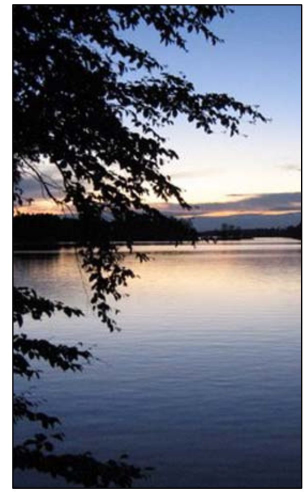

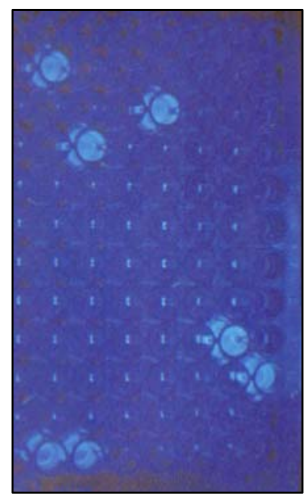

MUSKOKA LAKES ASSOCIATION

Water Quality Initiative

working in co-operation with citizens'environmentwatch

WQI Monitoring Program

Technical Report

January 31, 2009

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Executive Summary

The Water Quality Initiative (WQI) is a formal scientifically-based monitoring program that has been in operation for eight years. The WQI complements monitoring programs of other agencies. Scientific protocols were originally developed by Dr. Neil Hutchinson of Gartner Lee Ltd. The MLA has been co-operating with Citizens' Environment Watch (CEW), an Ontario-based environmental charity, to deliver the monitoring program and develop local Community Action Plans based on the results of the monitoring program since the fall of 2006.

Results of the WQI monitoring program are presented on an area-by-area basis in the WQI Summary Report. This Technical Report describes scientific methods, quality control measures and other technical information. It also outlines the general research conclusions. Site-by-site and year-by-year data is housed and accessible to the public online at both the MLA's (http://www.mla.on.ca) and CEW's (http://www.citizensenvironmentwatch.org) websites.

Monitoring efforts scaled back very slightly to 158 sites monitored by over 110 volunteers. As in previous years, the WQI monitoring program collected eight biweekly samples between Victoria Day and Labour Day. These samples were analysed for phosphorus concentration, total coliform, *E.coli*, water clarity and temperature. Turbidity measurements were discontinued in favour of the secchi depth protocol that was added in 2007. Total coliform and *E.coli* samples were analysed by volunteers using ColiPlates. Several sites that had not been monitored in the last few years were monitored for spring turnover total phosphorus by CEW staff.

The 'pyramid system' of volunteers created in 2007 was successfully implemented for all volunteer teams. 22 volunteers were designated Team Leaders to assist the rest of their team in carrying out the monitoring and analysis. Experience evaluations completed by Team Leaders and other volunteers were generally favourable; most indicated that the resources provided (training sessions, printed materials, etc.) were adequate.

The primary purpose of the WQI is to identify causes of problems with water quality, both high nutrient levels and high bacteria levels, identified by the District of Muskoka and previously identified by the WQI. These results are reported as part of Community Action Plans of the MLA. The secondary, but more general purpose, is to ensure that all vulnerable areas are appropriately protected by government through development regulations and restored using remedial actions. This work is discussed in Section 4 of this report. Therefore, areas of interest to the WQI generally fit into at least one of these categories:

1. lakes and bays with problems identified by DMM;
2. lakes and bays where past WQI data indicates a problem; and
3. lakes and bays where DMM does not monitor.

Results (Section 4) show that there are several simple actions that the MLA should take to ensure that our most vulnerable lakes and bays are adequately protected from development. These are:

1. Ensure the District recalibrates its water quality model (based on results at four WQI sampling areas);
2. Ensure the District begins to monitor $[TP]_{so}$ at two WQI sampling areas;
3. Request the District calculate specific thresholds or makes provisions for protecting local areas within large basins for a further six WQI sampling areas; and
4. Initiate WQI monitoring of [TP] for the entire season in the offshore and nearshore zones for three WQI sampling areas.

It is also important that the MLA secures enough volunteers for continuous sampling of priority areas and continues to support remedial action programs in 12 WQI sampling areas.

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Definitions

10-year Average Total Phosphorus: Arithmetic mean of all spring turnover total phosphorus concentration measurements collected within one program over a ten year period. In order for the District of Muskoka to classify a lake or segment as over-threshold, the 10-year average of measurements collected by the District of Muskoka through the Lake System Health Monitoring Program (consisting of at least three measurements) must exceed the threshold calculated by the Muskoka Recreational Water Quality Model.

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

Clarity: Water clarity is influenced both by dissolved and suspended matter. Clarity often indicates a lake's overall water quality, especially the amount of algae present. Algae are natural and essential, but too much of the wrong kind can cause problems (http://www.dnr.state.wi.us/org/water/fhp/lakes/under/wclarity.htm).

***E.coli*:** Fully known as *Escherichia coli,* it is a subset of total coliforms, and is exclusively associated with faecal waste making it a good indicator of faecal contamination. There are several different strains of *E.coli*; most waterborn strains are themselves not harmful, but some (such as *E.coli* O157:H7) can cause serious illness (OMH, 2001). For more information, please see http://www.citizensenvironmentwatch.org/wqi/muskoka_lakes/waterquality.php#bact.

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. Geometric mean is used to indicate the central tendency or typical value of a set of numbers (http://en.wikipedia.org/wiki/Geometric_mean). It is typically used to calculate average bacteria counts because as a living organism, bacteria counts are highly sporadic and inconsistent.

Lake System Health Monitoring Program: A field-based program designed and operated by the District of Muskoka that monitors approximately 192 sample locations across Muskoka on a rotating basis depending upon development pressures and the specific characteristics of the lake. The purpose of the program is to establish a long-term record of key water quality parameters so that trends in water quality can be identified. Spring turnover total phosphorus results of this program inform Muskoka's Recreational Water Quality Model. (http://www.muskoka.on.ca/siteengine/activepage.asp?PageID=230)

Natural Phosphorus: The "Natural" phosphorus concentration is the baseline concentration calculated by Muskoka's Recreational Water Quality Model to represent the expected phosphorus concentration within the lake or bay without any development.

Phosphorus: Phosphorus is a component of DNA and RNA and an essential element for all living cells (http://en.wikipedia.org/wiki/Phosphorus). It is found in fertilizers, soaps, and in human waste. Typically phosphorus is not removed from waste streams by conventional private treatment systems (septic systems) or by some municipal treatment systems.

Lakes on the Canadian Shield are typically oligotrophic, meaning poor in nutrients. Phosphorus is usually the limiting nutrient, that is, phosphorus is in short supply so every bit of phosphorus added to the lake system is directly used to create biological matter such as algae. This makes phosphorus the most important indicator of human-based environmental impacts on our lakes. For more information, please see http://www.citizensenvironmentwatch.org/wqi/muskoka_lakes/waterquality.php#eutro.

Phosphorus Threshold: The "Threshold" phosphorus concentration is 50% more than the baseline ("Natural") concentration calculated by the District of Muskoka. The threshold is used to classify lakes and bays as requiring a higher level of development control as a precautionary action to protect the long-term health of the lake.

Metadata: Data about data. It may include descriptive information on the characteristics of a dataset, e.g. its content, quality, quantity and condition.

Muskoka Recreational Water Quality Model: An advanced numerical model operated by the District of Muskoka designed to predict the response of all individual lakes in Muskoka to the input of phosphorus. The model is based on the Ontario Lakeshore Capacity Simulation Model, originally published in 1986 by a Provincial inter-ministerial working group. This model was substantially updated in 2005 by Dr. Neil Hutchinson of Gartner Lee Ltd. for the District of Muskoka (GLL, 2005).

The model includes a detailed phosphorus budget. Its inputs are the results of the District's Lake System Health Monitoring Program. Among the model's outputs is lake-specific Natural Phosphorus, Phosphorus Threshold and predicted phosphorus concentrations.

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

Secchi Depth: An expression 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.

Site: The discrete and unique location in a sampling area where samples are to be collected on each sample date.

Spring Turnover Phosphorus ($[TP]_{so}$): A single phosphorus concentration measurement taken in a stratified lake during the spring turnover period. This measurement has been shown to adequately represent the overall phosphorus concentration in a lake. Typically the spring turnover lasts for a few days when the temperature of the entire water column is consistent (usually 4˚C) allowing the water column to mix. In practice, measurements taken anytime in May are considered to be adequate by Ontario's Ministry of the Environment (http://www.ene.gov.on.ca/envision/water/lake_partner/index.htm).

Standard Deviation: The most common measure of statistical dispersion, measuring how widely spread the values in a data set are (http://en.wikipedia.org/wiki/Standard_deviation). The smaller the standard deviation, the more consistent and predictable are the numbers making up a data set. In the WQI, a large standard deviation within a year suggests that water quality is much different at different times throughout the sampling period, which could mean that specific conditions or influences are affecting water quality at a given site over the course of the season.

Total Epilimnetic Phosphorus ($[TP]_{epi}$): The arithmetic mean of phosphorus concentration measurements taken above a stratified water column's thermocline over the ice-free period. *Note:* average phosphorus concentration as reported by the WQI is not a true $[TP]_{epi}$ as samples are not collected over the entire ice-free period.

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. For more information, please see http://www.citizensenvironmentwatch.org/wqi/muskoka_lakes/waterquality.php#bact.

Turbidity: The cloudiness of a liquid (in this case lake water) caused by suspended particles. Turbidity is reported in Nephilometric Turbidity Units (NTU), an accurate measurement of the dispersion of light shone through the water column.

1 Introduction

The Muskoka Lakes Association (MLA) is a non-profit organization that represents the interests of lakefront residents in the Muskoka Lakes area of Central Ontario. The MLA began a formal scientifically-based ecological monitoring and lake water quality research program in 2001 with a pilot phase led by Dr. Neil Hutchinson of Gartner Lee Ltd. The MLA continued the Water Quality Initiative (WQI) as both a monitoring program and a formal research program until 2006.

The MLA's attention was refocused in 2007 following recommendations of the 2006 Annual Report. Using data collected by the monitoring program, the resources of the WQI have been directed to specific sampling areas where concerns about water quality have come to light (typically these areas are classified as "over-threshold" with respect to phosphorus concentration by the District of Muskoka). The research capacity has effectively been focused on **determining the sources** of phosphorus loading and other contaminants in these areas. In turn, attention turns to mitigating these sources in the form of community-based community action plans.

The MLA developed a partnership with Citizens' Environment Watch (CEW) following the 2006 monitoring season. CEW is an Ontario-based environmental charity whose mandate is to support environmental education and monitoring, as well as engage the public in local decision-making. CEW continues to provide the MLA with scientific advice and supports WQI participants by providing training, equipment, analysis etc. Several significant improvements were made by CEW to enhance the quality and the delivery of the program in 2008.

The monitoring program was funded entirely by MLA internal revenue streams and continues to be successful because of the hard work of MLA volunteers.

The scientific details of the 2008 monitoring program are presented here. Achievements and conclusions of CAP activities are reported separately.

The detailed results of the monitoring function of the MLA program have been published online for simplicity and to allow as wide an access to data as possible. This map-based website allows the average reader to easily access the specific results that most interest them, without having to review all the technical information produced for all data collection sites. These online results can be viewed at the MLA's website (http://www.mla.on.ca) as well as at CEW's website (http://www.citizensenvironmentwatch.org). Easy-to-read instructions and a tutorial for accessing the data are also published on the same websites. MLA members can choose to obtain a copy of the Summary Report of the 2008 Monitoring Program including instructions for accessing data via the Internet from the MLA office in Port Carling.

1.1 Water Quality Monitoring Context

The MLA WQI operates in a rich context of water quality monitoring. The monitoring program that is most directly related to the WQI is the District Municipality of Muskoka's (DMM) Lake System Health Monitoring Program, which has been monitoring for over 25 years.

> In early 2008, DMM announced that in Lake Joseph, their monitoring program had been returning results that were much higher than modeled for several years. In response, DMM is examining all results collected by WQI volunteers throughout Lake Joseph since 2002. DMM has also begun to monitor several sites in the lake bi-weekly, following the lead of the WQI monitoring program.
>
> Luckily, scientists are getting a head-start on determining how the model needs to be updated thanks to data collected by WQI volunteers in Lake Joseph!

The DMM program typically[1] collects duplicate samples at a single location and at a single time during the spring from lakes across the District. Larger lakes are divided into hydrodynamically unique lake segments; duplicate samples are collected from each of these. DMM analyzes the collected samples for total phosphorus (TP) concentration, dissolved oxygen, temperature and a number of chemical parameters including pH, conductivity, and dissolved organic carbon. There are approximately 192 monitoring sites within the district, and these are sampled on a rotational basis (Muskoka District, 2009).

[1] See inset.

The $[TP]_{so}$ results are used to calibrate and validate DMM's Recreational Water Quality Model, which predicts [TP] in each lake and unique lake segment in the Muskoka River watershed. Predicted [TP]s for each lake or segment include:

- the Natural level (the theoretical [TP] if there were no development),
- the Threshold level (50% greater than the Natural level) and
- the Developed level (the theoretical [TP] with existing development levels).

The Model also classifies lakes by their predicted sensitivity to nutrient loading.

By comparing both the predicted Developed [TP] and actual $[TP]_{so}$ measurements to the Threshold level, DMM classifies lakes and lake segments according to whether or not their [TP] exceeds the acceptable level (equal to the Threshold).

Sensitivity and threshold classifications each trigger specific development controls in the waterfront zone surrounding the lakes. For example, 'over-threshold' lakes (having TP concentrations that exceed the modeled Threshold level) and lakes that are highly sensitive to phosphorus loading are subject to development controls that are much stricter than other lakes. For more information on DMM's monitoring program and planning regime, please contact the District Municipality of Muskoka directly (http://www.muskoka.on.ca).

Expressed more simply, the DMM model and monitoring program is designed to detect whether or not there is a concern or problem with a lake's water quality. If a problem is identified, standardized development regulations are applied to protect the lake from further development. The program is not intended to discover the source of the problem.

Even though the purpose of the DMM model and monitoring program is to detect problems with a lake's water quality, there are barriers to this. Limited resources and political jurisdiction mean that DMM cannot monitor all lakes and lake segments required to ensure the model is working and all lakes are appropriately classified. It has also become very clear that the actual mechanism by which lakes are classified and in turn protected by development regulations is currently not responsive enough to adequately protect Muskoka's most vulnerable lakes[2].

1.2 Purpose of WQI

The primary purpose of the MLA WQI monitoring program is to **discover the source** of problems, identified both by DMM modelling and community members. This is accomplished through monitoring over a longer season (Victoria Day to Labour Day) in the deep water as well as the near shore zone of a number of lakes and bays. Results of monitoring in the nearshore zone are compared to comparable deep water monitoring results to indicate land-based problem sources.

The secondary purpose of WQI monitoring is to ensure that all vulnerable areas are appropriately protected by government through development regulations and restored using remedial actions. The WQI does this by identifying trophic status problems in areas where the DMM program cannot monitor due either to limited resources or political jurisdiction, identifying problems other than those with trophic status, and also provides additional evidence supporting regulation of vulnerable areas where DMM does monitor. Monitoring is therefore concentrated in three types of areas:

1. lakes and bays with problems identified by DMM;
2. lakes and bays where past WQI data indicates a problem; and
3. lakes and bays where DMM does not monitor.

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[2] Despite years of observing [TP] that exceed acceptable thresholds, areas such as the Main Basin of Lake Joseph remain unprotected from development because the model is recalibrated and list of protected lakes is updated very infrequently.

2 Program Delivery

2.1 Field Staff

A field staff person was hired from April to October 2008 to assist the Project Manager at CEW in implementing the WQI. The role of this new position is to perform site visits, prepare equipment kits, assist with training session, assist volunteers with any questions, and data management. The local on-the-ground field staff was a great resource for volunteers and enable questions or concerns to be addressed in a timely manner.

2.2 Training and Volunteer Roles

In 2008, the WQI began with two volunteer training sessions in May. The first was held on Saturday, May 10 at the Rosseau Memorial Hall. The second was held on Saturday, May 17 at the Port Carling Community Centre. Both sessions took place from 9:15 am to 12:00 pm. A representative from the MLA was present at each session. The sessions were lead by Michael Logan with assistance from Amy McLeish, both from CEW (Program Manager and field staff respectively). In total, 50 volunteers attended the training sessions (ten on the May 10th and 40 on May 17th). Each training session was divided into two sections, one for Team Leaders and another for new volunteers.

2.2.1 Team Leaders

The concept of Team Leaders was introduced to the WQI in 2007. The purpose of Team Leaders is to build the local capacity of volunteers and enable the program to be more sustainable. The position gave the opportunity to those who wanted to take on more responsibility in the program. Their roles include managing and supporting their team, coordinating the team equipment, analyzing bacteria samples, preparing phosphorus samples for analysis (e.g. keeping the samples cool), and data submission to CEW. A Team Leader Field Manual was created to guide them in these responsibilities.

In 2007, 15 volunteers were Team Leaders. Twenty of the 31 teams had a Team Leader. In 2008 all teams had a Team Leader; there were 22 Team Leaders in all (some Team Leaders coordinated volunteers from multiple sampling areas), eleven of which were leaders in 2007.

The first portion of each training session took place from 9:15 am to 10:45 am, and was tailored for Team Leaders. It included

- Team Leader registration and equipment kits assembly,
- A presentation on the analysis protocols for bacteria (total Coliform and *E.Coli*) and secchi depth,
- Practicing the protocols in small groups and a question/answer session around the protocols and program.

2.2.2 Team Members

The roles of the Team Members were to collect lake water samples and record water temperature and metadata at their designated sampling area according to the protocols outlined in the Field Manual. In addition, Team Members were responsible for delivering their samples to their Team Leader.

The second portion of each training session was an opportunity for new volunteers to register and learn about the WQI partners, program, protocols and parameters, as well as meeting their Team Leader who stayed for this section of the training.

2.3 Training Video

To improve the quality of the training session, CEW produced a training video for WQI volunteers. The training video outlines the methodologies in the training manual. It is a helpful resource as a visual aid for new volunteers who are unfamiliar with the monitoring protocols, as well as returning volunteers who may need a refresher. It is ready for distribution for the 2009 WQI sampling season.

2.4 Sampling Schedule

The WQI sampling season began on the Victoria Day weekend and ended on the Labour Day weekend. In 2008, sampling took place biweekly throughout the summer. Eight sampling dates were scheduled for all sites.

Unlike in previous years, samples could be collected anytime over the weekend (beginning Friday) rather than being restricted to Monday mornings. The flexibility was possible because the implementation of Team Leaders has made volunteer teams self-sufficient rather than reliant on central planning and coordination that required tighter timeframes. See Table 1 for a complete list of 2008 sampling dates.

Table 1. The eight sample dates for 2008.

Sample	Sample Date
Sample 1	May 16-19
Sample 2	May 30 - June 2
Sample 3	June 13-16
Sample 4	June 27-30
Sample 5	July 11-14
Sample 6	July 25-28
Sample 7	August 8-11
Sample 8	August 22-25

2.5 Water Quality Indicators

As in previous years, the following parameters were used as indicators of water quality in the District of Muskoka Lakes:

- Total Phosphorus: $[TP]_{so}$ and $[TP]_{epi}$
- Bacteria: Total coliform and *E.coli*
- Temperature

New to the WQI in 2007 was the addition of measuring secchi depth to determine water clarity as an alternative to measuring turbidity (or cloudiness). Since measuring turbidity requires the use of a costly turbidimeter (~$1000), it is not sustainable for the long term implementation for the program. In contrast, a secchi disk to measure secchi depth can be easily made with about $20 worth of supplies, or purchased for about $50. Other programs such as the Ministry of the Environment's Lake Partner Program also use secchi depth, enabling measurements to be compared across programs. In 2008, all water clarity measurements were measured by secchi depth.

2.6 Review Team

The monitoring protocols used in the MLA WQI were originally developed by Dr. Neil Hutchinson of Gartner Lee Ltd. prior to the launch of the WQI in 2001. These protocols govern the collection, analysis and reporting of bacteria (*E.coli* and total coliform), total phosphorus concentration and clarity of water samples.

