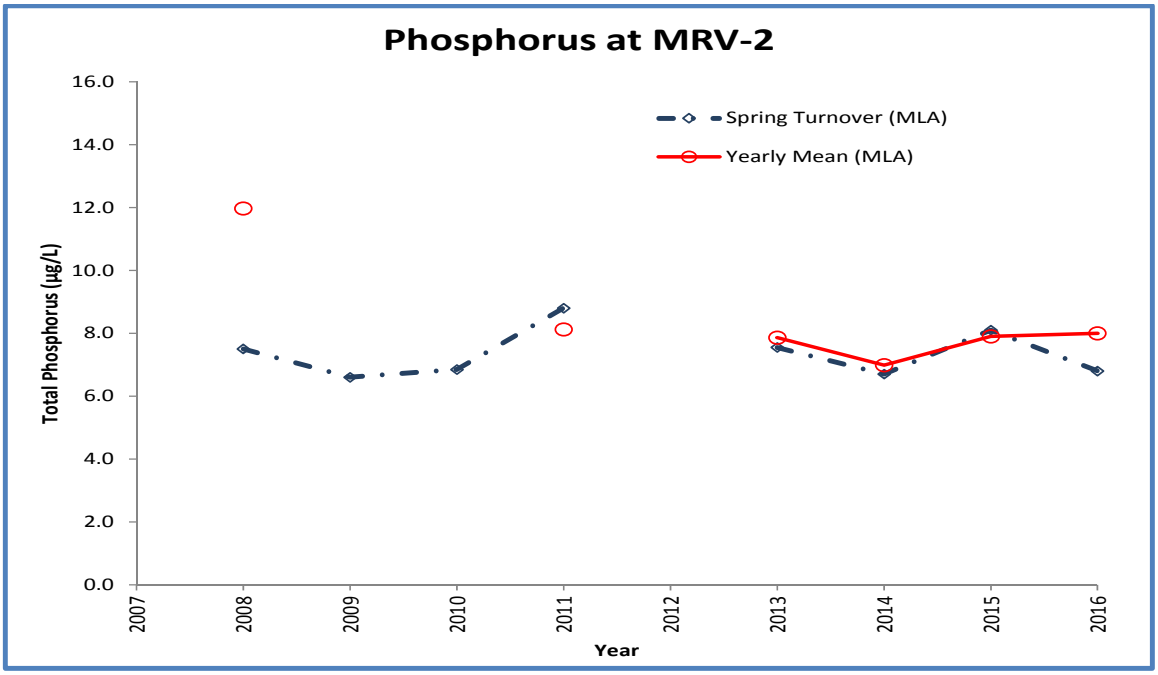
This sample area includes the most downstream reach of the Muskoka River where it flows from the Town of Bracebridge to Alport Bay, Lake Muskoka. This area is highly developed on both banks, and includes the Bracebridge urban area, large agricultural fields, and extensive residential properties along the entire reach of shoreline. Roads are located along both sides of the river for most of the reach length. Several creeks outlet into the river through this reach and there are limited wetland areas adjacent to the river. Monitoring started in 2008.

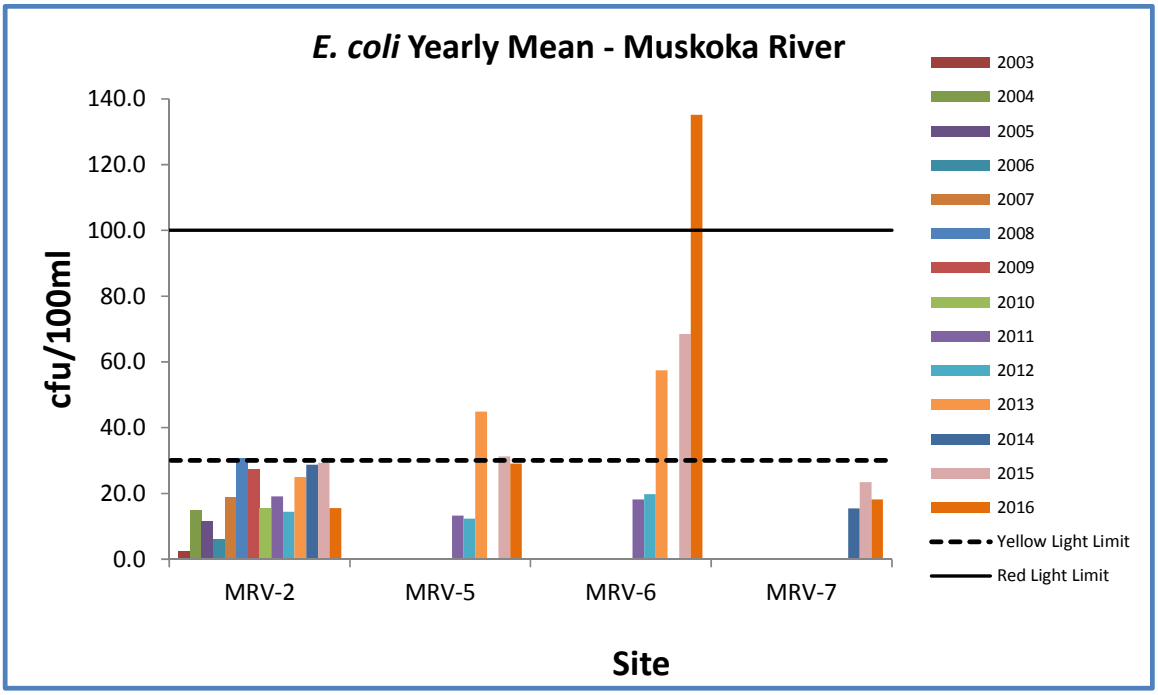
Volunteer Recognition: **John Wood** and Debbie Hastings.

Muskoka River (MRV)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
MRV-2	3.13	6.8	8.0	15.6	150.2
MRV-3	3.61	6.5	7.0		
MRV-4	3.14	7.2	7.0		
MRV-5		24.8	14.3	29.0	451.2
MRV-6		25.2	21.8	135.1	1232.3
MRV-7		7.9	8.3	18.2	223.6





Summary and Recommendations:

Phosphorus concentrations continue to remain consistent through the sampling years at MRV-2. Spring phosphorus turnover and yearly mean concentrations at the other stations remained consistent with the 2015 results, except for the yearly mean results at MRV-5 and MRV-6 which were higher than the 2014 and 2015 results. *E.coli* levels at MRV-6 in 2016 exceeded all of the MLA stoplight limits (details in report Section 3) and the field data sheets note that there was an indication of potential various animal activities in the area. Re-testing was required at MRV-5 and MRV-6. **Beacon recommends that all sampling be continued to monitor long-term trends, with special attention directed to *E.coli* samples at MRV-6 in 2017.**

Area Description:

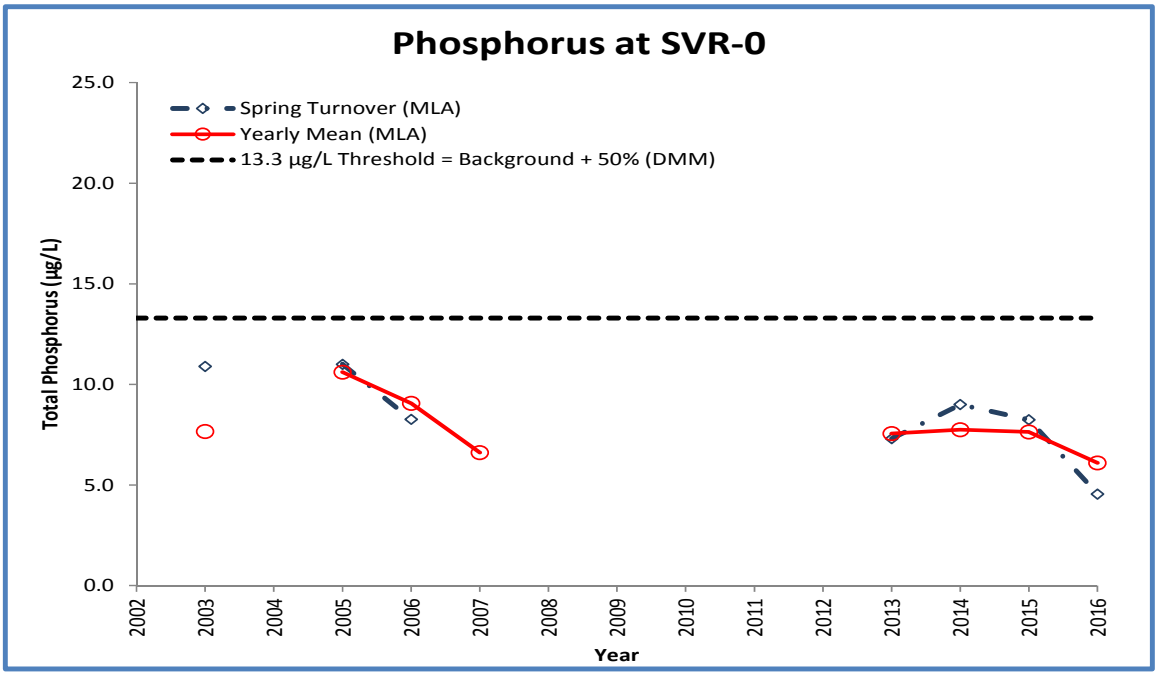
Silver Lake is located at the south end of Gull Lake. The lake is approximately 0.57 km² in area, with a maximum depth of 14 m. No fewer than 13 rivers and streams outlet into the lake. The northwestern portion of Silver Lake contains a navigable outlet into Gull Lake. The Silver Lake watershed is approximately 8 km² in size and contains a number of large lacustrine wetlands. Silver Lake is classified as moderately sensitive by the DMM. Monitoring started in 2003.