It is part of best practices to periodically review protocols to ensure that they are relevant and effective. CEW assembled a Review Team in February 2008 to advise on how to increase the effectiveness of WQI monitoring protocols. (To be effective, protocols must ensure scientific integrity while balancing the appropriateness for community-based monitoring.) The Review Team consisted of:

- Karl Schiefer, Ph.D. - Bluewater Biosciences
- Harvey Shear, Ph.D. - Professor, Department of Geography, University of Toronto

For details on the Review Team qualifications, see Appendix A. For a copy of the Terms of Reference, see Appendix B.

Each member provided guidance regarding the general appropriateness of bacteria and phosphorus concentration as indicators of ecosystem health. In addition, they considered both the bacteria and phosphorus concentration protocols provided suggestions for increasing their effectiveness considering:

- Materials and equipment used;
- Data collection techniques;
- Data analysis techniques (not methodologies or technology);
- Quality control/quality assurance measures (including collection and analysis);
- Reporting techniques; and
- On-going evaluation.

CEW staff compiled a set of final recommendations which were approved by the Review Team. For a copy of the approved recommendations, see Appendix C. These recommendations have been integrated into the 2008 WQI Field Manual, and are included in Section 3 (Scientific Methods).

The coordinator of the Lake Partner Program at the time, Bev Clark, also contributed to the Review Team. Given his specific expertise in phosphorus sampling however, Bev was not comfortable advising on bacteria monitoring and therefore did not feel qualified to approve the final set of recommendations.

2.7 Outcomes and Achievements

In 2008, 158 sites were monitored in 46 sampling areas on 18 lakes. See Table 2 for examples of these terms. For a list of the sampled sites, please refer to Appendix D.

Table 2. Examples outlining what is considered a lake, sampling area and site

Lake	Lake Muskoka	Star Lake
Sampling Area	Walker's Point	Star Lake
Sites	WAK-0 ,WAK-1, WAK-2, WAK-3	STR-0, STR-1, STR-2, STR-3, STR-4, STR-5

In total, 110 volunteers monitored 29 of the sampling areas. Eighty-two percent of volunteers who attended the training session went on to participate in the program. For a list of the 2008 volunteers, please refer to Appendix E. It is important to note that the volunteer list and these statistics were generated using submitted datasheets. Others may have volunteered without having their names recorded meaning 110 may be an underestimate.

Several sampling areas were only sampled during the spring turnover period, and therefore did not require a monitoring team. In these cases, CEW staff monitored these sites, e.g. one phosphorus, secchi depth and temperature measurement. Continued spring turnover monitoring at these sites is important so that there are temporally consistent datasets to track trends over time. Some other sampling areas were not monitored throughout the season because no volunteers were identified. Season-long monitoring at some of these areas is critical, and it is therefore important to make every effort to recruit volunteers for these areas in the future.

In 2008, there were three new sampling areas: Morgan Bay, Stephen's Bay, and Sunny Lake. These areas were added at the request of MLA members. Unless there was a new Affiliate organization who wanted to participate in the full WQI program, monitoring was limited to spring turnover phosphorus and secchi depth sampling to see if additional monitoring is required. Such sampling also enables comparisons with phosphorus data collected through the Lake Partners Program and the District Municipality of Muskoka.

2.8 Partnerships

There were ten affiliates with the MLA WQI in 2008, three of which are new. They were:

- Brandy Lake Association
- Clear Lake Association
- Leonard Lake Association (returning)
- Moon River Property Owners' Association
- Muldrew Lakes Association
- Silver Lake Association (Township of Muskoka Lakes)
- Skeleton Lake Cottagers' Association
- Star Lake Woods Association

- Sucker Lake Association (returning)
- Sunny Lake Association (new)

Two of these Affiliate groups returned to participation after several years without participating. Two other Affiliates from previous years (Bass Lake Association and the Gull & Silver Lakes Association) did not participate. It is important that the MLA maintain the ongoing participation of existing Affiliates for them to maintain a credible long-term water quality data set, and to gauge the interest of other local association and facilitate early involvement in WQI for 2009.

2.9 Volunteer Appreciation and Program Evaluation

On August 22nd, the MLA hosted a barbeque at Eleanor Lewis' home for all the WQI volunteers. At this event, certificates were presented to volunteers who had been volunteering with the program for over five years. These 24 dedicated volunteers were:

- Doug Applegath (Lake Rosseau)
- Bill Bougher (Lake Rosseau & Joseph)
- Perry Bowker (Silver Lake)
- Jim Cormack (Brandy Lake)
- Louise & Chris Cragg (Beaumaris)
- John & Liz Curran (Lake Rosseau)
- Liz Denyar (Willow Beach)
- John Duncan (Lake Rosseau)
- Beth Guy (Lake Joseph)
- Terry Johnson (Lake Joseph)
- Mark Johnstone (Little Lake Joseph)
- Gord Lee (Gull & Silver Lakes)
- Elaine Logan (Lake Rosseau)
- Beverly Manchee (Lake Rosseau)
- Arch Nordstrum (Bala Bay)
- Gord Ross (Cox Bay)
- Keith & Gayle Schantz (Lake Rosseau & Joseph)
- Bill Sloan (Bala Bay)
- Dirk Soutendijk (Little Lake Joseph)
- Len Wait (Bala Bay)
- John Wood (Muskoka River)

Volunteers were provided with the opportunity to submit evaluations on the WQI program through an online survey. Nineteen responses were received – seven from Team Leaders and twelve from Team Members. Overall, all volunteers appreciated the opportunity to be able to determine the water quality of their lakes themselves and contribute to a long-term dataset while working with others in teams.

A summary of the comments are as follows:

Team Size: For the majority of the responses, volunteers felt that they had just the right number of volunteers on their team. In two instances, respondents commented that there were too few volunteers and not enough trained volunteers.

Training: There was no strong consensus on where to hold future training session. The follow locations were suggested: Bala, Gravenhurst, Port Carling, Rosseau and Toronto. Everyone who attended the training session found it sufficient in preparing them for the program. There was a comment that the training was very useful for new volunteers, but not necessary for repeat volunteers, especially if there are no significant changes in the protocol. There were also no difficulties were reported in filling in the datasheets. There were suggestions on having pre-incubated bacteria samples for the training sessions and practice reading them.

Equipment: It was noted that before equipment kits are distributed, they should be checked to make sure there are enough sample tubes. New and or spare batteries should be provided for the UV lights as well.

Team Leaders: All surveyed Team Leaders found Team Leader Handbook useful, through the time commitment was reasonable, and would consider being a Team Leader in 2009. There was a suggestion of having two to three Team Leaders on rotation for a sampling area and a phosphorus pick-up scheduled should be included in the calendar of events so Team Leaders can make plans accordingly.

2.10 Program Recommendations

Some program recommendations for the 2009 WQI are to:

- Continue having Team Leaders and a Field Staff to support the volunteers

- Perform mid-way volunteer evaluation to address any concerns before the end of the sampling season,
- Improve volunteer tracking to properly assess the value of the program (e.g. number of volunteer hours) and recognize volunteers,
- Use the training DVD in 2009 and provide examples of incubated *ColiPlates* to demonstrate the bacterial analysis, and
- Include extra batteries in the equipment kits for the UV lights and have extra equipment available at the MLA office as a back-up in case any equipment is damaged or missing.

2.11 Conclusion

This WQI program is a valuable asset in building a better understanding of water quality in the Muskoka Lakes area. As its success relies on the regular commitment of volunteers, it is important that the program delivery is regularly evaluated and updated to provide WQI volunteers with the best resources possible.

The WQI volunteers should celebrate the existence of and their contribution to a long- term datasets readily available as it demonstrates the dedication of volunteers in the long-term understanding and protection of water quality in the Muskoka Lakes area.

> *"This is a very important initiative which I am very proud to be a part of.*
> *I am sure there are many other willing volunteers who would be interested in helping.*
> *...Our water is the most important resource we have and we need to protect it.*
> *Without our water we have nothing"*
>
> ~ WQI Volunteer

3 Scientific Methods

3.1 Schedule

Sampling occurred on a biweekly schedule between May 16-19 and August 25-25 (Table 1). Eight sampling dates were established over the course of this time.

3.2 Sites

The sites for each sampling area were predetermined. Volunteers were given a Google Map with satellite imagery with their sites marked, as well as digital photographs of each site. There are two types of sites: nearshore and offshore. Nearshore sites were taken where the water depth as between 50cm and 150cm. Offshore sites are located in deep water near the centre of the sampling area (e.g. lake or bay).

Rationale for site selection remained unchanged from previous years. Bacteria monitoring was maintained in the nearshore zone, with total phosphorus monitoring in the deep water zone. Nearshore phosphorus monitoring was also undertaken in areas that have been identified as 'over-threshold' by DMM as well as areas that are not monitored by DMM but previous WQI data suggest fit the 'over-threshold' criteria.

3.3 Monitoring Parameters

The following parameters were used as indicators of water quality:

- Total Phosphorus: $[TP]_{so}$ and $[TP]_{epi}$[3]
- Bacteria: Total coliform and *E.coli*
- Secchi depth
- Temperature

[3] See definition of Total Epilimnetic Phosphorus

The parameters measured at each sampling date were also predetermined based on the rationale for the site location. Volunteers followed the Field Manual in measuring these parameters. In addition, supplementary information was also recorded on the datasheet, e.g. rainfall, air temperature and sample time. For a copy of the data sheet, see Appendix F.

3.3.1 Phosphorus

Total phosphorus concentration ([TP]) was measured at sites indicated in Appendix G. Digest tubes were supplied by and returned to the Trent University Laboratory at the Ministry of Environment's Dorset Environmental Science Centre. Tubes were distributed to Team Leaders who applied appropriate labels and distributed them to Team Members.

The tubes were filled directly from surface water to avoid potential problems relating to the 'container effect' in which phosphorus may adhere to the sides of sampling vessels and not be transferred to the digest tube used for analysis (Clark and Hutchinson, 1992). Volunteers used the 'plunge and sweep' method to fill digest tubes; they turned the tubes upside-down, plunged them into the lake to approximately forearm depth, turned the tube 90° and 'swept' upwards towards the surface, filling the tube. Digest tubes were kept on ice and delivered to the Team where they stayed chilled until they were sent to the lab in Dorset.

3.3.2 Total Coliform

Volunteers collected samples for total coliform analysis using 300mL juice bottles. The bottles were purchased new from the Consolidated Bottle Company or reused from previous years. The bottles and caps were sterilized in boiling water, sealed and labelled either by CEW staff or Team Leaders.

The bottles were opened at the sampling location. Volunteers were instructed not to come in contact with either the inside of the bottle or the underside of the cap during sampling. The bottles were rinsed (completely filled and then emptied) with lake water three times. The bottle was then filled using the 'plunge and sweep' method described in Section 3.3.1. Samples were placed on ice in the field and returned to the Team Leader for analysis. If the bottle was contaminated, volunteers were instructed to empty any water in the bottle and rinse it with lake water three times before refilling.

Within the same day, analysis was completed as soon as possible after receiving all of the samples. The elapsed time was routinely within 3 hours of sample collection. The samples were kept on ice, in the dark to preserve the bacteria at the naturally occurring level. Water from each sample was poured into a commercially available bacteria testing kit, as shown in Figure 1. The kit is known by the trade name ColiPlate*,* and is manufactured by Bluewater Bioscience Inc. (http://www.bluewaterbiosciences.com).

Each ColiPlate has 96 wells containing an agar that reacts with coliform bacteria and turns blue. Actual bacterial counts are determined by comparing the number of blue cells to a table of Most Probable Numbers (MPN). The MPN table is shown in Appendix H.

Figure 1. ColiPlate with 11 blue wells.

Any well that could be identified as any shade of blue or green was counted as a positive blue well, as per instructions from Bluewater Bioscience. Note that the ColiPlates have a detection limit of three counts/100mL (a count of zero blue wells corresponds to a count of "less than three" coliform/100mL). This barrier was handled by assigning all readings of "less than three" counts of coliform/100mL sample as an absolute value of 1 count/100mL. This is a conservative estimate that reminds the reader that no untreated surface water is free from bacterial contamination.

3.3.3 *Escherichia coli*

After testing for total coliform, each ColiPlate was used to analyze for *Escherichia coli* (*E. coli*). This was done by exposing the plate to a 366nm ultraviolet light. The wells that tested positive for *E. coli* fluoresced under the UV light. The number of fluorescent wells was counted and the MPN of organisms/100 mL was determined by comparison with the MPN tables. After the readings were finished, the ColiPlates were emptied into a septic system and the plastic plates were returned to Bluewater Bioscience office to be cleaned and reused.

As with total coliform measurements, all readings of "less than three" counts of *E.coli*/100mL sample as an absolute value of 1 count/100mL. This is a conservative estimate that reminds the reader that no untreated surface water is free from bacterial contamination.

3.3.4 Secchi Depth

A secchi disk (Figure 2) was used to measure secchi depth in metres. Each disk was attached to with 15 metres of rope (length labeled at 50cm intervals). To record the secchi depth, the volunteer lowered the secchi disk on the rope into the water on the shady side of the boat until they could no longer see it. At this point, the volunteer recorded this depth on the sample date's data sheet, lowered the disk a little further, raised the disk towards the boat until it reappeared and recorded the second depth on the same data sheet. Secchi depth was calculated as the arithmetic mean of the two recorded measurements.

Figure 2. Secchi disk.
(http://www.uwosh.edu/news_bureau/releases/feb06/lake%20monitoring.htm)

3.3.5 Temperature

Temperature readings were recorded for all sites in degrees Celsius. Volunteers hung a pool thermometer from a rope into the surface water when first arriving at each site. After all of the other protocols were completed, the sampler then read the thermometer and recorded the reading.

3.4 Quality Assurance/Quality Control

Replicability of experiments and results is paramount to the effective use of the scientific method. Collecting environmental data in the field is unfortunately subject to countless uncontrollable variables, which makes replicability difficult. For this reason, quality control and quality assurance protocols that aim to identify misinformation and procedural error are of utmost importance in the WQI. As in all previous years since 2002, rigorous training, documentation and random duplicate measures were used throughout the 2008 season.

Quality assurance (QA) is a set of systematic procedures (i.e. preconditions and postconditions) designed to increase the probability of achieving reliable results, even though

QA cannot guarantee quality results. Quality Control (QC) are objective reports back on the reliability of results. QC is therefore the measure of reliability.

3.4.1 Quality Assurance

The QA procedures followed as part of the 2008 water quality initiative were:

- Volunteers filled out and submitted data sheets providing meta-data for every sample (a sample data sheet is found in Appendix F).
- A trained Team Member was required to participate in each sample collection (untrained "helpers" could always assist).
- Training sessions were provided by CEW in May prior to the first sampling date (see Section 2.2). If a volunteer was not able to attend the training session, they had the option of being trained by the CEW field staff at a mutually convenient time. Some experienced volunteers who were also not able to attend the training session were approved as "trained" volunteers based on their previous experience.
- Results of samples were recorded on paper, in MS Excel spreadsheets, and in an MS Access database. Data is additionally stored on Web servers that host the MLA water quality initiative website.

3.4.2 Phosphorus Quality Control

More than ten percent of all phosphorus samples were duplicated. Most duplicates took place during the spring turnover period at deep water sites (sites which stratify). The samples were collected at the same time as the regular phosphorus samples using identical TP tubes and protocols. The duplicate measurements show the range of phosphorus results that can be expected as a result of sampling and laboratory variation.

3.4.3 Bacteria Quality Control

Between 2002 and 2007, the WQI protocols included duplicating ten percent of all bacteria samples and comparing a further five percent of all bacteria samples with "blank" samples of commercially available bottled water. After these six years of study, we felt that the general reliability of the ColiPlate technology had been well demonstrated. We also felt that the literature available on the ColiPlate technology sufficiently confirmed its efficacy (http://www.bluewaterbiosciences.com/products_coliplate_verification.html; Lifshitz and Joshi, 1998). Moreover, volunteers often confuse the various types of bacteria duplicate tests, which cause anxiety and cast doubt on the QC results that are reported. For these reasons, duplicates and "blank" samples were discontinued in 2008.

Five percent of all bacteria (total coliform and *E.coli*) samples were duplicated and analyzed using the ColiPlate technology. These duplicate samples were spread evenly over all sampling areas, but were concentrated on sample dates 1 and 8. (Concentrating the duplicate samples made it easier to ensure volunteer teams collected the duplicate samples).

The samples were collected at the same time as the regular bacteria samples using identical collection vessels and protocols. The duplicate measurements show the range of coliform and *E.coli* results that can be expected.

3.4.4 Results of QC Program

Results of the QC program are found in Appendix I.

3.5 Analysis

The raw data was entered, analyzed and graphed using Microsoft Excel. Statistical calculations, e.g. T-tests, were also calculated using Microsoft Excel. The most recent spring turnover phosphorus data from the District Municipality of Muskoka and the Lake Partner Program were compiled for data comparisons. These were compared to $[TP]_{so}$ that were collected by MLA volunteers in May. $[TP]_{epi}$ were calculated only if the sample size was at least six.

4 Research Program Results

The long-term goal of the MLA water quality initiative is to protect and enhance environmental quality by changing the way lands adjacent to the lakes and rivers are used and developed. This also means ensuring that lands adjacent to sensitive and overburdened lakes and rivers are appropriately protected from development.

As outlined in Section 1.2, the MLA's primary purpose is to objectively determine what factors are causing water quality and environmental impairment in lakes and then to act to mitigate these factors. A secondary research function is to ensure all vulnuerable areas are being adequately protected by policies in the regional and local Official Plans (OPs). This "watchdog" role is appropriate and important for the WQI because its proponent is an independent non-governmental organization. But it is also important to note that it is the strong desire of both the MLA and CEW to help the District as well as neighbouring jurisdictions to ensure that all areas are being appropriately protected through corresponding development regulations. In turn these areas can then be improved through Community Action Plans.

The results of activities carried out as part of Community Action Plans are discussed under separate cover. Comparison of WQI data with phosphorus thresholds is further discussed in Section 4.1 below.

4.1 WQI Data and Phosphorus Thresholds

The District of Muskoka's LSHP, including its classification of lakes and lake segments has been discussed at some length in Section 1.1. In addition, the mechanism used to classify lakes and lake segments was discussed at length in Section 5.1 of the 2007 WQI Monitoring Program Technical Report. In summary, a lake is classified as over-threshold if it meets both of the following criteria:

a) the [TP] predicted by the Muskoka Water Quality Model must be over the threshold calculated for that lake
b) the long-term average [TP] measured by DMM must be over the threshold calculated for that lake (the long-term average is a rolling average of measurements gathered in the last ten years and must be made up of at least three DMM $[TP]_{so}$ measurements, and the three most recent $[TP]_{so}$ measurements must each be over the calculated threshold)

A lake could be de-classified if it met the inverse criteria (i.e. all measurements under-threshold).

Table 3 shows the phosphorus concentration measured in each lake and lake segment monitored as part of the 2008 water quality initiative. The table also compares these results with the lake-specific thresholds identified by the Muskoka Recreational Water Quality Model. The table indicates whether the OP classifies the lake as over-threshold, shows DMM's 2008 $[TP]_{so}$ measurements, ten-year averages of $[TP]_{so}$ measurements and number of $[TP]_{so}$ measurements collected in the past ten years to make up that average by both the MLA and DMM.

If no threshold has been calculated for a sampling area, the "Threshold Area" column indicates the nearest area that does have a threshold associated with it. For example, the Willow Beach area on Lake Muskoka does not have a threshold associated with it in the OP. But this area is part of the larger Lake Muskoka South basin, which does have a threshold associated with it. In this case, the "Threshold Area" column refers to the South basin, and monitoring results are compared to that threshold value.

If the reading in the "Threshold" column is shaded red, that sampling area is classified as over-threshold by the Muskoka OP. Other red cells indicate that that measurement is over the phosphorus threshold. Some 2008 WQI $[TP]_{so}$ samples were either missed or spoiled. These are denoted in the table with a *.

Table 3. 2008 [TP]so (µg/L)Comparison to Threshold Concentrations Identified in Muskoka OP.