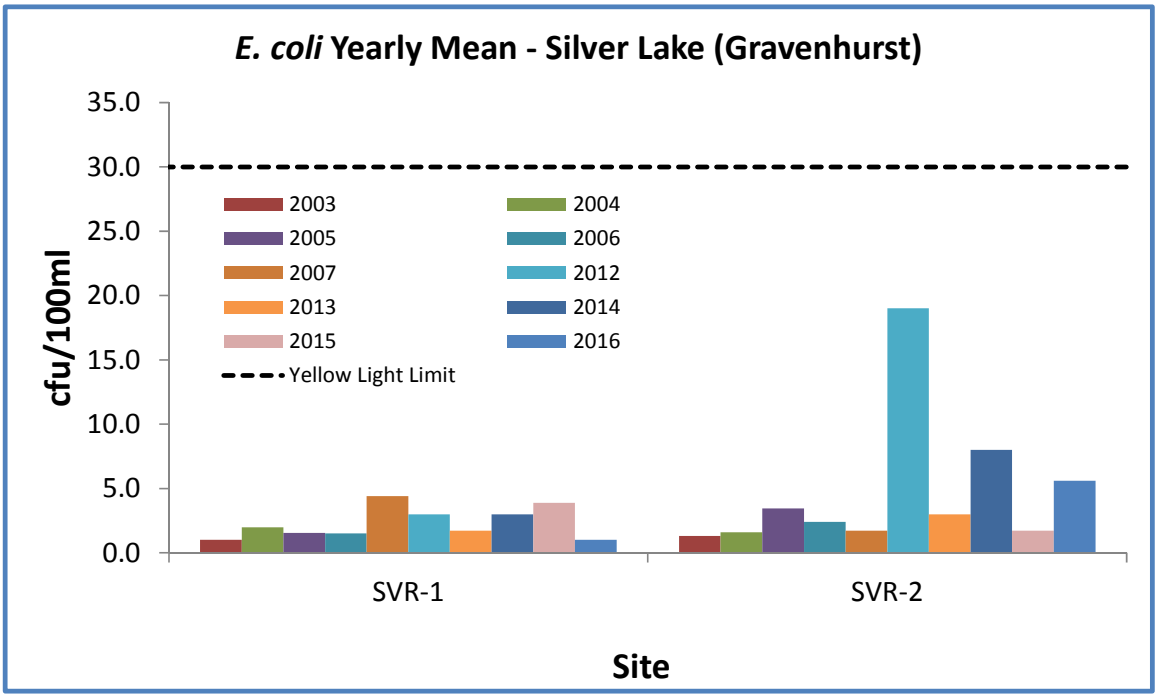
Volunteer Recognition: **Gregory Bertrand,** Roger Bertrand, and Alexander Bertrand.