			WQI Data			DMM Data		
Sampling Area	Threshold Area	Threshold	2008 $[TP]_{so}$	10 Year Average	No. of Samples	2008 $[TP]_{so}$	10 Year Average	No. of Samples
Arthurlie Bay	Rosseau Main Basin	6.22	6.1	6.1	3			0
Arundle Lodge	Muskoka South Basin	7.9	6.5	6.5	1			0
Bala Bay		6.58	5.85	6.71	6	6.5	6.12	6
Beaumaris		6.73	6.6	6.51	7		5.8	2
Boyd's Bay	Muskoka South Basin	7.9	8.9	7.83	2			0
Brackenrig Bay		5.18	12.9	10.37	6	10.1	8.04	5
Brandy Lake		28.39	19.75	20.89	4	20.5	21.7	2
Clear Lake		4.79	7.35	9.87	2	6.5	6	5
Cox Bay		3.85	8.4	6.09	7	6.6	5.48	6
Dudley Bay		6.6	5.6	5.47	3	7.1	6.22	4
East Bay	Bala Bay	6.58	6.05	9.72	6			0
East Portage Bay		3.92	6.3	5.97	3	7.8	7.1	5
Eilean Gowan Island	Muskoka South Basin	7.9	7.4	7.7	2			0
Gordon Bay	Joseph Main Basin	3.47	3.7	5.22	4			0
Hamer Bay	Joseph Main Basin	3.47	4.65	5.27	7	4.1	4.1	1
Hoc Roc River		25.06	*	25.89	4			0
Indian River		6.22	5.4	6.35	7			0
Joseph River		4.23	6.8	7.05	4	7.1	8.45	4
Lake Joseph Main Basin		3.47	4.95	4.46	4	4.7	5.6	6
Lake Muskoka South Basin		7.9	7.7	6.2	2	5.6	5.47	4
Lake Rosseau Main Basin		6.22	6.75	7.08	3	6.1	5.74	5
Leonard Lake		6.09	6	6	1		7.2	4[4]
Minett	Rosseau Main Basin	6.22	5.55	6.62	5			0
Mirror Lake		6.21	6.85	6.58	2	6.7	7.38	5
Morgan Bay		4.24	5.35	5.35	1			0
Muskoka Bay		10.25	10.5	10.43	7	12.2	13.23	6

[4] Data collected by DMM not yet received.

Sampling Area	Threshold Area	Threshold	WQI Data			DMM Data		
			2008 $[TP]_{so}$	10 Year Average	No. of Samples	2008 $[TP]_{so}$	10 Year Average	No. of Samples
Muskoka Lakes G&CC	Rosseau Main Basin	6.22	4.25	4.51	2			0
Muskoka River		11.08	8.15	8.04	4			0
Muskoka Sands (no Hoc Roc)	Muskoka South Basin	7.9	*	8.77	4			0
North Bay	Whiteside Bay	10.16	5.9	6.7	2			0
North Muldrew Lake		12	12.25	10.42	2	9.4	10.71	5
Rosseau	Morgan Bay	4.24	10.9	8.54	4	6.8	6.8	1
Royal Muskoka Island	Rosseau Main Basin	6.22	5.85	7.39	4			0
Skeleton Bay		5.53	6.15	5.75	3	6.9	7.3	4
Skeleton Lake		4.45	3.9	3.87	3	7.2	5.7	2
Silver Lake (Muskoka Lakes)		5.23	5.45	11.46	5		12.5	4
South Muldrew Lake		9.99	9.45	8.17	2	8.7	8.12	5
Stanley Bay	Joseph Main Basin	3.43	4.4	5.92	4			0
Star Lake	N/A	N/A	14.65	11.02	2			0
Stephen's Bay	Muskoka South Basin	7.9	7	7	1			0
Sunny Lake		10.68	8.6	8.6	1			0[1]
Tobin's Island	Rosseau Main Basin	6.22	6.4	6.13	2			0
Walker's Point	Muskoka South Basin	7.9	7.6	6.36	5			0
Whiteside Bay		10.16	6.25	5.88	3	6.5	6.28	4
Windermere	Rosseau Main Basin	6.22	9.6	6.57	4			0
Willow Beach	Muskoka South Basin	7.9	8.15	12.08	3			0

All [TP] data from the water quality initiative and DMM and MOE Lake Partner Program (LPP) monitoring where available are shown in Appendix I plotted against lake-specific threshold.

4.1.1 Comments and Monitoring Recommendations

Arthurlie Bay – Three $[TP]_{so}$ measurements indicate that [TP] is only slightly below the threshold for Lake Rosseau's south basin. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Arundle Lodge - Measurements indicate that [TP] is below the threshold for Lake Muskoka's south basin. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Bala Bay – WQI 10-year average is slightly above threshold, while DMM data shows area is under threshold. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Beaumaris – All WQI and DMM measurements are slightly below threshold. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Boyd's Bay – The 2008 $[TP]_{so}$ measurement and the 10-year average are over threshold. Recommendation: Initiate [TP] monitoring over the entire season and in the nearshore zone to identify sources of TP loading.

Brackenrig Bay - Brackenrig Bay is identified as over-threshold by DMM. Every measurement of $[TP]_{so}$ (WQI, DMM and LPP) dating back to 1996 has been over-threshold. Recommendation: Continue with monitoring [TP] over the season and in the nearshore zone to identify sources of TP loading. Continue actions to remediate these sources.

Brandy Lake – All data (WQI, DMM and LPP) show that Brandy Lake is under-threshold. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Clear Lake – Clear Lake is identified as over-threshold by DMM. Most measurements of $[TP]_{so}$ (WQI and DMM) dating back to 1987 have been over-threshold. Recommendation: Continue with monitoring [TP] over the season and in the nearshore zone to identify sources of TP loading. Initiate actions to remediate these sources.

Cox Bay - Cox Bay is identified as over-threshold by DMM. Every measurement of $[TP]_{so}$ (WQI and DMM) dating back to 1996 has been over-threshold. Recommendation: Continue with monitoring [TP] over the season and in the nearshore zone to identify sources of TP loading. Continue actions to remediate these sources.

Dudley Bay - WQI and DMM measurements are below threshold. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

East Bay - WQI data is the only data available for this area; while 2008 $[TP]_{so}$ was just under the threshold, the 10-year average is over-threshold. Recommendation: Request that DMM calculate a specific threshold. Continue monitoring $[TP]_{so}$ to ensure that threshold is not exceeded.

East Portage Bay – East Portage Bay is identified as over-threshold by DMM. Every measurement of $[TP]_{so}$ (WQI and DMM) dating back to 2001 has been over-threshold. Recommendation: Continue with monitoring [TP] over the season and in the nearshore zone to identify sources of TP loading. Initiate actions to remediate these sources.

Eilean Gowan Island - Measurements indicate that [TP] is slightly below the threshold for Lake Muskoka's south basin. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Gordon Bay - While 2008 $[TP]_{so}$ was just under the threshold, the 10-year average is over-threshold. Recommendation: Request specific threshold to be calculated. Continue monitoring $[TP]_{so}$ to ensure that threshold is not exceeded.

Hamer Bay – Hamer Bay first monitored by DMM in 2008. Every measurement of $[TP]_{so}$ (WQI and DMM) dating back to 2002 has been over the threshold for Lake Joseph's main basin. Recommendation: Request that DMM calculates a specific threshold. Continue with monitoring [TP] over the season and in the nearshore zone to identify sources of TP loading. Initiate actions to remediate these sources.

Hoc Roc River – Even though DMM has calculated a threshold for the Hoc Roc River, and predicts that the [TP] is over-threshold, DMM does not monitor here and therefore cannot classify the area as over-threshold. WQI data is the only data available for this area; while $[TP]_{so}$ was not collected in 2008, the 10-year average, previous $[TP]_{so}$ measurements and seasonal average [TP] measurements all suggest that the area is over-threshold. Recommendation: Request that DMM begins to monitor and/or classifies this area as over-threshold. Initiate actions to remediate possible sources of TP loading.

Indian River - Even though DMM has calculated a threshold for the Indian River, and predicts that the [TP] is over-threshold, DMM does not monitor here and therefore cannot classify the area as over-threshold. WQI data is the only data available for this area; while 2008 $[TP]_{so}$ was under threshold, the 10-year average is slightly over-threshold. Recommendation: Request that DMM begins to monitor. Continue monitoring $[TP]_{so}$ to ensure that threshold is not exceeded.

Joseph River – Even though every single $[TP]_{so}$ measurement collected in the Joseph River dating back to 2003 (collected by WQI and DMM) has been over-threshold, DMM does not classify this area as over-threshold because its model does not predict that the [TP] is over-threshold. Recommendation: Insist that DMM recalibrates the model immediately and/or classifies the Joseph River as over-threshold. Restart [TP] monitoring throughout the season and in the nearshore zone in order to identify sources of TP loading. Initiate actions to remediate sources of TP.

Lake Joseph (main basin) - Even though every $[TP]_{so}$ measurement collected by DMM and all but one $[TP]_{so}$ measurement collected by the WQI in the main basin of Lake Joseph dating back to 1996 has been over-threshold, DMM does not classify this area as over-threshold because its model does not predict that the [TP] is over-threshold. Recommendation: Insist that DMM recalibrates the model immediately and/or classifies the main basin of Lake Joseph as over-threshold. Continue [TP] monitoring in various areas around the basin in order to identify sources of TP loading. Initiate actions to remediate sources of TP.

Lake Muskoka (south basin) - WQI and DMM measurements are below threshold. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Lake Rosseau (main basin) – WQI measurements tend to be over-threshold while DMM measurements are below-threshold. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Leonard Lake - Leonard Lake is identified as over-threshold by DMM; the WQI first measured $[TP]_{so}$ in 2008. Recommendation: Initiate monitoring [TP] over the season and in the nearshore zone to identify sources of TP loading. Initiate actions to remediate these sources.

Minett - WQI data is the only data available for this area; while the 10-year average $[TP]_{so}$ is over-threshold, it has been under-threshold since 2006. Recommendation: Continue monitoring $[TP]_{so}$ to ensure that threshold is not exceeded.

Mirror Lake – Mirror Lake is identified as over-threshold by DMM. All but one measurement of $[TP]_{so}$ (WQI and DMM) dating back to 1999 has been over-threshold. Recommendation: Continue with monitoring [TP] over the season and in the nearshore zone to identify sources of TP loading. Initiate actions to remediate these sources.

Morgan Bay - Even though DMM has calculated a threshold for Morgan Bay, and predicts that the [TP] is over-threshold, DMM first monitored here in 2008 and therefore cannot classify the area as over-threshold. All $[TP]_{so}$ measurements collected in this area (by WQI, DMM and LPP) dating back to 2004 are over-threshold. Recommendation: Initiate [TP] monitoring over the season and in the nearshore zone to identify sources of TP loading.

Muskoka Bay – Muskoka Bay is identified as over-threshold by DMM. While 2008 $[TP]_{so}$ measurements and 10-year averages are over-threshold, [TP] has been decreasing for several years. Recommendation: Continue with monitoring [TP] over the season and identify sources of TP loading in the nearshore zone. Continue with actions to remediate these sources.

Muskoka Lakes Golf & Country Club - Measurements indicate that [TP] is below the threshold for Lake Rosseau's main basin. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Muskoka River - Measurements indicate that [TP] is below the threshold. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Muskoka Sands - While the 10-year average $[TP]_{so}$ is over-threshold, it has been under-threshold since 2004. Recommendation: Continue monitoring $[TP]_{so}$ to ensure that threshold is not exceeded.

North Bay - Two $[TP]_{so}$ measurements indicate that [TP] is below the threshold for Whiteside Bay. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

North Muldrew Lake – Most $[TP]_{so}$ measurements collected since 1998 indicate that the area is under-threshold, even though the 2008 $[TP]_{so}$ measurement was slightly over-threshold. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Rosseau - Every single $[TP]_{so}$ measurement collected near Rosseau dating back to 2002 has been over the threshold established for Morgan Bay. Recommendation: Request that DMM calculates a specific threshold for this area and begin to monitor it. Restart [TP] monitoring throughout the season and in the nearshore zone in order to identify sources of TP loading.

Royal Muskoka Island - The 2008 $[TP]_{so}$ measurement was under the threshold established for Lake Rosseau's south basin, while the 10-year average is over-threshold. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Skeleton Bay - Even though all but one $[TP]_{so}$ measurement collected in Skeleton Bay dating back to 2003 (collected by WQI and DMM) has been over-threshold, DMM does not classify this area as over-threshold because its model does not predict that the [TP] is over-threshold. Recommendation: Insist that DMM recalibrates the model immediately and/or classifies Skeleton Bay as over-threshold. Initiate [TP] monitoring throughout the season and in the nearshore zone in order to identify sources of TP loading.

Skeleton Lake – Most $[TP]_{so}$ measurements collected in Skeleton Lake dating back to 1994 (collected by WQI, DMM and LPP) indicate that the area is under-threshold. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Silver Lake – Silver Lake is identified as over-threshold by DMM. Every measurement of $[TP]_{so}$ (WQI and DMM) dating back to 1994 has been over-threshold. Recommendation: Continue with monitoring [TP] over the season and in the nearshore zone to identify sources of TP loading. Initiate actions to remediate these sources.

South Muldrew Lake - All but one data (WQI and DMM) show that South Muldrew Lake is under-threshold. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Stanley Bay – Even though every single $[TP]_{so}$ measurement collected by the WQI in Stanley Bay dating back to 2004 has been over-threshold, DMM does not classify this area as over-threshold because its model does not predict that the [TP] is over-threshold and they do not monitor it. Recommendation: Insist that DMM/Seguin Township recalibrates the model immediately, begins monitoring in this area and/or classifies Stanley Bay as over-threshold. Continue [TP] monitoring throughout the season and in the nearshore zone in order to identify sources of TP loading. Initiate actions to remediate sources of TP.

Star Lake – Star Lake is not part of the Muskoka River watershed, and as such, is not modelled by DMM (no lake specific threshold calculated). Recommendation: Continue to monitor $[TP]_{so}$ in order to establish and evaluate trend in [TP].

Stephen's Bay - WQI data is the only data available for this area, and 2008 was the first year it was monitored. Measurements indicate that [TP] is below the threshold for Lake Muskoka's south basin. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Sunny Lake - Data (collected by WQI, DMM and LPP) show that Sunny Lake is under-threshold. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Tobin's Island - While 2008 $[TP]_{so}$ is slightly over-threshold, the 10-year average is under-threshold. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Walker's Point - All data show that [TP] is under the threshold identified for Lake Muskoka's south basin. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Whiteside Bay – All data (collected by WQI and DMM) show that Whiteside Bay is under-threshold. Recommendation: Continue monitoring $[TP]_{so}$ to ensure threshold is not exceeded.

Windermere - WQI data indicates that [TP] is slightly over-threshold. Recommendation: Request that DMM calculates a lake-specific threshold for this area. Restart [TP] monitoring throughout the season and in the nearshore zone to identify the sources of TP loading. Initiate actions to remediate sources.

Willow Beach - Every measurement recorded since 2004 has been over-threshold. Recommendation: Request that DMM calculates a lake-specific threshold. Continue with monitoring [TP] over the season and in the nearshore zone to identify sources of TP loading. Initiate actions to remediate these sources.

4.1.2 Conclusion

The $[TP]_{so}$ data that the WQI has accumulated since 2002 can be used by the MLA to help the District of Muskoka and neighbouring jurisdictions protect our lakes within existing regulatory regimes. It is up to the MLA and local governments to use this data to ensure that as many areas as possible are being appropriately classified, protected by development regulations and improved using Community Action Plans. For this reason, the MLA should continue to collect $[TP]_{so}$ measurements from all of the areas monitored in 2008 for the foreseeable future, and where requested by members, add additional sites. These measurements are relatively easy to collect, relatively cheap to analyze and provide a good 'return on investment.' The analysis found in Section 4.1 can further simplify to five recommendations found in Section 5.

5 Recommendations

The analysis found in Section 4.1 can further simplify to five general recommendations. Four of these can easily be carried out before the 2009 monitoring season begins, while the fifth will require long-term commitment from the MLA, local community members and other stakeholders. The MLA should:

A. Recommend that the District of Muskoka **recalibrate** the Muskoka Water Quality Model **with actual results** to ensure that the LSHP effectively protects all vulnerable areas through development regulations. The MLA should also recommend that if an area is over threshold, the policies in place to stop development in such circumstances are adhered to. Four areas considered by the WQI have a phosphorus concentration that exceeds the accepted threshold but are currently not protected by development regulations. These areas are the Main Basin of Lake Joseph, the Joseph River, Stanley Bay and Skeleton Bay.

B. Request that the District of Muskoka **begin monitoring** $\mathbf{[TP]_{so}}$ in areas where the Muskoka Water Quality Model already predicts that [TP] thresholds are exceeded, but no monitoring has taken place to confirm the model's predictions. These specific areas are the Indian River and Hoc Roc River.

C. Request that the District of Muskoka either **calculate specific thresholds** for areas that have [TP] that clearly exceed the threshold for the larger lake basin which they are a part of, or **protect these areas** with development regulations based on the larger basin threshold. Specifically, these areas are East Bay, Gordon Bay, Hamer Bay, Rosseau (village), Windermere, and Willow Beach.

D. Recruit volunteers to initiate [TP] monitoring for the entire monitoring season in the offshore and nearshore zones where $[TP]_{so}$ measurements indicate that it may be vulnerable to increased nutrients. This monitoring should be used to **identify sources of TP loading**, and as a foundation for remedial measures in the future. Specific areas are Boyd's Bay, Morgan Bay and Skeleton Bay.

E. In support of community members and partnership with local governments and other stakeholders, **continue or initiate Community Action Plans** in areas where [TP] measurements show nutrient levels in lakes have already surpassed acceptable thresholds. These plans should be community-based and spearheaded by community members themselves; the MLA in partnership with local governments should work with community members to build their capacity for improving and protecting their local environment. Specific areas are Brackenrig Bay, Clear Lake, Cox Bay, East Portage Bay, Hamer Bay, Hoc Roc River, Leonard Lake, Mirror Lake, Muskoka Bay, Silver Lake, Stanley Bay and Willow Beach.

In addition, the Summary Report and online map should be widely distributed to MLA members. Educational articles should also be written on the MLA website and for MLA newsletters to educate members on the findings of this Technical Report.

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Joyce Chau, BScH
Program Manger, Science & Research
Citizens' Environment Watch

January 31, 2009

References

Brouse, Judi, Director of Water Programs, District of Muskoka. Telephone conversation, 18 May 2006.

Clark, B.J. and N.J. Hutchinson, 1992. Measuring the trophic status of lakes : sampling protocols. Ontario Ministry of the Environment Technical Report. 36 pp.

District Municipality of Muskoka (DMM), November 12, 2007. Office Consolidation of the Official Plan of the Muskoka Planning Area. Planning & Economic Development Department, Bracebridge, ON.

Gartner Lee Limited (GLL), June 2005. Recreational Water Quality Management in Muskoka. Gartner Lee Limited, Bracebridge, ON. 98 pp.

Lifshitz, Ran and Renu Joshi, 1998. Comparison of a Novel ColiPlateTM Kit and the Standard Membrane Filter Technique for Enumerating Total Coliforms and *Escherichia coli* Bacteria in Water. Environmental Toxicology and Water Quality 13: 157-164.

Citizens' Environment Watch, 2007. WQI Monitoring Program Technical Report, November 30, 2007. Citizens' Environment Watch, Toronto, Ontario.

Muskoka District (http://www.muskoka.on.ca/siteengine/activepage.asp?PageID=230), viewed January 15, 2009.

Appendix A

Review Team Qualifications

Prof. Harvey Shear

Born in Toronto

Ph.D. University of London (UK) – Freshwater ecology of blue green algae

B.Sc. University of Toronto - Aquatic ecology

Present Position: Professor (part time)

Department of Geography, University of Toronto

Mississauga.

- **Former Canadian Chair and now member of the International Joint Commission's Council of Great Lakes Research Managers**
- **Member, Board of Directors, Great Lakes Observation System**
- **Member of the Town of Oakville Environmental Strategic Plan Advisory Committee.**
- **Previous position as Regional Science Advisor Environment Canada-Ontario Region. Involved provision of scientific advice in Ontario on all environmental issues.**
- **Former Canadian Chair of the Biennial State of the Lakes Ecosystem Conference (SOLEC) with USEPA**
- **Previous positions with Department of Fisheries and Oceans (DFO) and the International Joint Commission Regional Office. These involved development of biological monitoring programs, an intensive monitoring program for Lake Superior, establishment of a habitat management program for DFO in Ontario, and the land mark Pollution from Land Use Activities Reference Group (PLUARG) amongst other achievements.**

Prof. Shear teaches three undergraduate courses on 1) world freshwater resources, 2) on ecology / economy and 3) on the Great Lakes.

He has published numerous scientific papers on aquatic ecology and management, on ecological and sustainability indicators for the Great Lakes, and on the hydrology and nutrient regime in Lake Chapala, Mexico's largest lake.

He is now actively involved in research on Lake Zapotlán (Mexico), including the development of a basin wide management plan and a set of ecosystem health indicators for this lake and its basin through extensive public consultation.

He is also working on a set of sustainability indicators for the Town of Oakville, Ontario as part of its Environmental Strategic Plan.

Karl Schiefer, Ph.D.
Professional Biologist
Fishery and Aquatic Sciences

Dr. Karl Schiefer is a professional fishery biologist and aquatic ecologist with over 25 years of research and resource management experience. He carried out M.Sc., Ph.D. and post-doctoral research on fisheries and aquatic ecosystems prior to being appointed Research Assistant Professor at the University of Waterloo in 1972. Following three additional years of biological research at Waterloo and the Matamek Salmon Research Station, he became an environ-mental consultant specializing in fisheries and aquatic ecosystem research and management.

Karl has been directly involved with over 250 environmental projects in the fields of fisheries and aquatic sciences, environmental assessment and natural resource management. His particular specialization covers biological studies and management of Atlantic salmon and other freshwater fish species, including stock assessments, habitat studies, fishery enhancement programs, fishery and aquatic ecosystem management, and environmental assessment. He has provided expert testimony in the fields of environmental damage assessment, environmental planning and impact mitigation, and aquatic habitat restoration and enhancement.

Karl is the author of numerous scientific and technical reports, publications and presentations, and is an active member of several professional and environmental organizations and advisory committees.

Accomplishments

Actively involved as senior scientist or specialist advisor on major fisheries and environmental projects in Canada and internationally.

Research Supervisor at the Matamek Salmon Research Station and Research Assistant Professor, University of Waterloo (1971-1974).

Clients include numerous corpora-tions in the forest products, mining, electrical utilities, oil and gas, manufacturing, chemical and pipe- line sectors, as well as federal, provincial and municipal governments.

Director of ten Canadian and U.S. corporations in the business of environmental research and consulting.

President and Senior Principal of Beak Consultants Limited and Beak International for over 15 years, during which time the company grew to be one of the foremost providers of biologically-based research and professional consulting services in Canada and North America.

Expertise

- fisheries ecology and management
- limnology and water quality
- aquatic ecosystem processes
- fish habitat protection, restoration and enhancement
- watershed studies and management
- environmental impact assessment on aquatic ecosystems

Experience

University of Guelph 1967, B.Sc.

University of Waterloo 1969, M.Sc., and 1971, Ph.D. (Atlantic Salmon Biology)

Post-doctoral Fellowship 1971, Woods Hole Oceanographic Institute (Fisheries Research and Management)

Banff School of Advanced Management 1976

Member of the Canadian Society of Environmental Biologists

Member of the Canadian Environ-mental Industry Association

Member of the Rawson Academy of Aquatic Sciences

Scientific Advisor to the International Atlantic Salmon Federation

Member of the Canadian Electrical Association - Environmental Subcommittee

Appendix B

Review Team Terms of Reference

The "Ontario Lakes for the Future" Review Team

Terms of Reference

Drafted: February 15, 2008

The Review Team will be composed of three members with expertise in surface water quality monitoring. The mandate of the Review Team shall be governed by these Terms of Reference, and will end March 31, 2008.

The role of the Review Team is to advise CEW program staff on how to increase the effectiveness of its water quality monitoring protocols. Effective protocols must ensure scientific integrity while balancing the appropriateness for community-based monitoring.

Each member will provide guidance to CEW program staff regarding the general appropriateness of bacteria and phosphorus concentration as indicators of ecosystem health. In addition, the Review Team will consider both the bacteria and phosphorus concentration protocols currently used by CEW and provide suggestions for increasing their effectiveness considering:

- Materials and equipment used;
- Data collection techniques;
- Data analysis techniques (not methodologies or technology);
- Quality control/quality assurance measures (including collection and analysis);
- Reporting techniques; and
- On-going evaluation.

All information supplied to the Review Team in the course of the review process shall be considered confidential, and may not be distributed without the written consent of CEW.

CEW staff will compile final recommendations based on all submitted comments. The Review Team will then have the opportunity to refine and reach a consensus on these recommendations, as well as provide written approval of them.

The time commitment is expected to be about five hours. There is no remuneration for Review Team members.

CEW will endeavour to implement all recommendations while taking into account various limitations (e.g. equipment, finances, training, etc.).

The "Ontario Lakes for the Future" Review Team Timeline

Completion Date	**Item**
February 29	Review Team established Approval of Terms of Reference
March 14	Review materials in package Review Team meeting (conference call) Circulation of minutes and draft recommendations
March 21	Revisions to recommendations
March 28	Written approval of the final list of recommendations

Appendix C

Review Team List of Recommendations

ONTARIO LAKES FOR THE FUTURE
REVIEW TEAM RECOMMENDATIONS
April 2008

Review Team (listed alphabetically):
Bev Clark[5]
Coordinator, Lake Partner Program, Dorset Environmental Science Centre

Karl Schiefer, Ph.D.
Bluewater Biosciences, Mississauga

Harvey Shear, Ph.D.
Professor, Department of Geography, University of Toronto (Mississauga)

GENERALLY
The protocols under review represent the standard practice for this type of water quality monitoring and analysis, and generally very good.

MONITORING PROTOCOLS
At each site:
- There should be some explanation of site selection, e.g. control sites and test sites, or bacterial "hot spots".
- Explain why nearshore bacterial samples are taken where the water depth is between 50 cm and 150 cm: this is an area of primary recreational use/water contact, e.g. swimming.
- Update the manual to specify that turbidity will be measured using secchi depth only. Footnote 1 should be removed entirely as all volunteers will be measuring turbidity using secchi depth as of 2008.
- Ensure that the protocol for secchi depth measurement is standardized in a temporal and spatial context.

ANALYSIS PROTOCOLS
Before the season starts:
- Update the manual should indicate that the bottles are drained and sealed after being removed from the boiling water bath.
- An alternative to sterilizing the water bottles was suggested:

---

[5] CEW intended to secure representation from academia, the private sector and the government on the Ontario Lakes for the Future Review Team. Multiple individuals within the Ontario Ministry of the Environment (i.e. Andrew Patterson, Beth Gilbert and Wolfgang Scheider) all recommended Bev Clark. As Bev's expertise is in phosphorus sampling, he submitted comments and suggestions around this parameter. However, he did not feel comfortable commenting on the monitoring of other parameters such as bacteria. As such, Bev has chosen to not sign off on the following list of recommendations.

- Sterilize all the bottles (include spares) at the beginning of the sampling program and appropriately label both the caps and bottles
  - After the sample water is removed for analysis, rinse each bottle and cap with sterilized or distilled water and set aside, cap on, for use on the next sampling date
  - Before collecting the next sample, rinse the bottle and cap three times in the lake at the sampling location. The sample is then collected, ensuring that the same bottle is always used at the same site for which it is labeled.
  - This process is repeated for each sampling period.
  - This procedure reduces the number of sampling bottles required, is simple for the operator to follow, and QA/QC testing has confirmed that it avoids sample contamination.

Prepare the collected samples:

- Include more detailed instructions on pouring sample water from the bottle into the ColiPlate, referring to the Bluewater Biosciences procedure - www.bluewaterbiosciences.com/products_coliplate_direct_pour_method.html

Analysis of samples:

- For counting blue cells, the ColiPlate should be placed on a white sheet of paper in bright light.
- For counting fluorescing cells, the ColiPlate should be placed on a black or dark surface in as dark a room as possible.
- When counting the fluorescing cells to confirm *E. coli*, only those cells which were blue and fluorescing should be counted. Occasionally, there will be white fluorescing cells which are a species of algae, not bacteria. The blue colour indicates coliforms while the fluorescence of a blue cell confirms that the *E. coli* group of coliforms is present.
- After emptying the used ColiPlate, it should be rinsed prior to placing in a box or bag for returning at the end of the season. This greatly helps in the cleaning and refurbishing of the used plates.
- Reference the Bluewater Biosciences Inc. website for more background information and user guidance for ColiPlates.

STATEMENT OF AGREEMENT

I have read, understood and agree with the Ontario Lakes for the Future Review Team Recommendations as stated above.

Harvey Shear		April 28, 2008
Name	Signature	Date
Karl Schiefer		2 MAY 2008
Name	Signature	Date

Appendix D

List of Sampled Sites

Table 4. A list of all the sampled sites in 2008 and the parameters monitored at each site.

A white circle indicates that less than 6 samples were taken (i.e., there was not enough samples to calculated meaningful averages, namely $[TP]_{epi}$).

Lake/River	Sample Area	Site	Phosphorus	Bacteria	Secchi Depth	Temperature
Brandy Lake	Brandy Lake	BDY-0	○		●	○
		BDY-1		●		●
		BDY-2		●		●
		BDY-3		●		●
		BDY-5		●		●
		BDY-6		●		●
Clear Lake (TML)	Clear Lake (TML)	CLR-0	●		●	
		CLR-1	●	●		●
		CLR-2	●	●		●
		CLR-3	●	●		●
		CLR-4	●	●		●
Hoc Roc River	Hoc Roc River	MSN-4	●	●		●
Indian River	Indian River	IND-0	○		○	○
Joseph River	Joseph River	JOR-0	○		○	○
Lake Joseph	Cox Bay	COX-0	●		●	●
		COX-1	●	●		●
		COX-2	●	●		●
		COX-3	●	●		●
		COX-4	●	●		●
	Gordon Bay	GNB-0	○		●	●
		GNB-1		●		●
		GNB-2		●		●
		GNB-3		●		●
		GNB-4		●		●
	Hamer Bay	HMB-0	●	●	●	●
		HMB-1	●	●		●
		HMB-2	●	●		●
		HMB-3	●	●		●
		HMB-4	●	●		●

Lake/River	Sample Area	Site	Phosphorus	Bacteria	Secchi Depth	Temperature
Lake Joseph	Main Joseph	JOS-1	●		●	●
	Stanley Bay	STN-0	●		●	●
		STN-1	●			●
		STN-2	●			●
		STN-3	●			●
Lake Muskoka	Arundle Lodge	ARN-0	○		○	○
	Bala Bay	BAL-0	○		○	○
	Beaumaris	BMR-0	●	●	●	●
		BMR-2	●	●		●
		BMR-3		●		●
		BMR-5	●	●		●
		BMR-6	●	●		●
		BMR-7	○	●		●
	Boyd's Bay	BOY-0	○	●	●	●
		BOY-1		●		●
		BOY-2		●		●
		BOY-3		●		●
	Dudley Bay	MUS-2	○		○	○
	East Bay	EAS-0	●	●	●	●
		EAS-1	●	●		●
		EAS-2	●	●		●
		EAS-3	●	●		●
	Eilean Gowan	ELG-0	○		○	○
	Main Muskoka	MUS-3	○		○	○
	Muskoka Bay	MBA-0	●	●	●	●
		MBA-2	●			●
		MBA-3	●	●		●
		MBA-4	●	●		●
		MBA-5	●	●		●
		MBA-7	●			
		MBA-8	●			
		MBA-9	●			
		MBA-10	○			

Lake/River	Sample Area	Site	Phosphorus	Bacteria	Secchi Depth	Temperature
Lake Muskoka	Muskoka Sands	MSN-0	●	○	●	●
		MSN-1		○		●
		MSN-2		○		●
		MSN-3		○		●
	North Bay	NRT-0	○		○	○
	Stephen's Bay	STE-0	○		○	○
	Walker's Point	WAK-0	○	●	●	●
		WAK-1		●		●
		WAK-2		●		●
		WAK-3		●		●
	Whiteside Bay	WTS-0	○		○	○
	Willow Beach	WLB-0	●	●	●	●
		WLB-1	●	●		●
		WLB-2	●	●		●
		WLB-3	●	●		●
Lake Rosseau	Arthurlie Bay	ART-0	○		○	○
	Brackenrig Bay	BRA-0	●			
		BRA-1	●			
		BRA-2	●			
		BRA-3	●			
	Mid Rosseau	ROS-1	○		○	○
	Minett	MIN-0	○	●	○	●
		MIN-1		●		●
		MIN-4		●		●
		MIN-5		●		●
	Morgan Bay	MGN-0	○		○	○
	Muskoka Lakes G&CC	MLG-0	○		○	○
	Portage Bay	POR-0	●	●	●	●
		POR-1	●	●		●
		POR-2	●	●		●
		POR-3	●	●		●
		POR-4	●	●		●
		POR-5	●	●		●

Lake/River	Sample Area	Site	Phosphorus	Bacteria	Secchi Depth	Temperature
Lake Rosseau	Rosseau (north)	RSH-0	●		●	●
		RSH-2	●			●
		RSH-3	●			●
		RSH-4	●			●
	Royal Muskoka Island	RMI-0	○		○	○
	Skeleton Bay	ROS-2	○		○	○
	Tobin's Island	TOB-0	○		○	○
	Windermere	WIN-0	○	●	●	●
		WIN-1		●		●
		WIN-3		●		●
		WIN-4		●		●
		WIN-5		●		●
Leonard Lake	Leonard Lake	LEO-0	●	●	●	●
		LEO-1		●		●
		LEO-2		●		●
		LEO-3		●		●
Mirror Lake	Mirror Lake	MIR-0	○		●	●
		MIR-1	●			●
		MIR-2	●			●
		MIR-3	●			●
Moon River	Moon River	MOO-1		●		●
		MOO-3		●		●
		MOO-4		●		●
		MOO-5		●		●
		MOO-6		●		●
		MOO-7		●	●	●
		MOO-8		●		●
		MOO-9		●		●
Muldrew Lakes	Muldrew Lakes	MLD-1	●		●	
		MLD-2	●		●	
		MLD-3	●		●	
		MLD-4		●		●
		MLD-5		●		●
		MLD-6		●		●
		MLD-7		●		●

Lake/River	Sample Area	Site	Phosphorus	Bacteria	Secchi Depth	Temperature
Muskoka River	Muskoka River	MRV-1	●	●	●	●
		MRV-2	●	●	●	●
		MRV-3	●	●	●	●
		MRV-4	●	●		●
Silver Lake (TML)	Silver Lake (TML)	SPC-0	●		●	
		SPC-1		●		●
		SPC-2		●		●
		SPC-3		●		●
Skeleton Lake	Skeleton Lake	SKL-1		●		●
		SKL-2		●		●
		SKL-3		●		●
		SKL-4		●		●
		SKL-5	○	●	●	●
Star Lake	Star Lake	STR-0	○		●	
		STR-1		●		●
		STR-2		●		●
		STR-3		●		●
		STR-4		●		●
		STR-5		●		●
Sucker Lake	Sucker Lake	SUC-0			●	
		SUC-1		●		●
		SUC-2		●		●
		SUC-3		●		●
		SUC-4		●		●
Sunny Lake	Sunny Lake	SUN-0	○			
		SUN-1		●		●
		SUN-4		●		●
		SUN-5		●		●

Appendix E

Volunteer Teams

Table 5. A list of 2008 sampled lakes, areas and volunteer teams. Team Leaders are in bold font. (This list was compiled from the submitted datasheets and some names may be omitted if they were not recorded on the datasheet). Shaded areas indicate that the areas were sampled by CEW, not volunteers.

Lake	Sample Area	Volunteers
Brandy Lake	Brandy Lake	Barbara Fraser Tony Mathia Donna Sale **Peter Sale** Gary Staley
Clear Lake (TML)	Clear Lake (TML)	Bob Cleverdon **Sharon Cleverdon**
Indian River	Indian River	
Joseph River	Joseph River	
Lake Joseph	Cox Bay	**Gord Ross**
	Gordon Bay	Kerry Davies **Andrew Watson** Keith Watson
	Hamer Bay	Kerry Davies **Andrew Watson** Keith Watson
	Main Joseph	Anne Jonker Gerry Jonker **Andrew Watson**
	Stanley Bay	Anne Jonker Gerry Jonker **Andrew Watson**
Lake Muskoka	Arundle Lodge	
	Bala Bay	
	Beaumaris	Cheryl Cragg Chris Cragg **Louise Cragg** Eliza Nevin Susan Ross Lloyd Walton
	Boyd's Bay	Chris Blaymires Dave Langford Lynne Langford **John Wood**
	Dudley Bay	
	East Bay	Julie Bullen Chris Cragg **Louise Cragg** Verna Ray Brenda Walton Lloyd Walton

Lake	Sample Area	Volunteers
Lake Muskoka	Eilean Gowan	
	Main Muskoka	
	Muskoka Bay	George Genereux Juris Svistuenko Brian Yeates **Diane Yeates**
	Muskoka Sands	**Al Ward** Carole Ward
	North Bay	
	Stephen's Bay	
	Walker's Point	Sam Crabbe **Marilyn Gibson** Caelon Kavcic Fiona Kavcic Howard Quennell Joanne Quennell Beth Tate Doug Tate
	Whiteside Bay	
	Willow Beach	Liz Denyar **John Wood**
Lake Rosseau	Arthurlie Bay	
	Brackenrig Bay	**Janet Palmer**
	Mid Rosseau	
	Minett	**Doug Applegath** John Curran Liz Curran
	Morgan Bay	
	Muskoka Lakes G&CC	
	Portage Bay	Natalie Hibert **Joan McKinnon** Marcia Shortreed Jen Westcott Sarah Westcott
	Rosseau (north)	Keith Morrison David Peacock Mary Anne Peacock **Barry Rowland**
	Royal Muskoka Island	
	Skeleton Bay	
	Tobin's Island	
	Windermere	**Doug Applegath** Bev Manchee Morgan Simmonds

Lake	Sample Area	Volunteers
Leonard Lake	Leonard Lake	**Gord Roberts**
Mirror Lake	Mirror Lake	Carling Spence Rick Spence **Sandy Tozer Spence**
Moon River	Moon River	Allen Bossin Jane Bossin Steve Burdick Bruce Calder Nancy Calder Jon Gurr **Peter Hemming** Brian McDonald Bob McTavish Linda Neumann Werner Neumann Bill Niess Walt Scott
Muldrew Lake	Muldrew Lake	**Lola Bratty** Alex Brown Beverly Brown Michael Foster Jane Gunther Cameron Hammond Catherine Hammond Steven Hammond Susan Hammond Brian McDonald Eric Steeves Barbara Vandevalk
Muskoka River	Muskoka River	Debbie Hastings **John Wood**
Silver Lake (TML)	Silver Lake (TML)	**Perry Bowker**
Skeleton Lake	Skeleton Lake	Jermie Rivest Carol Shepherd Chloe Shepherd **Alex Shepherd** Emma Ward

Lake	Sample Area	Volunteers
Star Lake	Star Lake	Charolette Baker Emmateen Baker Victoria Baker Elles D'Wolf Ralph D'Wolf **Karen Gillies** Kate Gillies Neil Gillies Nadia Mokriy Peter Mokriy Terry Mokriy Harold Slater Sara Slater Donna Williamson
Sucker Lake	Sucker Lake	**Greg Clarkson** Randy Haber
Sunny Lake	Sunny Lake	**Denis Butcher** Drew Kivel Ian (last name not provided)

Appendix F

Data Sheet

BDY – Brandy Lake

General Information

Date		**Sample Time**	
Trained Sampler		**Other Volunteers**	
Rainfall (heavy, moderate, light, none)		**Air Temp.**	

Secchi Depth (if necessary)

"Down" Depth		**"Up" Depth**	

For Lab use

Preparation Time		**Analysis Time**	

Site Specific Information

For lab use

Site Code	Water Temp.	Waves	Water Depth	Distance from Shore	Blue	TC Count	Flor.	EC Count	Turb.
BDY-0		☐ Calm ☐ Rough							
BDY-1		☐ Calm ☐ Rough							
BDY-2		☐ Calm ☐ Rough							
BDY-3		☐ Calm ☐ Rough							
BDY-5		☐ Calm ☐ Rough							
BDY-6		☐ Calm ☐ Rough							

Figure 3. An example of the WQI datasheet.