Silver Lake (SVR)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
SVR-0	3.11	4.6	6.1		
SVR-1				1.0	19.9
SVR-2				5.6	44.4





Summary and Recommendations:

Spring phosphorus and yearly phosphorus mean concentrations continue to remain well below the DMM threshold (13.3 µg/L). *E. coli* yearly mean values for both SVR-1 and SVR-2 in 2016 remain below the MLA stoplight limits (details in report Section 3). **Beacon recommends sampling continue to monitor long-term trends.**

Area Description:

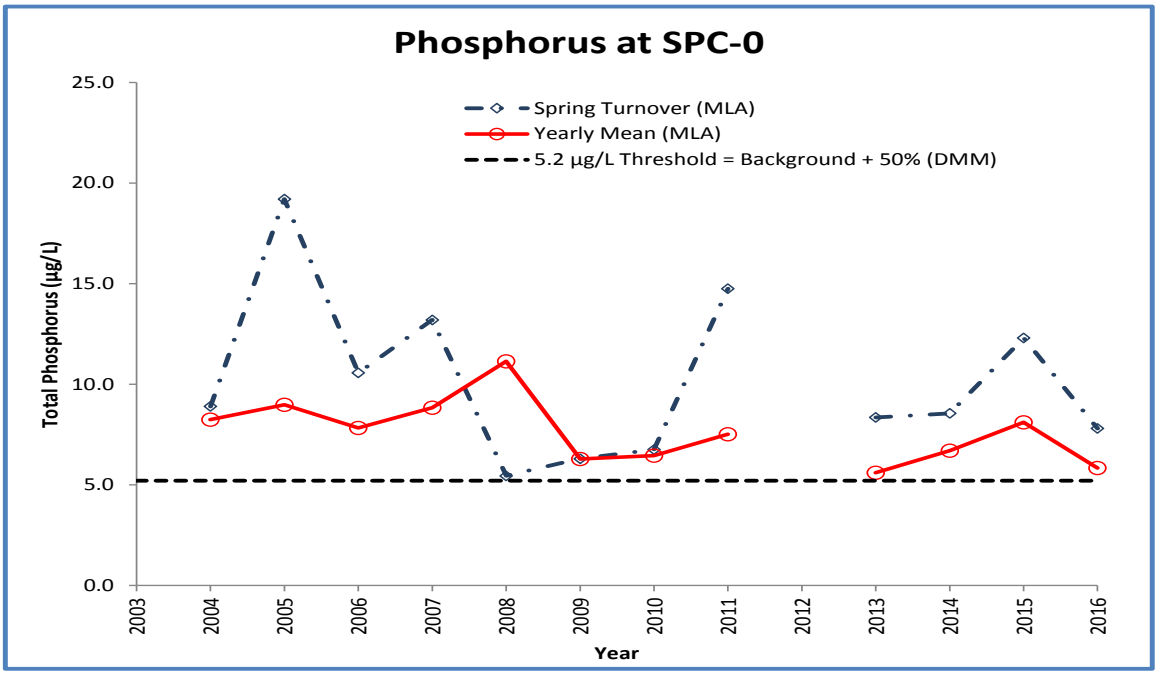
Silver Lake is immediately adjacent to Port Carling, with 0.57 km² in surface area and a maximum depth of 14 m. This lake has a moderate amount of shoreline residential development with alteration in the form of lawns and thinned forest occurring over approximately 50% of the upland area. The riparian area is well buffered with 90% of the immediate shoreline in a natural state. The southwestern portion of this lake receives drainage from part of the Port Carling urban area. There is limited flow into the lake with one identified outlet in the south. Silver Lake is classified as moderately sensitive by the DMM.