Appendix G

Most Probable Number Table

Bluewater Biosciences Incorporated

14 Abacus Road, Brampton, Ontario, Canada, L6T 5B7
Tel: (905) 794-3274 Fax: (905) 794-2338

COLIPLATE™-400

INTENDED USE The ColiPlate™-400 is a rapid, convenient and accurate test for quantitative measure of total coliforms and *E. coli*. The test is designed to meet regulatory guidelines for surface water, recreational water, processing water and wastewater. The ColiPlate enables quantification of coliforms and *E. coli* density ranging between ca. 3 to 2,400 cfu/ 100 mL in a single test unit without dilution. The distinctive blue/green coloration of positive tested samples enables analysis of brownish, turbid or rust filled waters.

TEST PRINCIPLE AND FEATURES The ColiPlate test utilizes the proven X-Gal and MUG techniques to detect viable coliforms and/or *E. coli* bacteria. The ColiPlate contains selective media to provide nutrients to stimulate the growth of coliforms and *E. coli*. The media also contains inducers and chromogenic/fluorogenic substrates. These substrates react with specific enzyme indicative of coliforms (beta-D-galactosidase) and *E. coli* (beta-D-glucoronidase) to provide color change to blue/green and fluorescence by coliforms and *E. coli* respectively. Test results are recorded after just 24 hours of incubation with the appearance of blue/green color for coliforms. *E. coli* can be detected by the appearance of fluorescence under a long wavelength UV light. Quantification is based on Most Probable Number (MPN) of colony forming-units (cfu) per 100 mL sample.

MPN TABLE

No. Wells Giving Positive Reaction	MPN per 100 mL Sample	No. Wells Giving Positive Reaction	MPN per 100 mL Sample	No. Wells Giving Positive Reaction	MPN per 100 mL Sample	No. Wells Giving Positive Reaction	MPN per 100 mL Sample
0	<3						
1	3	25	76	49	182	73	388
2	5	26	79	50	188	74	403
3	8	27	83	51	194	75	418
4	11	28	87	52	200	76	434
5	13	29	90	53	206	77	451
6	16	30	94	54	213	78	469
7	19	31	98	55	219	79	489
8	22	32	102	56	226	80	510
9	25	33	106	57	233	81	534
10	28	34	110	58	240	82	559
11	30	35	114	59	247	83	587
12	33	36	119	60	255	84	619
13	36	37	123	61	263	85	654
14	39	38	127	62	271	86	694
15	43	39	132	63	280	87	740
16	46	40	136	64	289	88	794
17	49	41	141	65	298	89	858
18	52	42	146	66	307	90	938
19	55	43	151	67	317	91	1,038
20	59	44	156	68	328	92	1,174
21	62	45	161	69	339	93	1,370
22	65	46	166	70	350	94	1,696
23	69	47	171	71	362	95	2,424
24	72	48	177	72	375	96	>2,424

Figure 4. MPN Table

Appendix H

QA/QC Results

E.1 Bacteria Duplicates

ColiPlate duplicate measurements are intended to determine the range and variation of counts returned by the ColiPlates.

Table 6 shows the results of total coliform duplicates analyzed using ColiPlates, sorted by sampling date. All units are counts/100mL. The mean absolute difference between the measurements is 102 counts/100mL, the median absolute difference is 13.5 counts/100mL and the standard deviation of the difference is 261 counts/100mL. The maximum difference is 1130 counts/100mL. While the difference observed in total coliform counts is most often small (13.5 counts or less) there is a wide range of values that can be expected due to the sporadic nature of bacteria in the natural environment.

Table 6. Total Coliform Duplicates Analyzed with ColiPlates.

Sample Number	Site	Total Coliforms	TC ColiPlate Duplicate	Absolute Difference	Sampler
1	BDY-5	22	25	3	Tony Mathia
1	COX-2	3	19	16	Gord Ross
1	COX-4	5	5	0	Gord Ross
1	GNB-1	8	22	14	Andrew Watson
1	MLD-7	25	16	9	michael foster
1	MRV-1	339	177	162	John Wood
1	POR-0	3	1	2	Marcia Shortreed
1	SPC-1	22	22	0	Perry Bowker
1	STR-5	22	19	3	Karen Gillies
1	WAK-2	19	22	3	Doug Tate
1	WLB-2	72	123	51	Liz Denyar
2	COX-2	33	65	32	Gord Ross
2	COX-4	3	16	13	Gord Ross
2	MRV-4	127	146	19	John Wood
3	COX-2	5	13	8	Gord Ross
3	COX-4	22	16	6	Gord Ross
3	MIN-0	19	22	3	John Curran
4	COX-2	114	119	5	Gord Ross
4	COX-4	36	25	11	Gord Ross
5	COX-2	52	55	3	Gord Ross
6	COX-4	72	65	7	Gord Ross
7	COX-2	141	307	166	Gord Ross
7	COX-4	271	362	91	Gord Ross
8	BDY-5	22	25	3	Tony Mathia
8	BMR-0	36	65	29	Susan Ross
8	BOY-0	194	794	600	Chris Blaymires
8	BOY-1	1174	83	1091	Chris Blaymires
8	CLR-2	52	65	13	Sharon Cleverdon
8	COX-2	200	317	117	Gord Ross
8	COX-4	59	102	43	Gord Ross
8	MBA-4	219	156	63	Brian Yeates
8	MBA-5	119	119	0	Brian Yeates
8	MIN-0	13	30	17	John Curran
8	MLD-4	69	102	33	Eric Steeves
8	MRV-1	79	87	8	John Wood
8	MRV-4	109	177	68	John Wood
8	WIN-0	36	13	23	Bev Manchee
8	WLB-2	1370	2500	1130	Liz Denyar

Table 7. *E.coli* Duplicates Analyzed with ColiPlates.

Sample Number	Site	EColi	EC ColiPlate Duplicate	Absolute Difference	Sampler
1	BDY-5	1	5	4	Tony Mathia
1	COX-2	1	1	0	Gord Ross
1	COX-4	1	1	0	Gord Ross
1	GNB-1	3	5	2	Andrew Watson
1	MLD-7	5	3	2	michael foster
1	MRV-1	5	8	3	John Wood
1	POR-0	3	1	2	Marcia Shortreed
1	SPC-1	3	8	5	Perry Bowker
1	STR-5	5	1	4	Karen Gillies
1	WAK-2	1	1	0	Doug Tate
1	WLB-2	1	1	0	Liz Denyar
2	COX-2	1	1	0	Gord Ross
2	COX-4	1	1	0	Gord Ross
2	MRV-4	30	1	29	John Wood
3	COX-2	1	1	0	Gord Ross
3	COX-4	1	1	0	Gord Ross
3	MIN-0	13	16	3	John Curran
4	COX-2	11	3	8	Gord Ross
4	COX-4	5	5	0	Gord Ross
5	COX-2	1	1	0	Gord Ross
6	COX-4	5	5	0	Gord Ross
7	COX-2	33	46	13	Gord Ross
7	COX-4	13	16	3	Gord Ross
8	BDY-5	1	1	0	Tony Mathia
8	BMR-0	3	5	2	Susan Ross
8	BOY-0	1	1	0	Chris Blaymires
8	BOY-1	1	5	4	Chris Blaymires
8	CLR-2	1	1	0	Sharon Cleverdon
8	COX-2	1	5	4	Gord Ross
8	COX-4	1	3	2	Gord Ross
8	MBA-4	1	5	4	Brian Yeates
8	MBA-5	5	13	8	Brian Yeates
8	MIN-0	1	1	0	John Curran
8	MLD-4	1	1	0	Eric Steeves
8	MRV-1	11	11	0	John Wood
8	MRV-4	16	1	15	John Wood
8	WIN-0	3	3	0	Bev Manchee
8	WLB-2	213	43	170	Liz Denyar

Table 7 shows the results of *E.coli* duplicates analyzed using ColiPlates, sorted by sampling date. All units are counts/100mL. The mean absolute difference between the measurements is 7.5 counts/100mL, the median absolute difference is 2 counts/100mL and the standard deviation of the difference is 27.5 counts/100mL. The maximum difference is 170 counts/100mL. While the difference observed in *E.coli* counts is most often small (2 counts or less) there is a wide range of values that can be expected due to the sporadic nature of bacteria in the natural environment.

Even with relatively high variability observed in the duplicate bacteria samples, evidence from previous years and other sources indicate that ColiPlates provide reliable results.

38 out of 42 scheduled ColiPlate duplicate samples were submitted by volunteers (90%), the second-highest return rate in the seven years of the water quality initiative. This return rate is attributable to the simplification of duplicate protocols, and the training of Team Leaders.

E.2 Phosphorus Duplicates

Phosphorus duplicate measurements are intended to determine the range and variation of phosphorus measurements returned by the lab.

Table 8. Phosphorus Duplicates.

Sample Number	Site	Phosphorus Concentration	P Duplicate	Absolute Difference	Sampler
1	ARN-0	6	7	1	Logan
1	ART-0	6	6.2	0.2	Logan
1	BAL-0	5.9	5.8	0.1	Logan
1	BDY-0	21.8	17.7	4.1	Tony Mathia
1	BMR-0	7.5	6.6	0.9	Louise Cragg
1	BOY-0	8.6	9.2	0.6	Dave Langford
1	CLR-0	6.7	8	1.3	Sharon Cleverdon
1	COX-0	8.4	20.8	12.4	Gord Ross
1	EAS-0	6	6.1	0.1	Lloyd Walton
1	ELG-0	7.4	7.4	0	Logan
1	GNB-0	3.4	4	0.6	Andrew Watson
1	HMB-0	5.2	4.1	1.1	Andrew Watson
1	IND-0	5.4	5.4	0	Logan
1	JOR-0	7.2	6.4	0.8	Logan
1	JOS-1	4.4	5.5	1.1	Gerry Jonker
1	MGN-0	5.3	5.4	0.1	Logan
1	MIN-0	5.2	5.9	0.7	Logan

Sample Number	Site	Phosphorus Concentration	P Duplicate	Absolute Difference	Sampler
1	MIR-0	7.6	6.1	1.5	Sandy Tozer Spence
1	MLD-1	8.9	7.3	1.6	michael foster
1	MLD-2	9.3	9.6	0.3	michael foster
1	MLD-3	14.8	9.7	5.1	michael foster
1	MLG-0	4.4	4.1	0.3	Logan
1	MRV-1	7.5	8.5	1	John Wood
1	MRV-2	7.7	7.3	0.4	John Wood
1	MRV-3	8.7	7.5	1.2	John Wood
1	MRV-4	8	8.3	0.3	John Wood
1	MUS-1	6.7	5.8	0.9	Logan
1	MUS-2	6.4	4.8	1.6	Logan
1	MUS-3	6.9	8.5	1.6	Logan
1	NRT-0	5.8	6	0.2	Logan
1	RMI-0	5.8	5.9	0.1	Logan
1	ROS-1	6.1	7.4	1.3	Logan
1	ROS-2	6.4	5.9	0.5	Logan
1	RSH-0	10.5	11.3	0.8	Mary Anne Peacock
1	SKL-5	3.9	2.9	1	Alex Shepherd
1	SPC-0	5.2	5.7	0.5	Perry Bowker
1	STE-0	6.9	7.1	0.2	Logan
1	STN-0	5.4	3.4	2	Andrew Watson
1	STR-0	14.8	14.5	0.3	Karen Gillies
1	SUN-0	8.6	10.3	1.7	Denis
1	TOB-0	6.6	6.2	0.4	Logan
1	WAK-0	7.6	7.6	0	Doug Tate
1	WIN-0	10.7	8.5	2.2	Bev Manchee
1	WLB-0	8.9	7.4	1.5	Liz Denyar
1	WTS-0	6.7	5.8	0.9	Logan
2	BRA-0	11.4	14.4	3	
2	MSN-0	10.3	12	1.7	Al Ward
3	MBA-0	20.4	14.1	6.3	George Genereux
4	MBA-0	13	9.6	3.4	George Genereux
4	MIR-2	13.5	16.5	3	Sandy Tozer Spence
4	MRV-2	23.9	27.7	3.8	John Wood
4	MRV-4	13.3	15.8	2.5	John Wood
4	STN-1	2.8	3.8	1	Jerry Jonker
4	WLB-0	8.9	10.7	1.8	Liz Denyar
4	WLB-1	17.6	21.9	4.3	Liz Denyar
5	CLR-0	12.4	10.9	1.5	Sharon Cleverdon
5	MBA-0	8.4	11.6	3.2	George Genereux
6	MBA-0	8.1	14.5	6.4	George Genereux

Table 8 shows the results of phosphorus duplicates sorted by sampling date. The absolute value of the difference betweens P and P duplicate measurements are also shown. All units are μg/L.

The mean absolute difference between the measurements is 1.66 μg/L, the median absolute difference is 1.0 μg/L and the standard deviation is 2.08 μg/L. The maximum difference is 12.4 μg/L. This suggests that most often, the error observed in phosphorus concentration is +/- 2.08 μg/L.

Appendix I

WQI [TP] Results Plotted Against Threshold Values

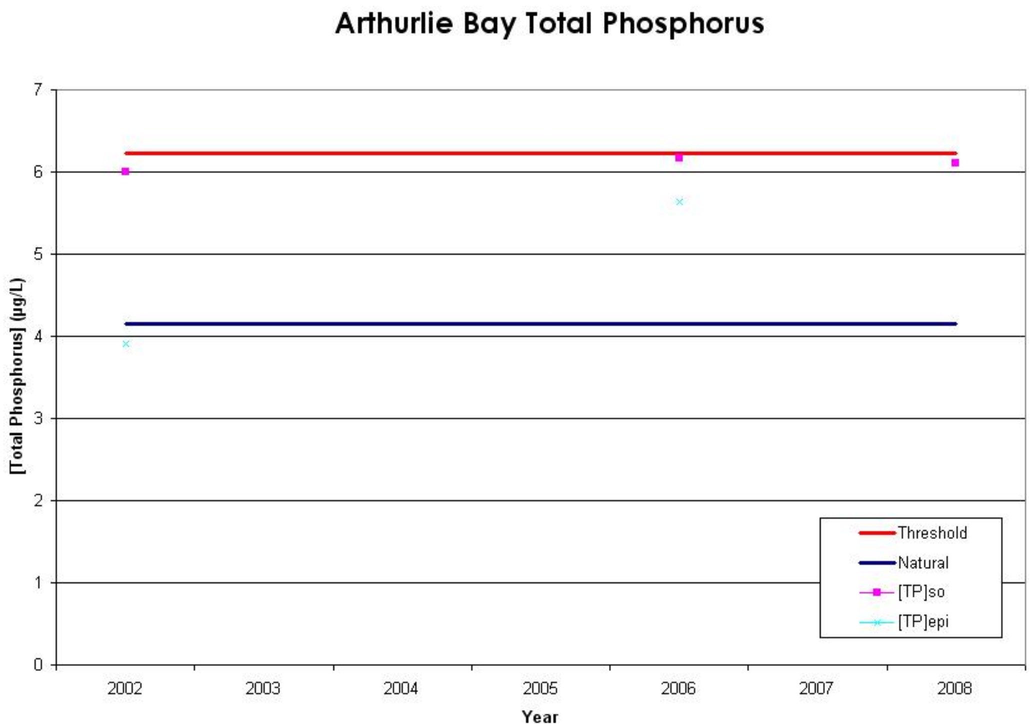

Figure 5. Arthurlie Bay Total Phosphorus

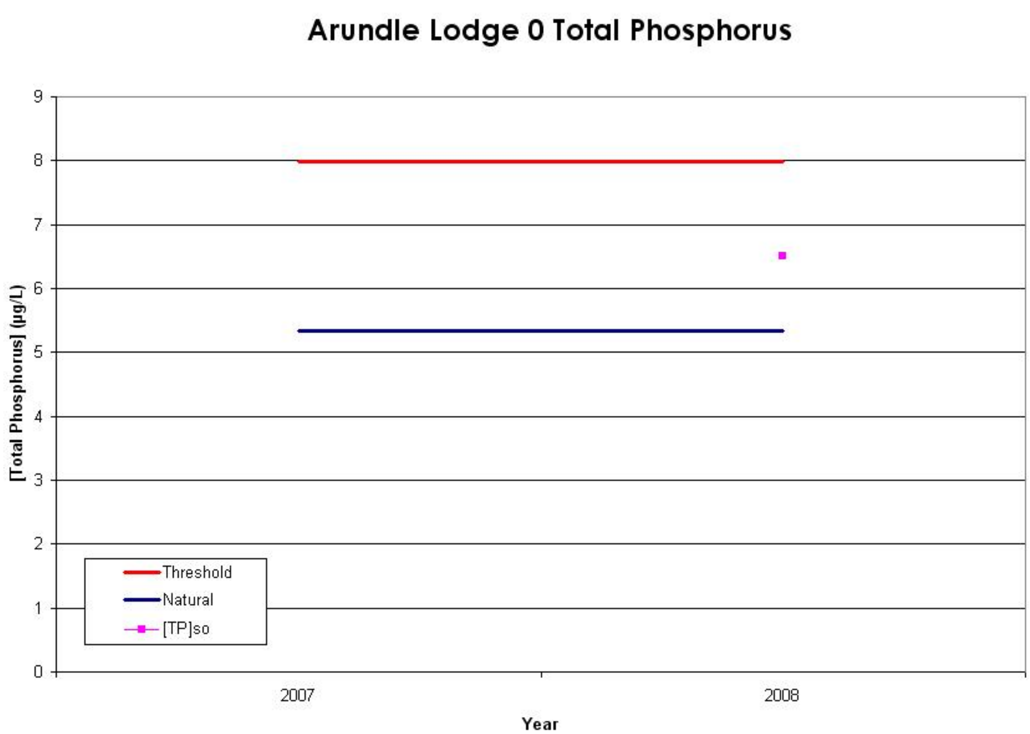

Figure 6. Arundle Lodge Total Phosphorus

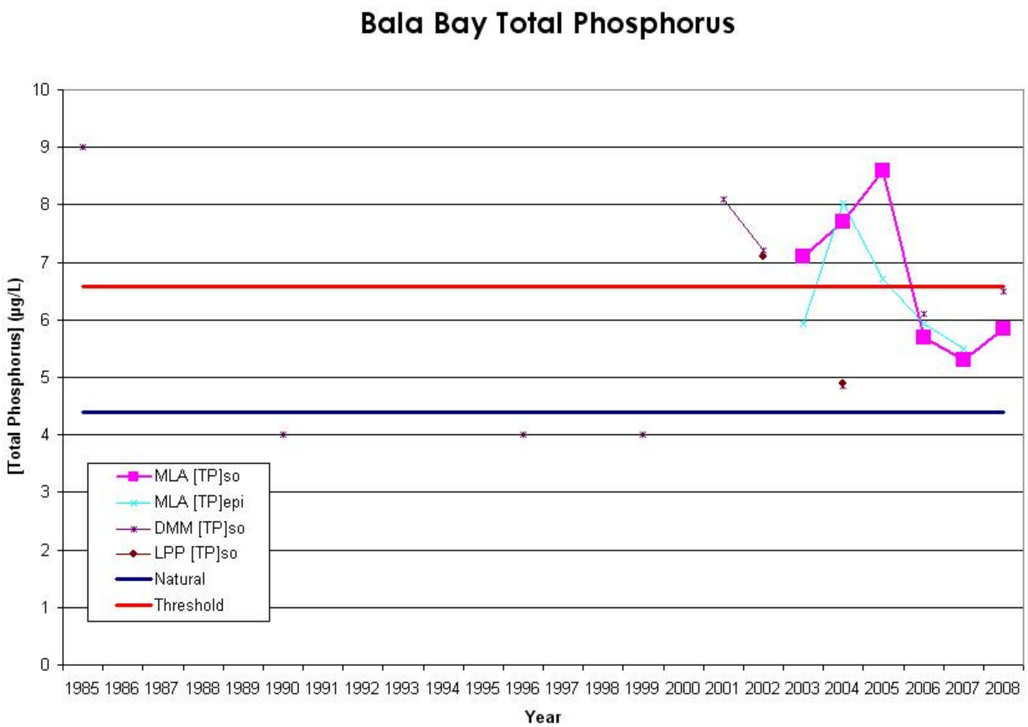

Figure 7. Bala Bay Total Phosphorus

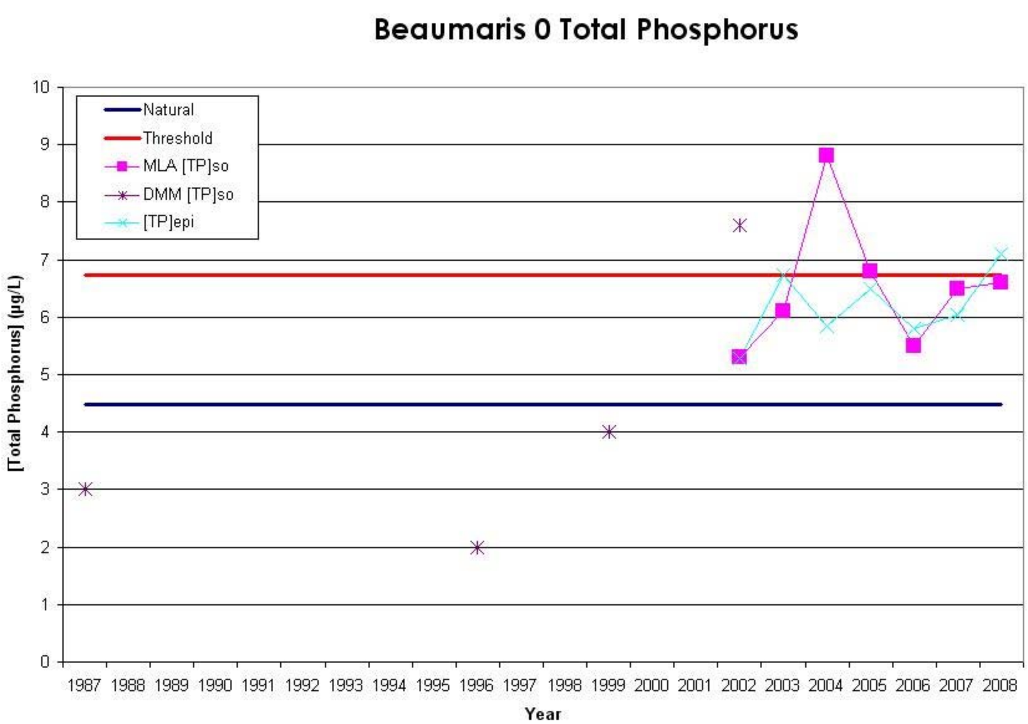

Figure 8. Beaumaris Total Phosphorus

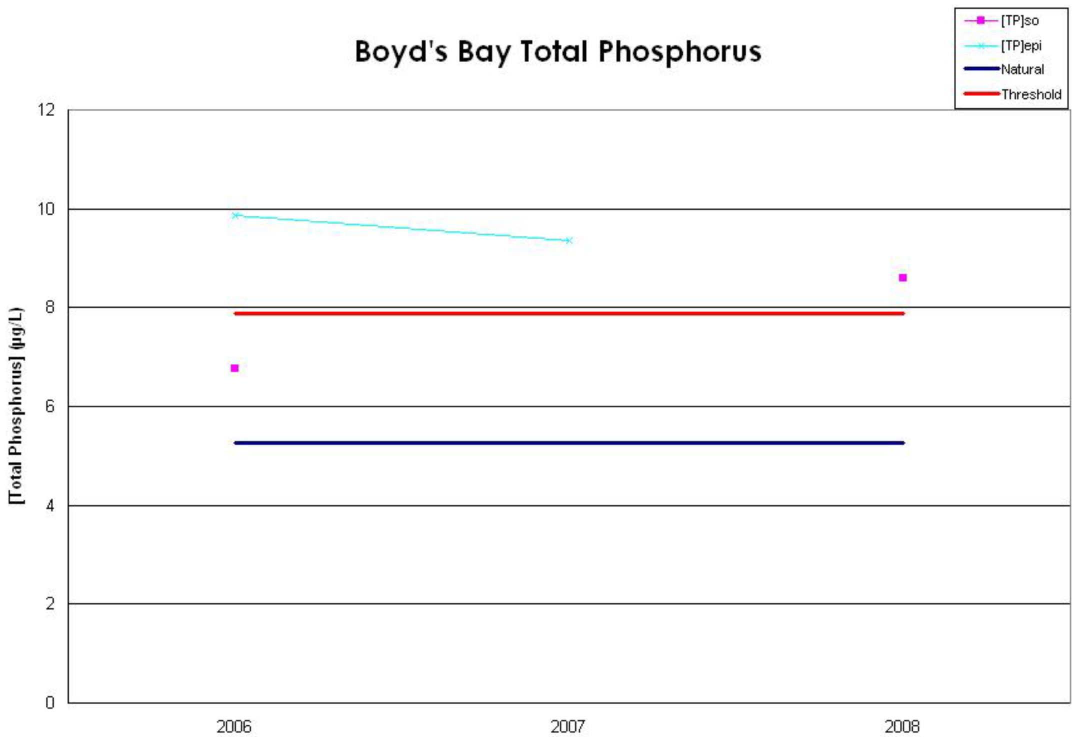

Figure 9. Boyd's Bay Lake Total Phosphorus

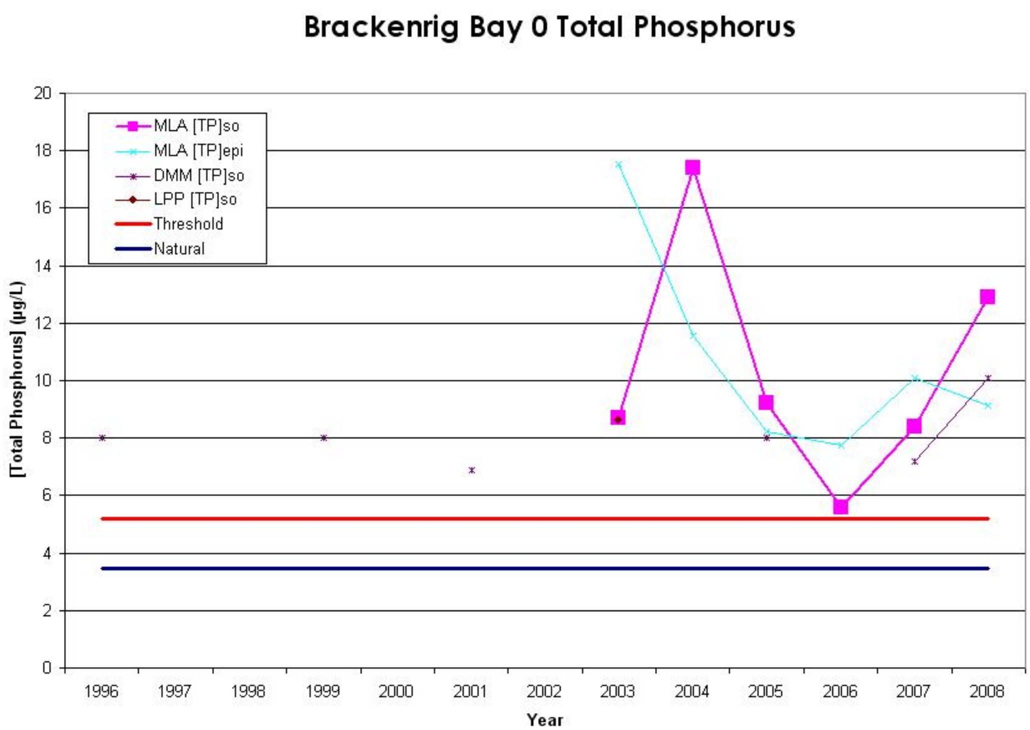

Figure 10. Brackenrig Bay Total Phosphorus

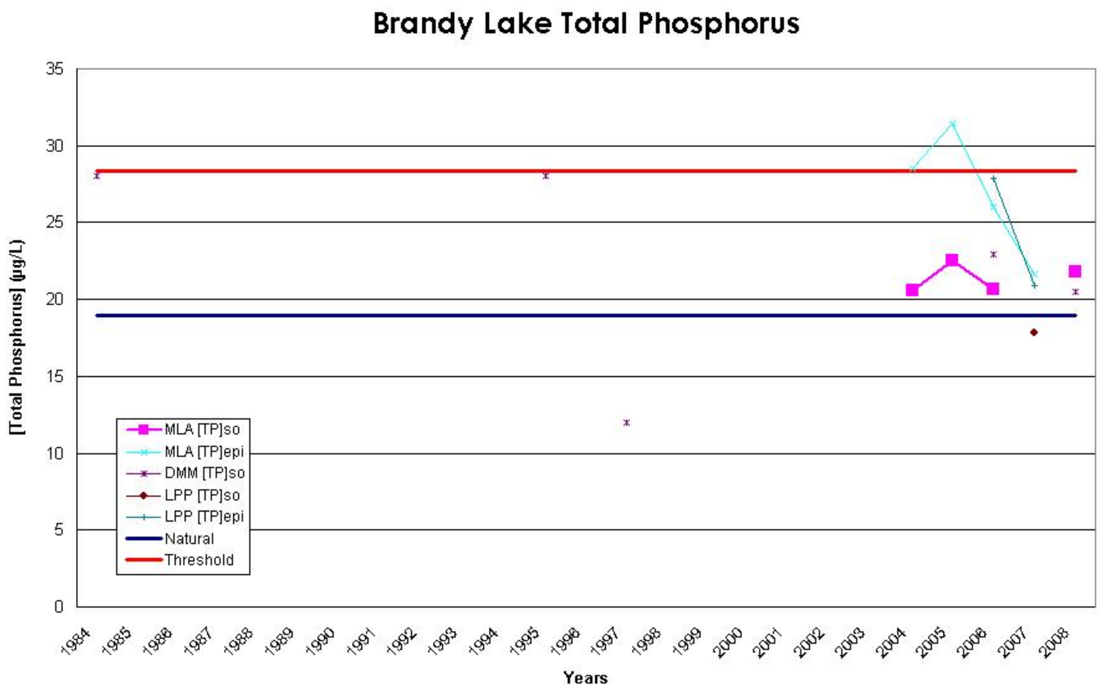