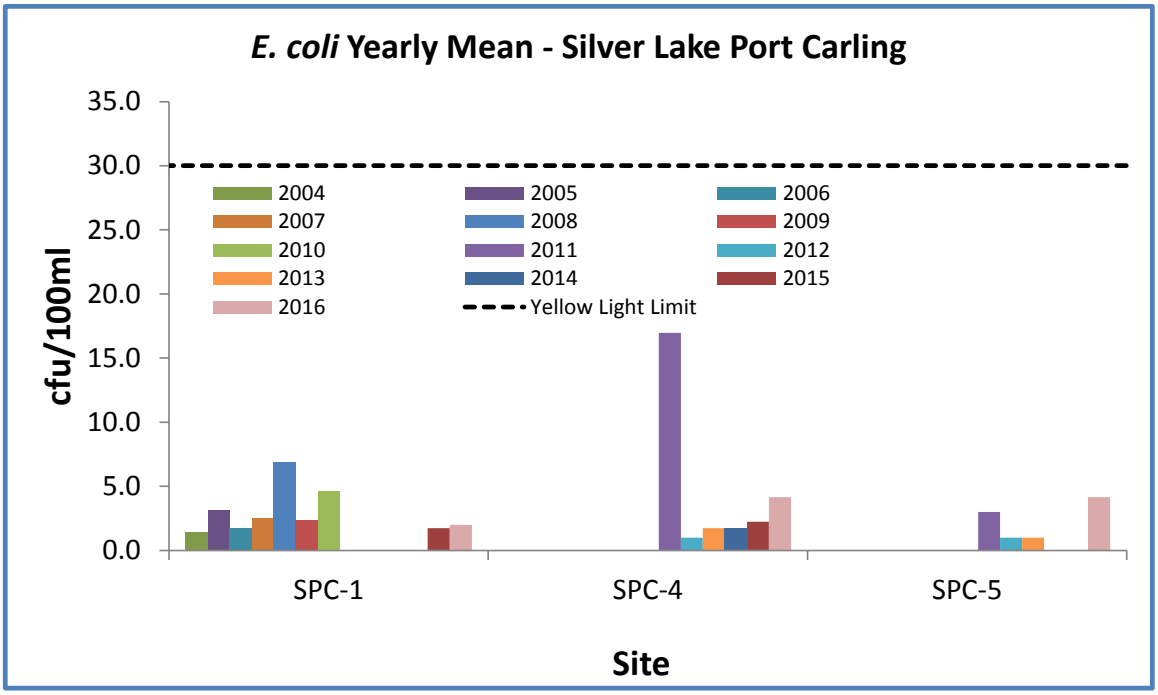
Volunteer Recognition: **Barbara Graydon** and Matthew Graydon.

Silver Lake (SPC)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
SPC-0	5.97	7.4	5.8		
SPC-1				2.0	26.0
SPC-4				4.2	18.6
SPC-5				4.2	17.1





Summary and Recommendations:

The spring phosphorus and yearly phosphorus mean concentrations at the deep station (SPC-0) remain elevated compared with the DMM threshold of 5.2 µg/L. *E. coli* counts remain low at all nearshore sampling locations in 2016 and well below the MLA stoplight limits (details in report Section 3). SPC-2 was discontinued for 2016, while SPC-5 was restarted. **Beacon recommends that all sampling be continued to monitor long-term trends.**

Area Description:

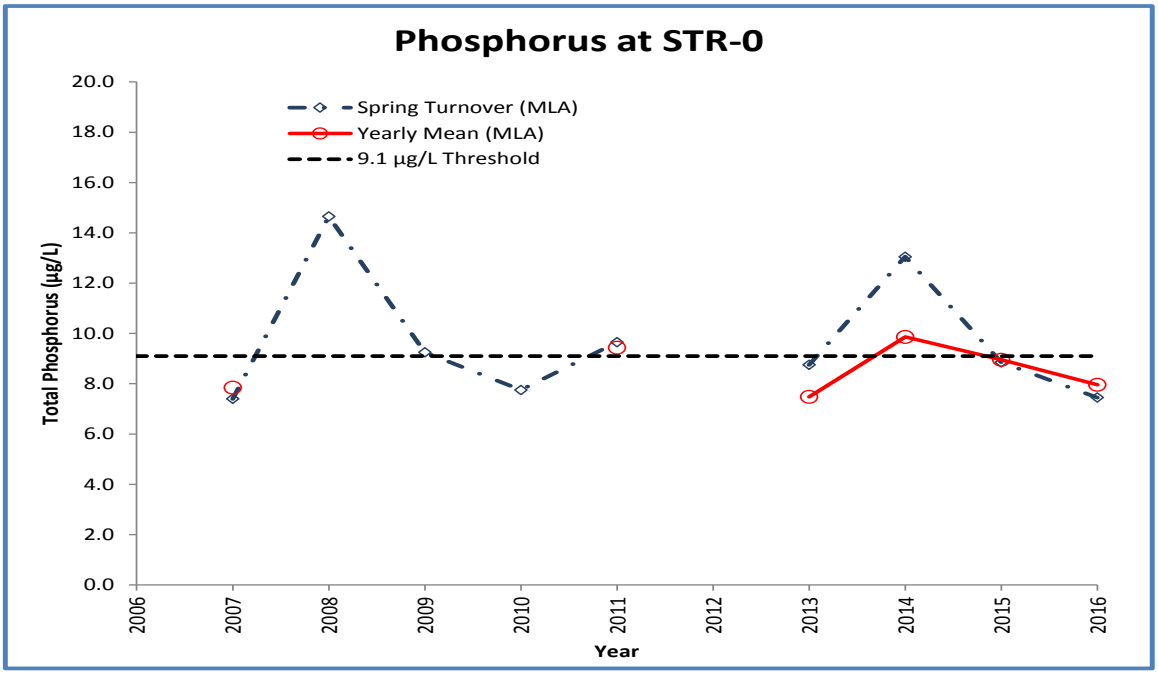
Star Lake is located in the Township of Seguin and is approximately 158 ha in area with a maximum depth of 23 m. This lake has a moderate to high level of shoreline development in the form of residential properties. Many of these properties maintain natural riparian vegetation along their shorelines, but some have extensive clearings and lawns. There is a large agricultural area adjacent to the northwestern shore and several roads located in close proximity to the lake. This lake has several inflow and outflow creeks, with limited wetland areas in the upper watershed. Monitoring started in 2007.

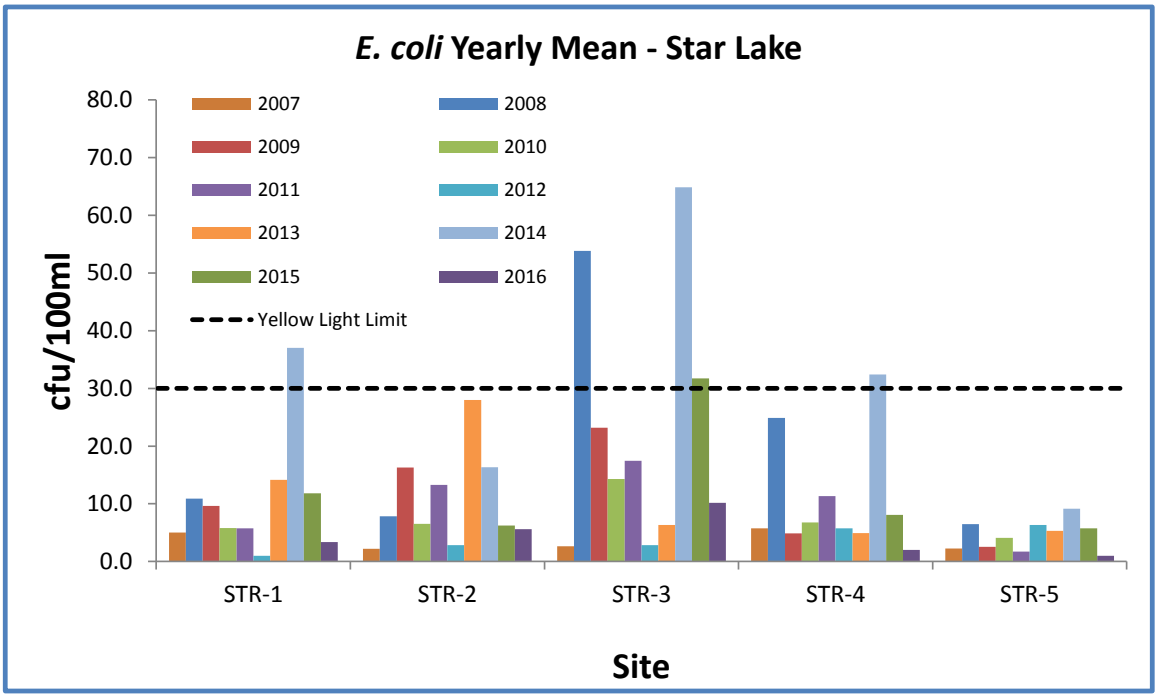
Volunteer Recognition: **Karen Gillies,** Sara Slater, Melaney Kerley, Kelly Mazza and Chris Mazza. .