Figure 11. Brandy Lake Total Phosphorus

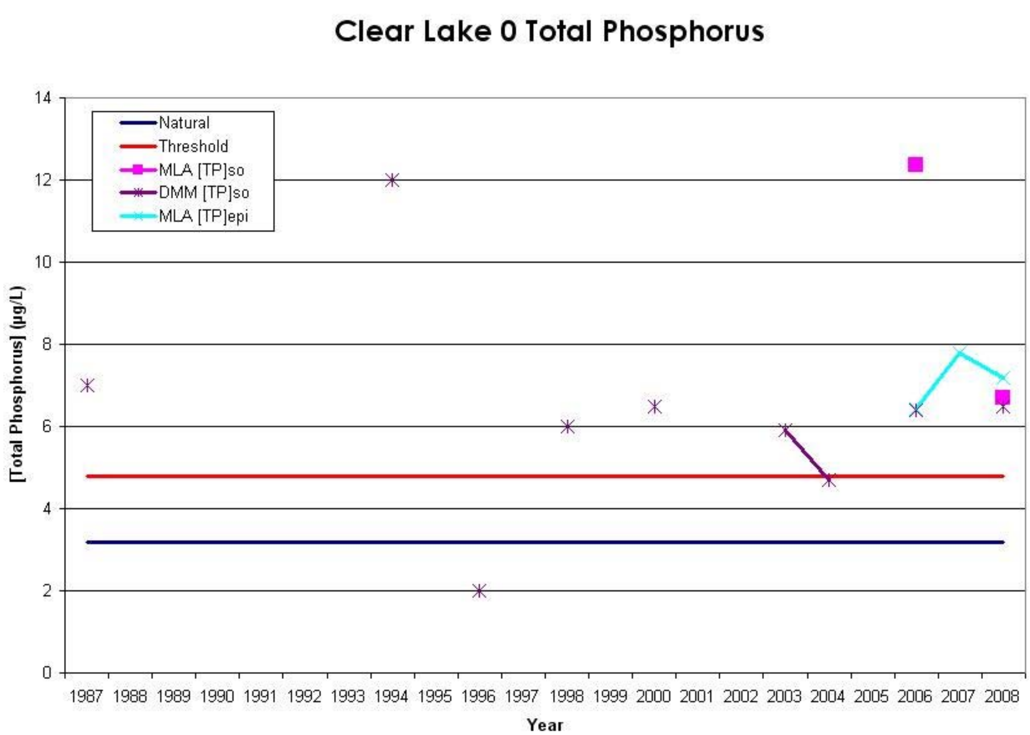

Figure 12. Clear Lake Total Phosphorus

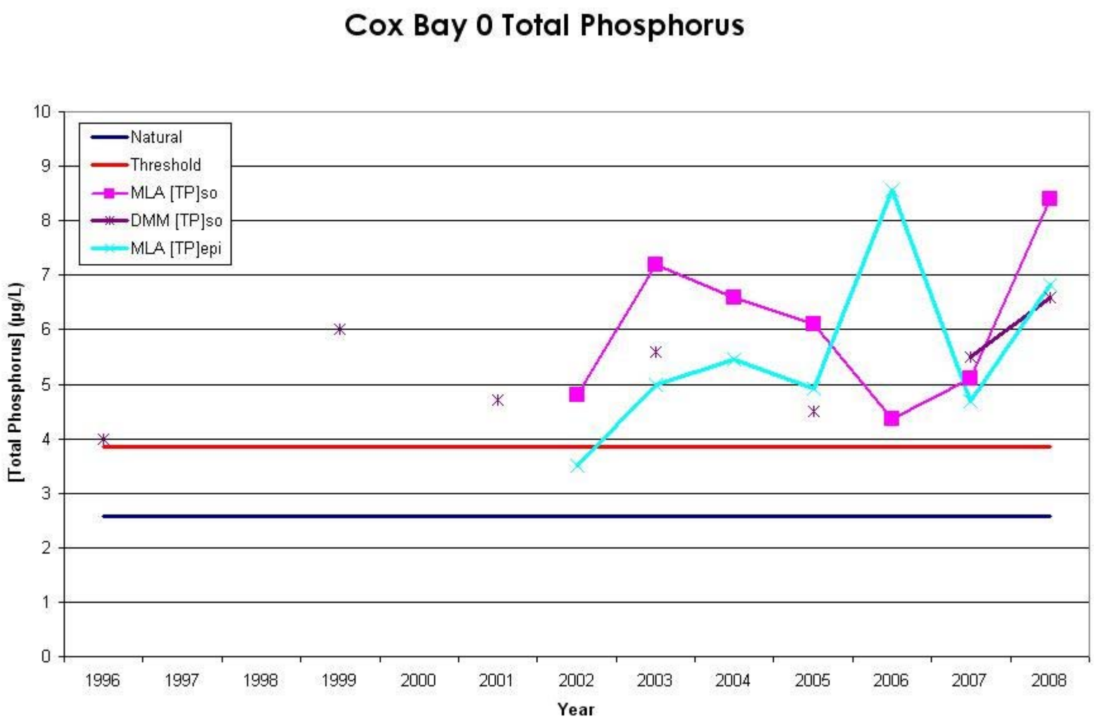

Figure 13. Cox Bay Total Phosphorus

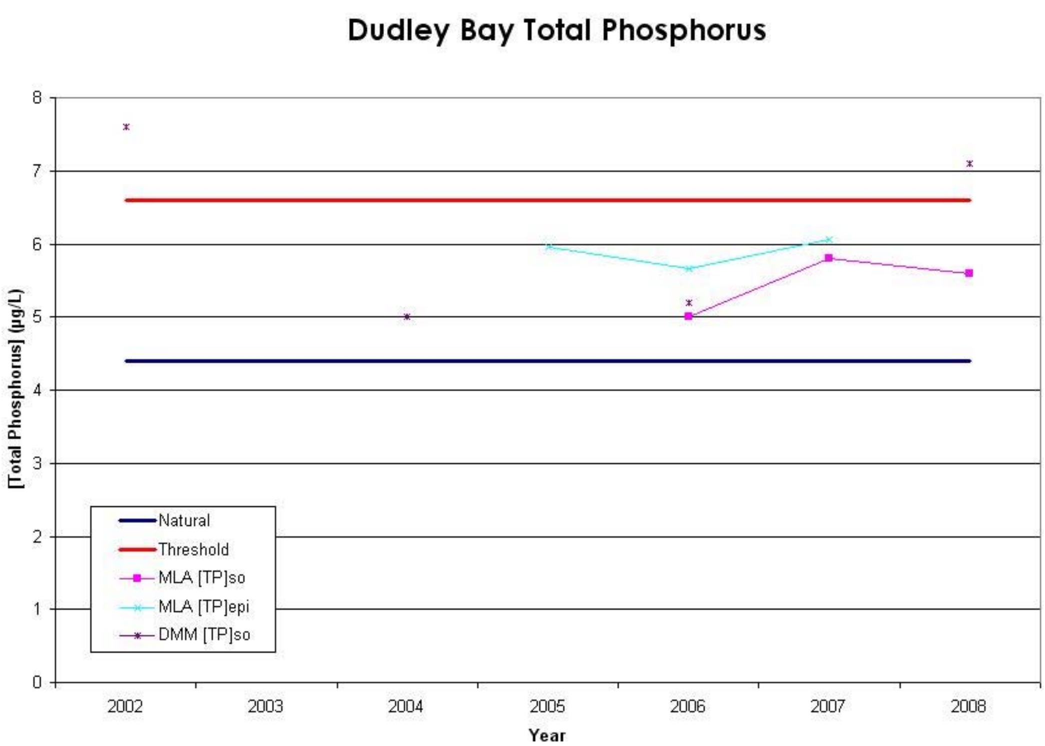

Figure 14. Dudley Bay Total Phosphorus

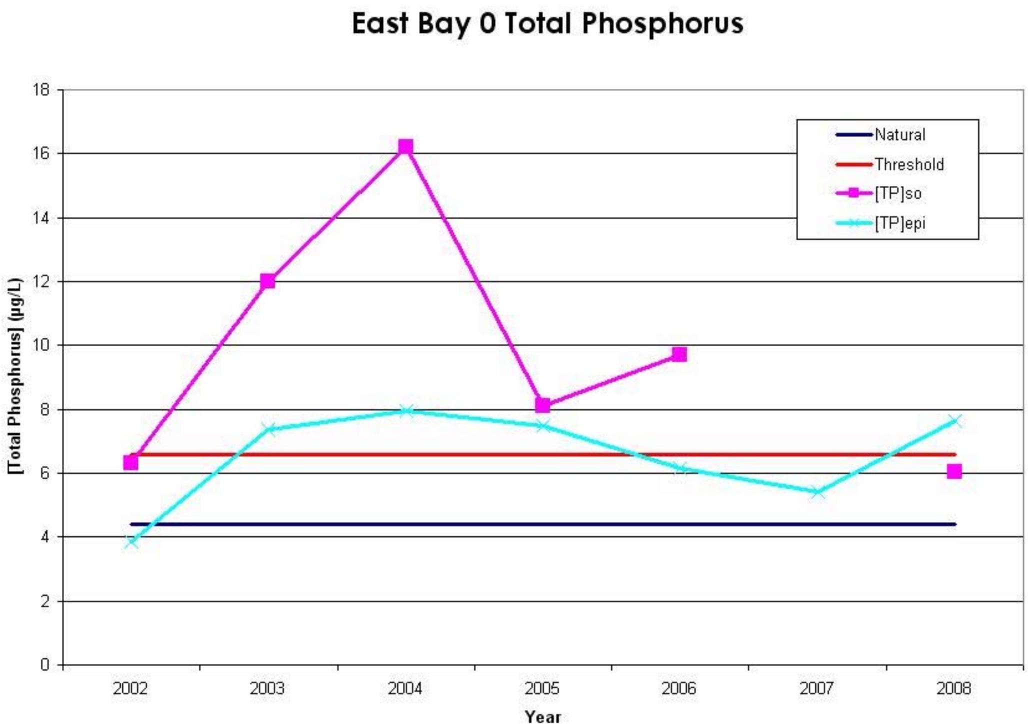

Figure 15. East Bay Total Phosphorus

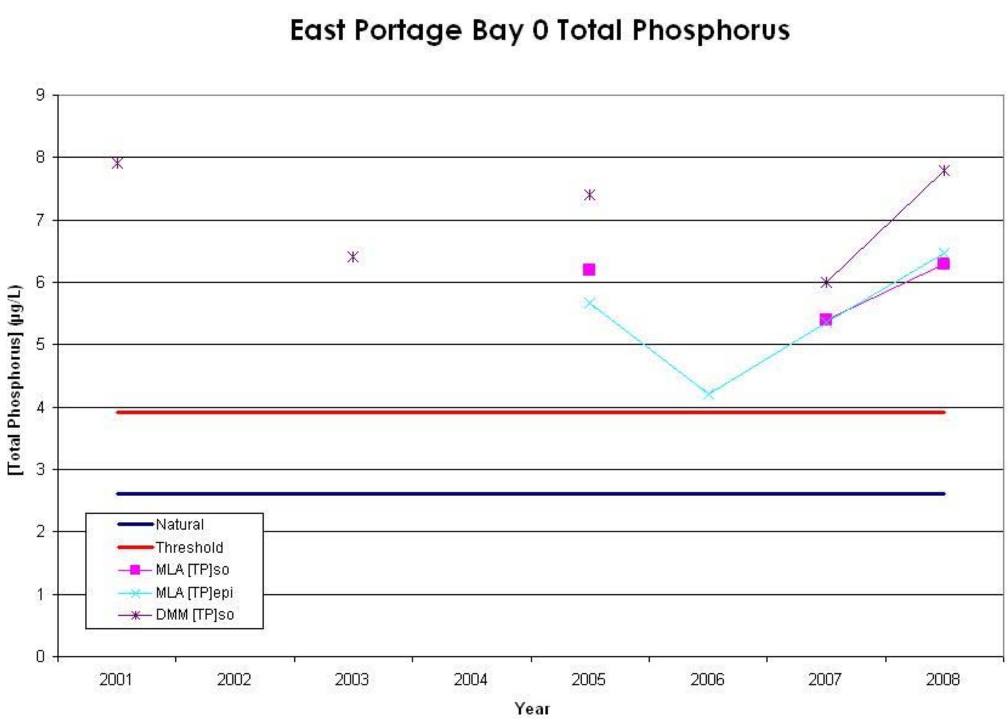

Figure 16. East Portage Bay Total Phosphorus

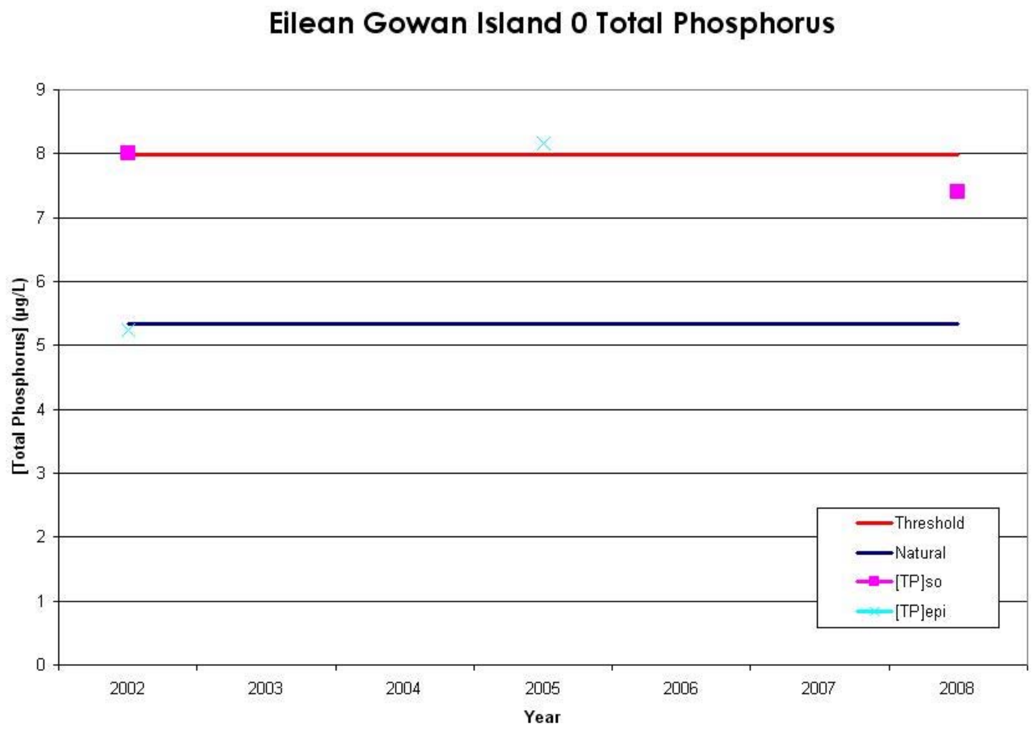

Figure 17. Eilean Gowan Island Total Phosphorus

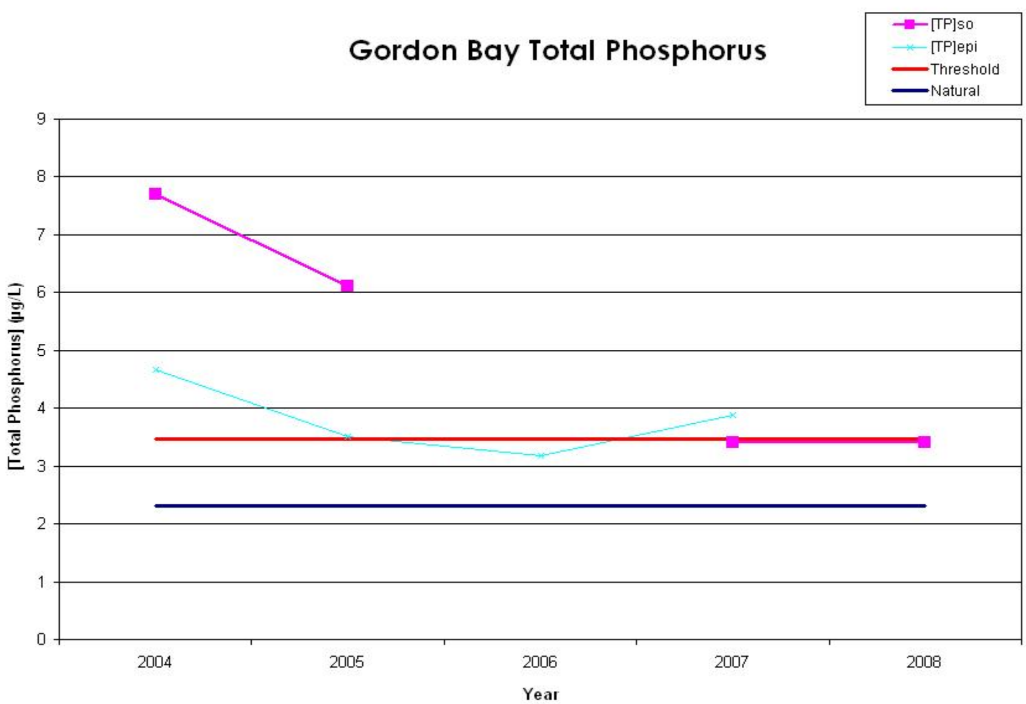

Figure 18. Gordon Bay Total Phosphorus.