Star Lake (STR)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)
		Spring Turnover	Yearly Mean		
STR-0	2.54	7.5	8.0		
STR-1				3.4	145.8
STR-2				5.6	66.7
STR-3				10.1	133.0
STR-4				2.0	85.4
STR-5				1.0	63.1





Summary and Recommendations:

The spring turnover phosphorus and yearly phosphorus mean at the deep station (STR-0) were below the threshold of 9.1 µg/L. *E. coli* concentrations in 2016 at all stations were below the MLA stoplight limits (details in report Section 3). **Beacon recommends that all sampling be continued to monitor long-term trends.**

Area Description:

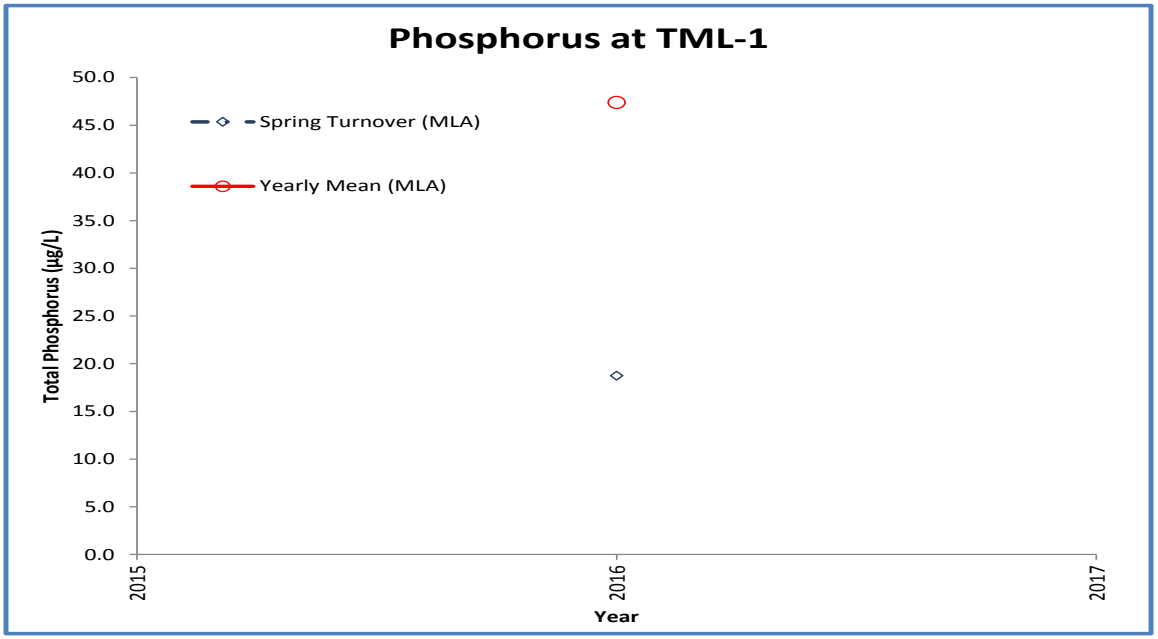
Three Mile Lake is a mesotrophic lake. The Three Mile Lake Watershed covers approximately 14,600 ha and includes portions of the Township of Muskoka Lakes, Town of Huntsville, and Town of Bracebridge. The Three Mile Lake Watershed is 3% Crown land and 97% privately owned and is atypical within the Muskoka region as it supports a comparatively large agricultural community (8% of the watershed area). Three Mile Lake consists of a shallow main basin and a deeper bay (Hammel's Bay). Monitoring started in 2016.

Volunteer Recognition: **Sue Walker,** Rob Fullerton and Al Holley.

Three Mile Lake (TML)

2016 Water Quality Results: (**Note**: Hatched cell signifies not tested for in 2016)

Station	Mean Secchi Disk (m)	Total Phosphorus (µg/L)		*E. coli* Yearly Geometric Mean (cfu/100 ml)	Total Coliform Yearly Geometric Mean (cfu/100 ml)	DOC Yearly Mean
		Spring Turnover	Yearly Mean			
TML-1		18.8	47.4			18.32
TML-2		22.5	42.6			13.4
TML-3		6.4	8.1			5.6
TML-4		18.4	22.6			6.1



Summary and Recommendations:

The sampling stations were established in 2016. **Beacon recommends that sampling continue to monitor long-term trends.**