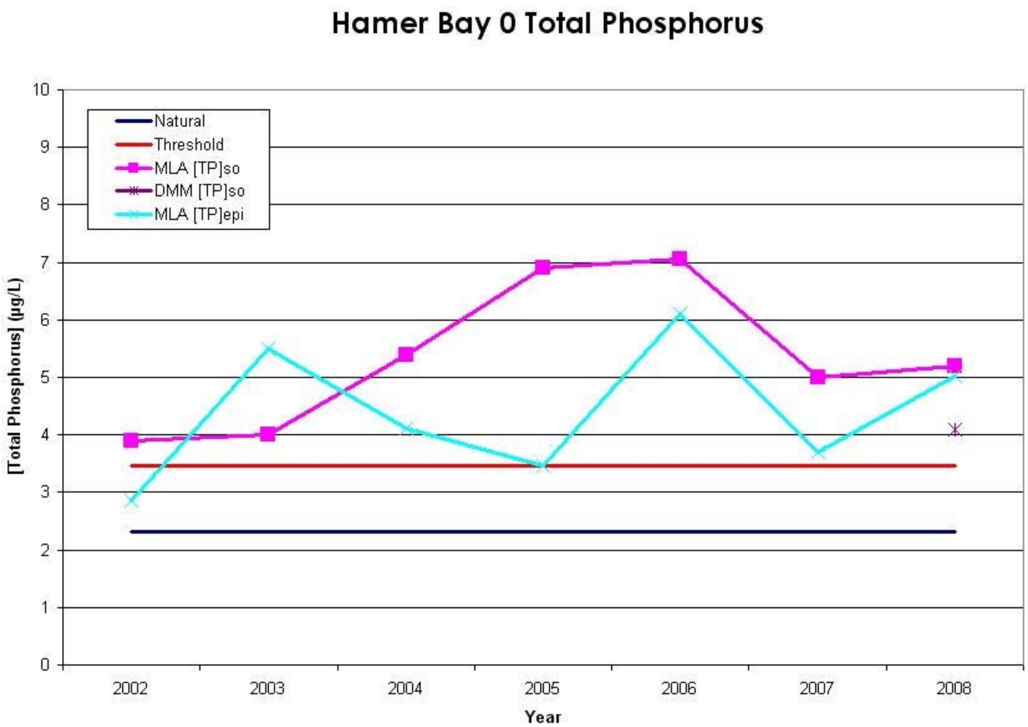

Figure 19. Hamer Bay Total Phosphorus

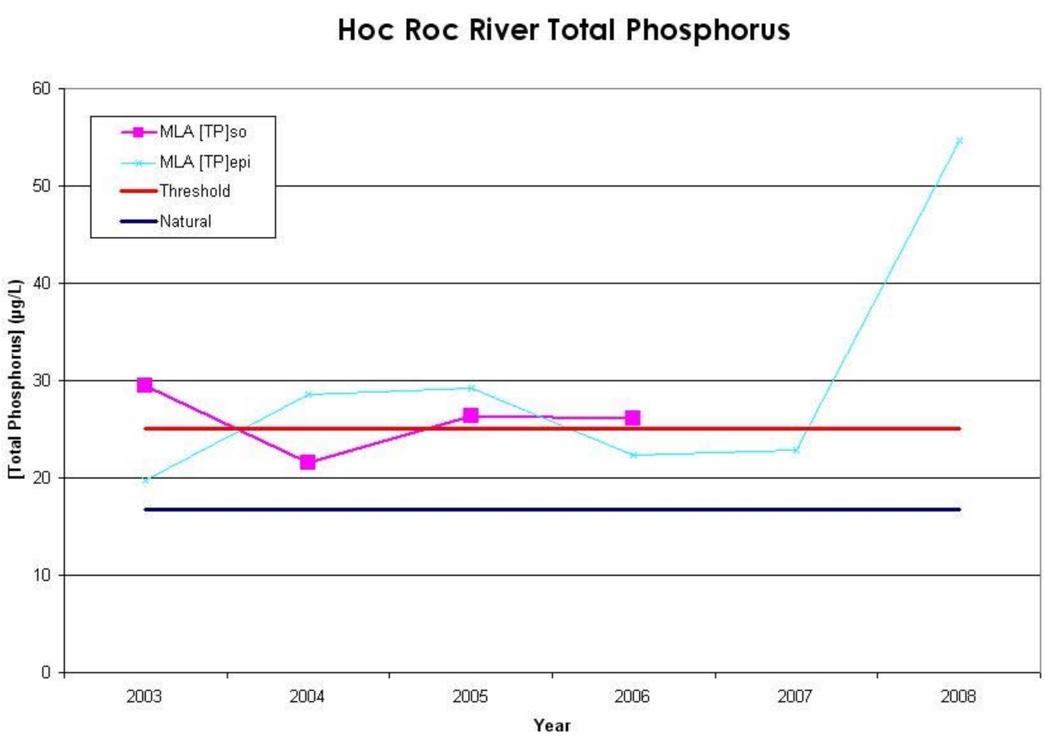

Figure 20. Hoc Roc River Total Phosphorus

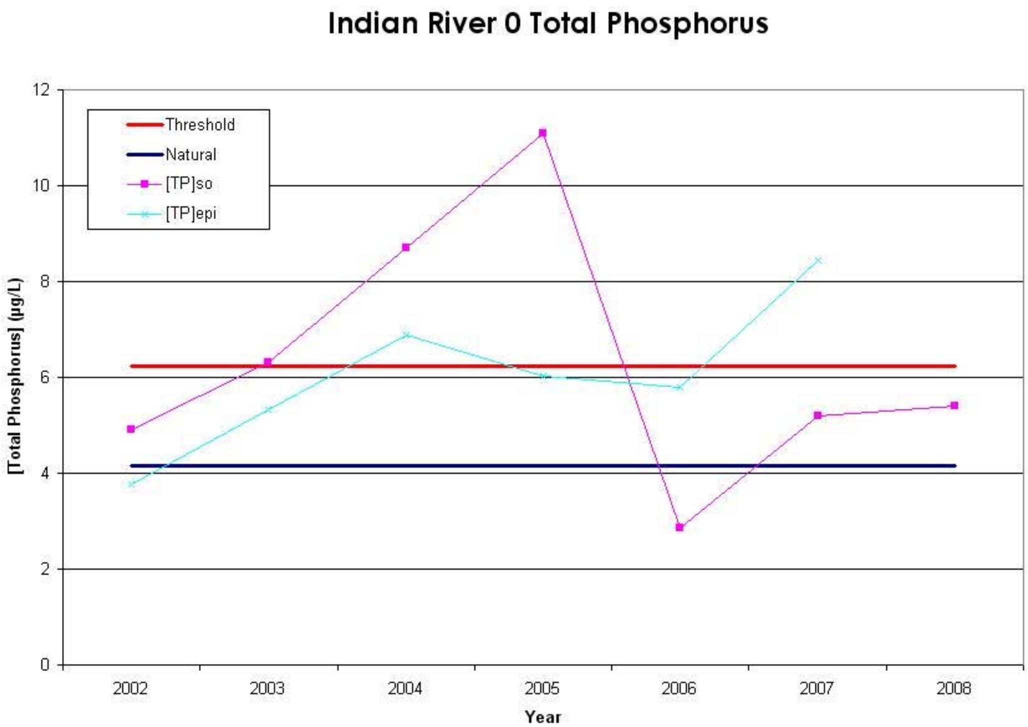

Figure 21. Indian River Total Phosphorus

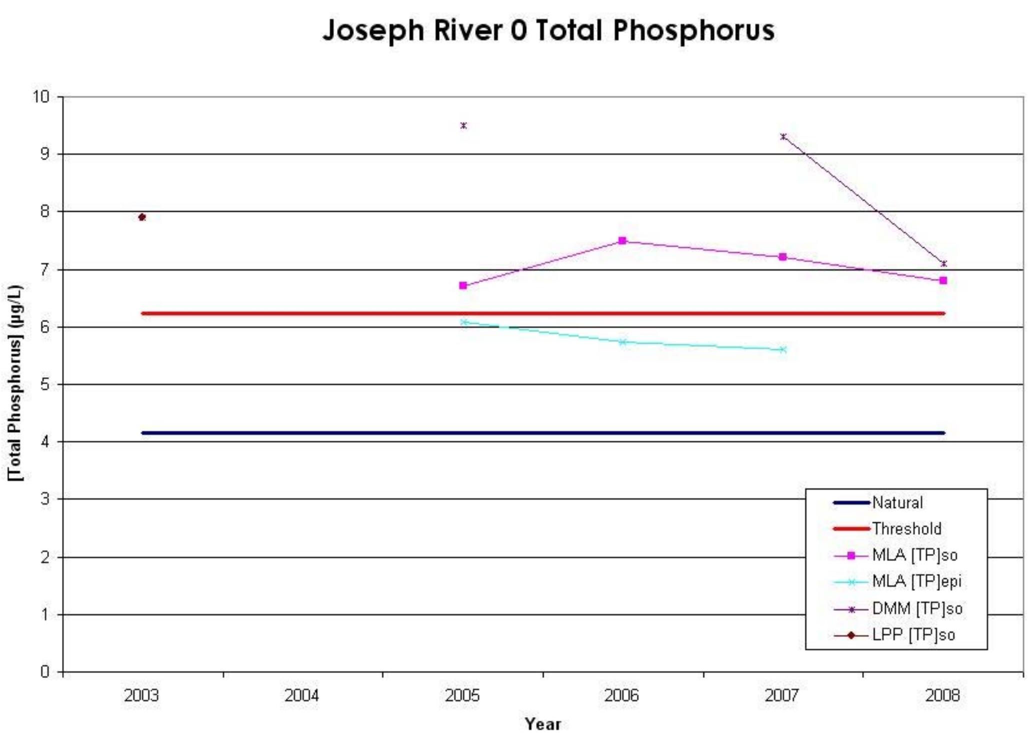

Figure 22. Joseph River Total Phosphorus

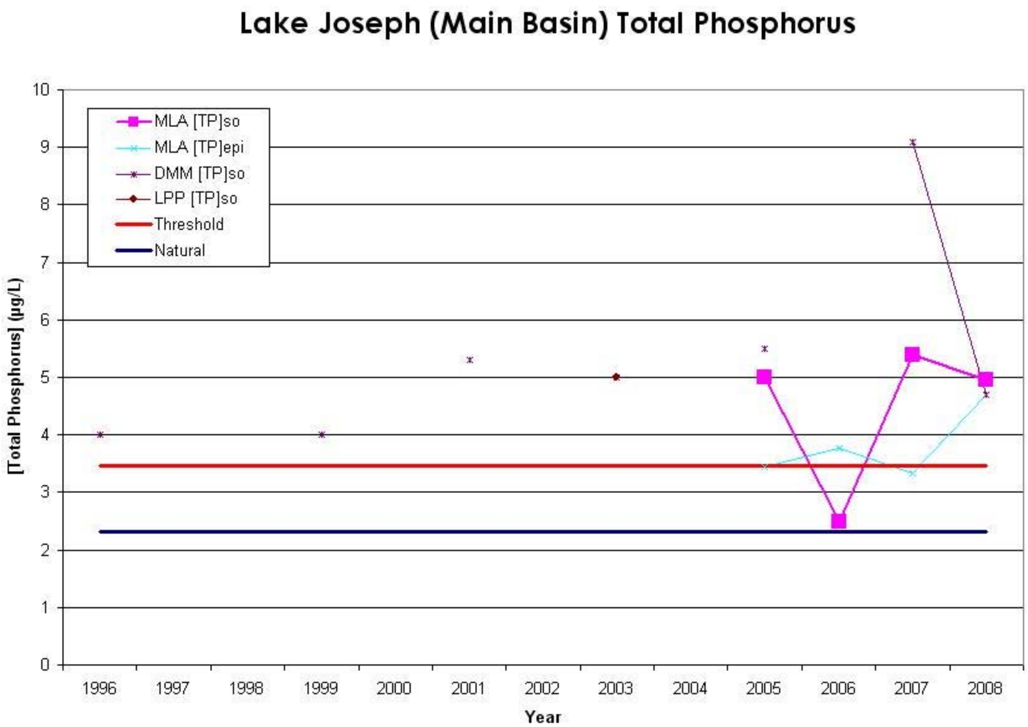

Figure 23. Lake Joseph (Main Basin) Total Phosphorus

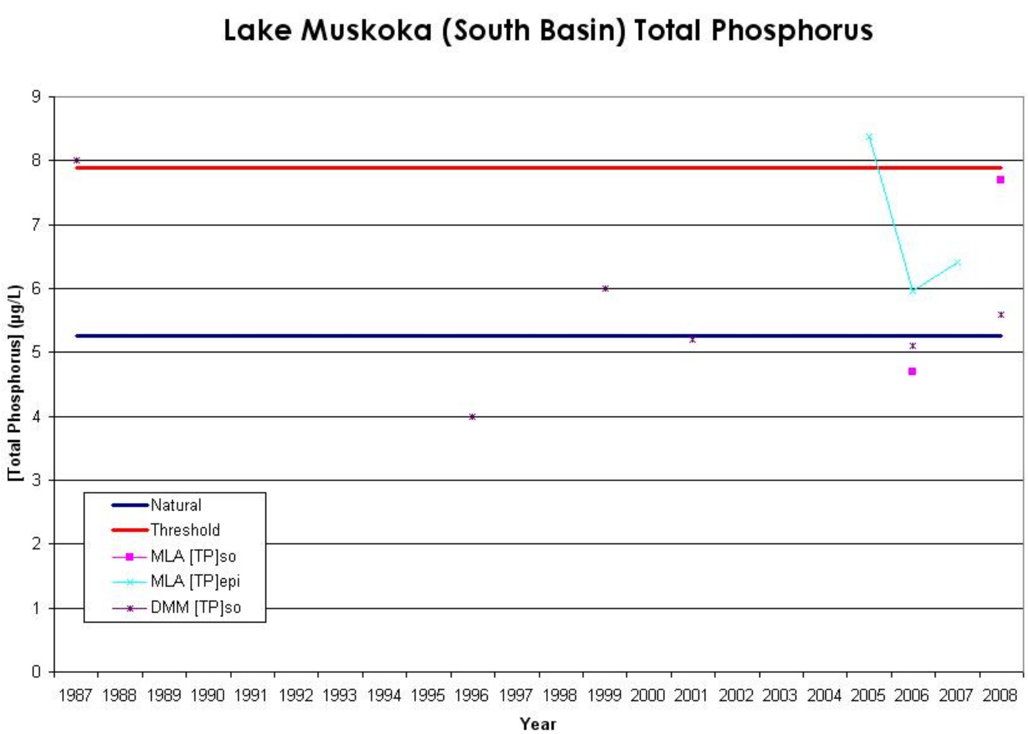

Figure 24. Lake Muskoka (South Basin) Total Phosphorus

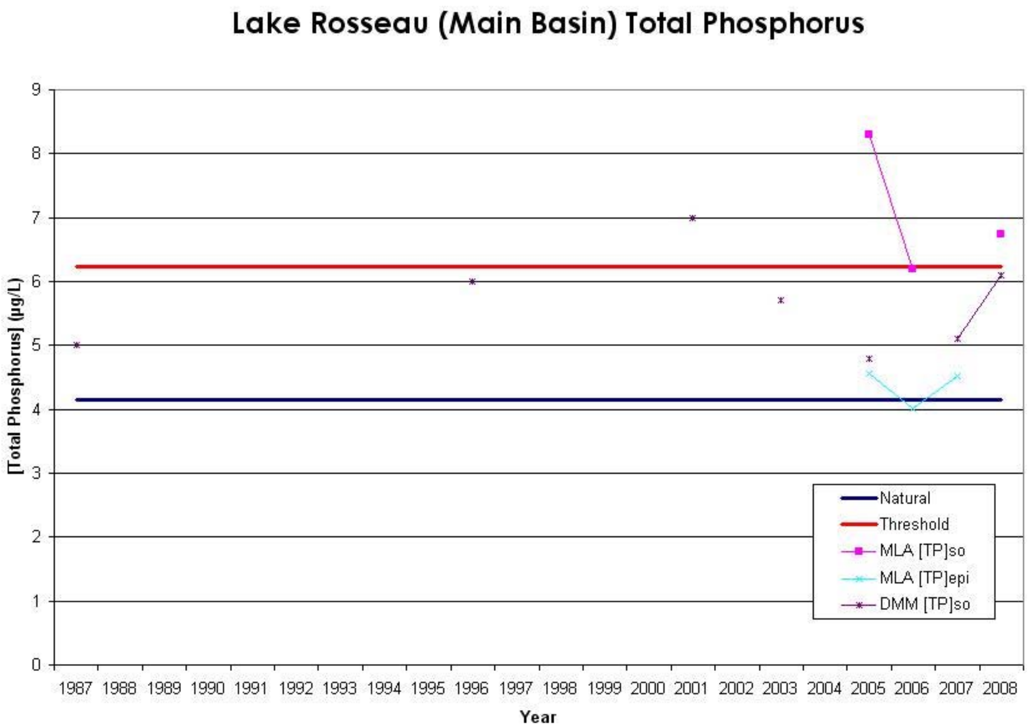

Figure 25. Lake Rosseau (Main Basin) Total Phosphorus

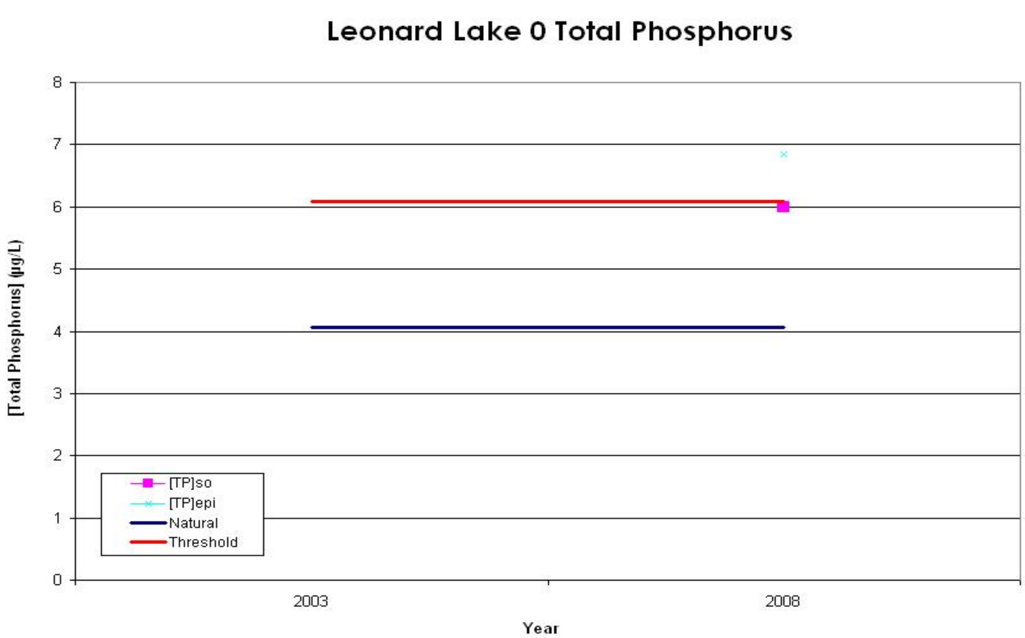

Figure 26. Leonard Lake Total Phosphorus

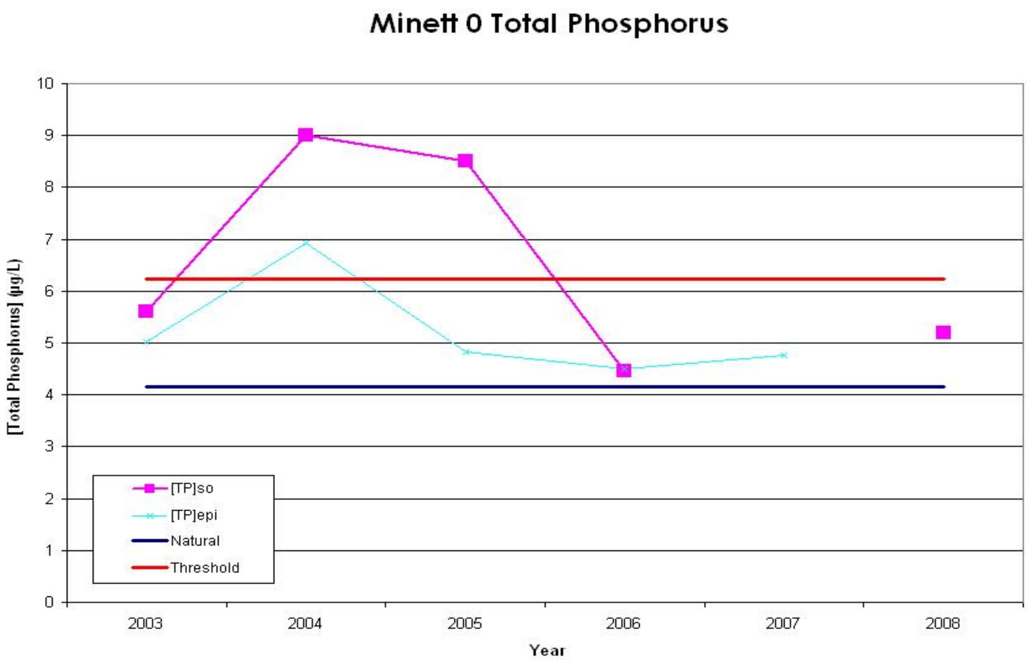

Figure 27. Minett Total Phosphorus

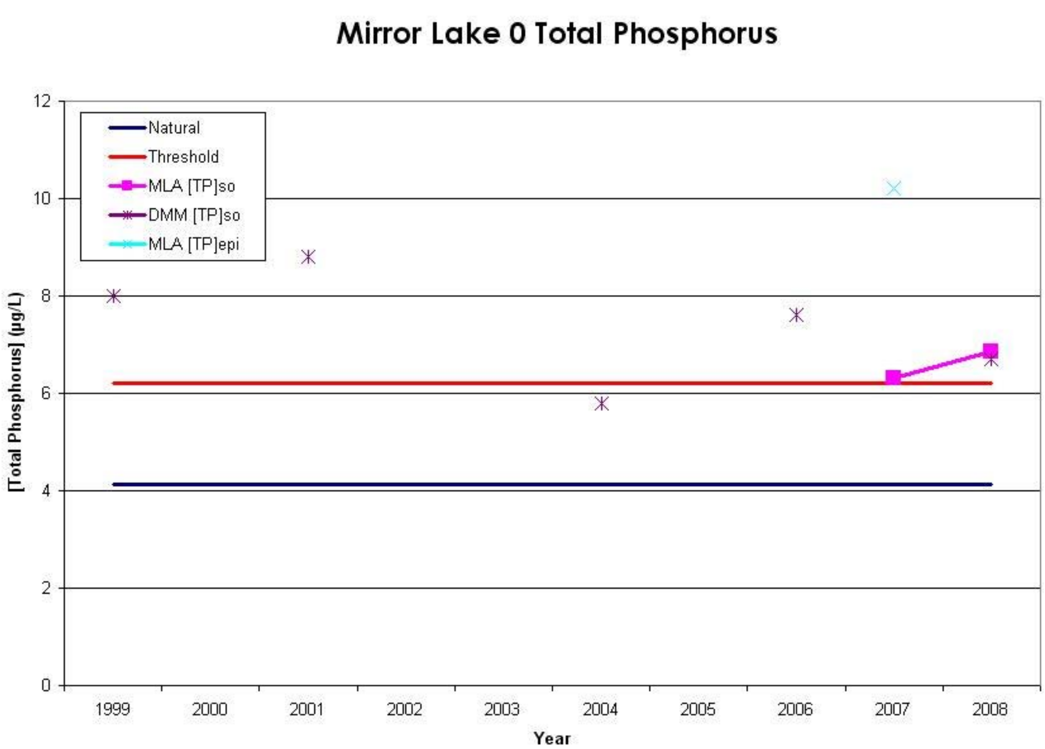

Figure 28. Mirror Lake Total Phosphorus

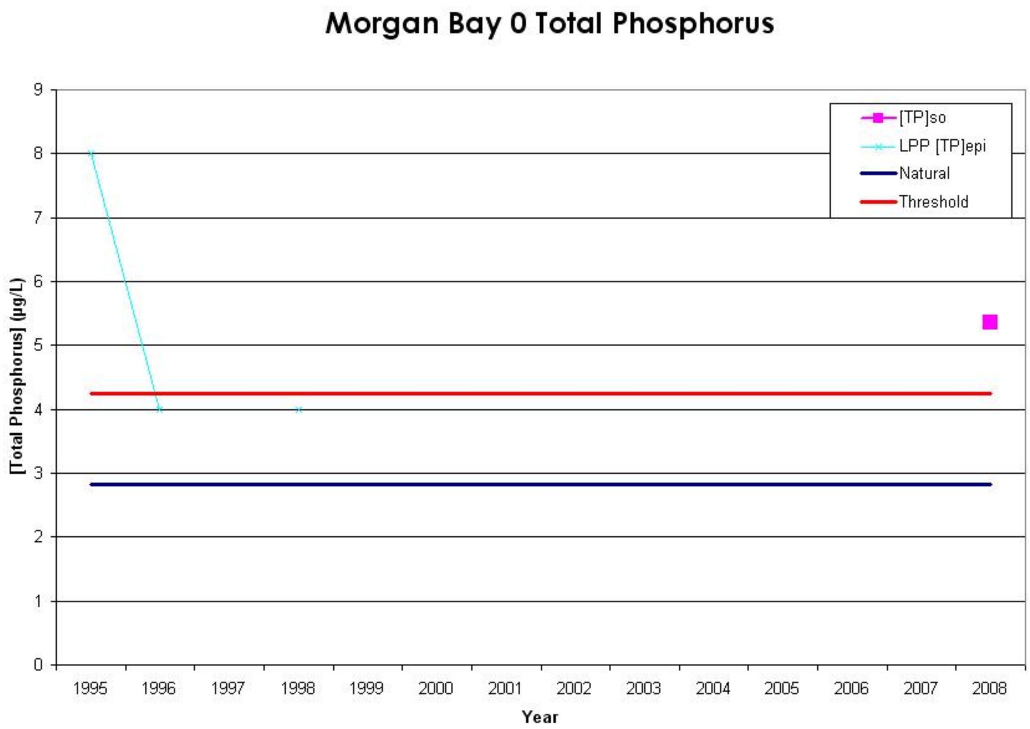

Figure 29. Morgan Bay Total Phosphorus

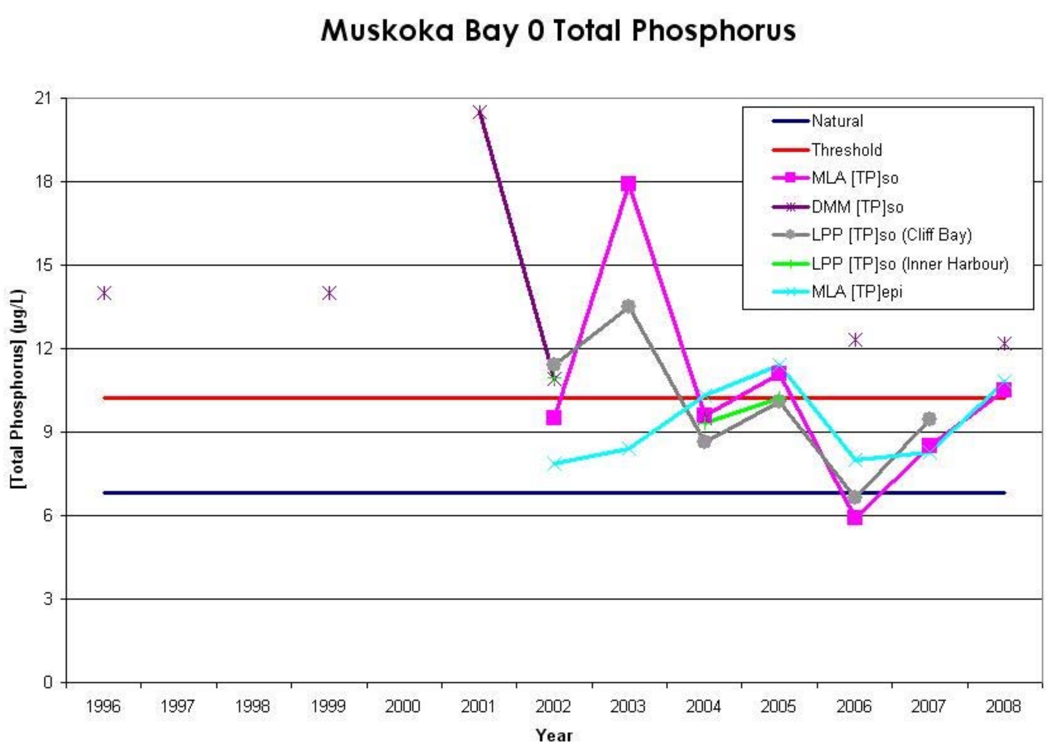

Figure 30. Muskoka Bay Total Phosphorus

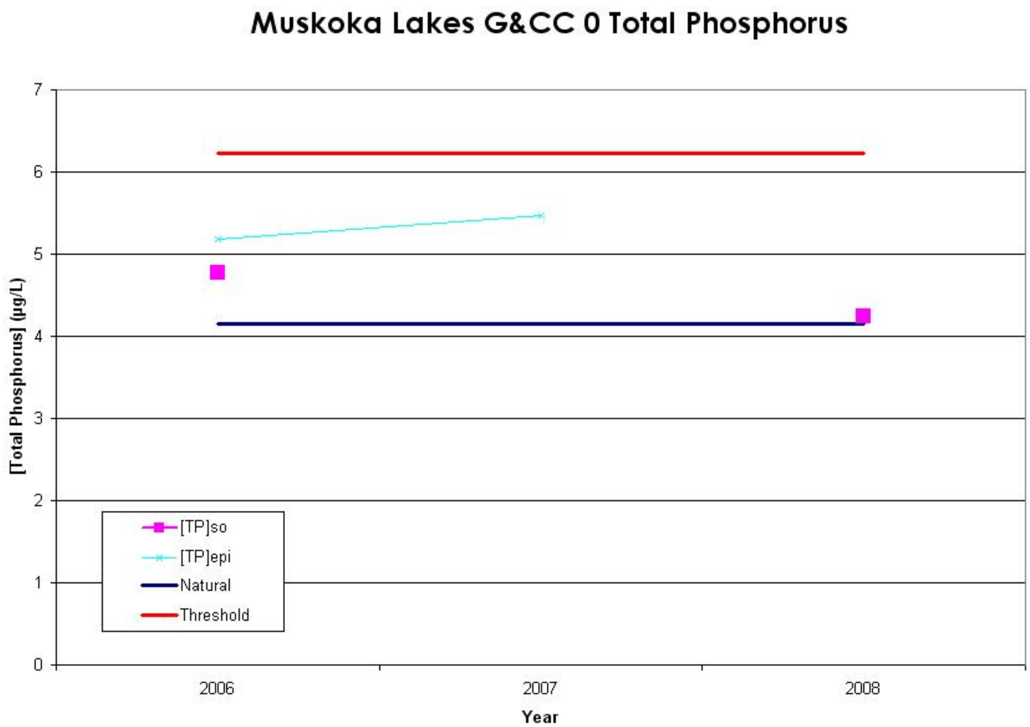

Figure 31. Muskoka Lakes Golf and Country Club Total Phosphorus

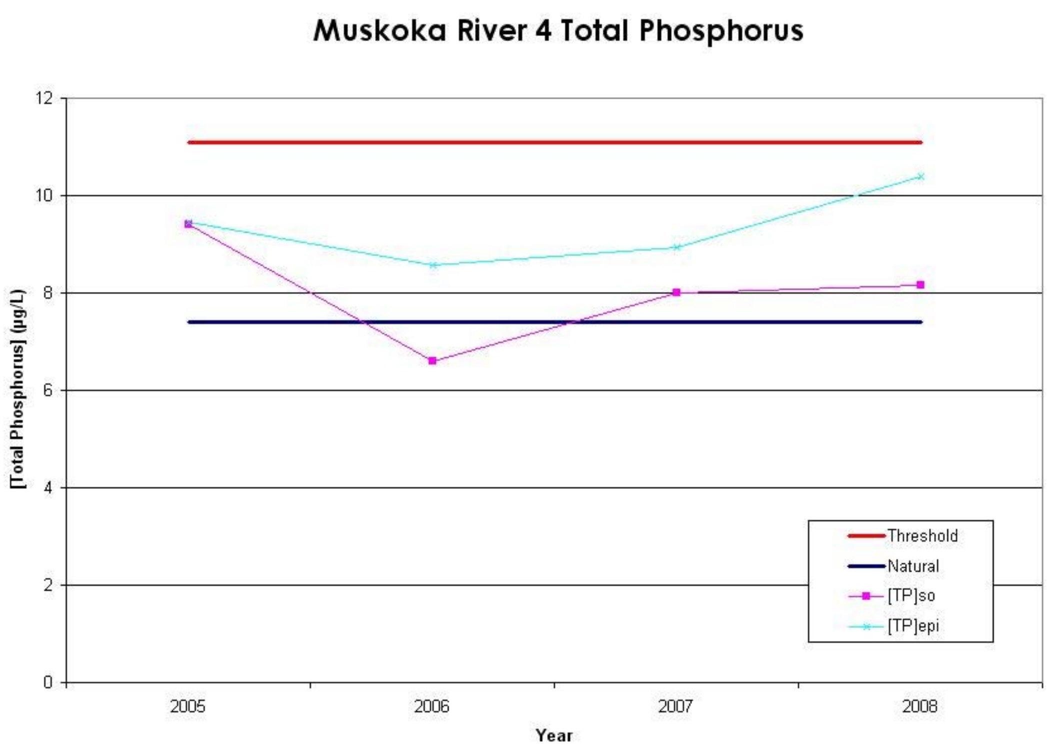

Figure 32. Muskoka River Total Phosphorus

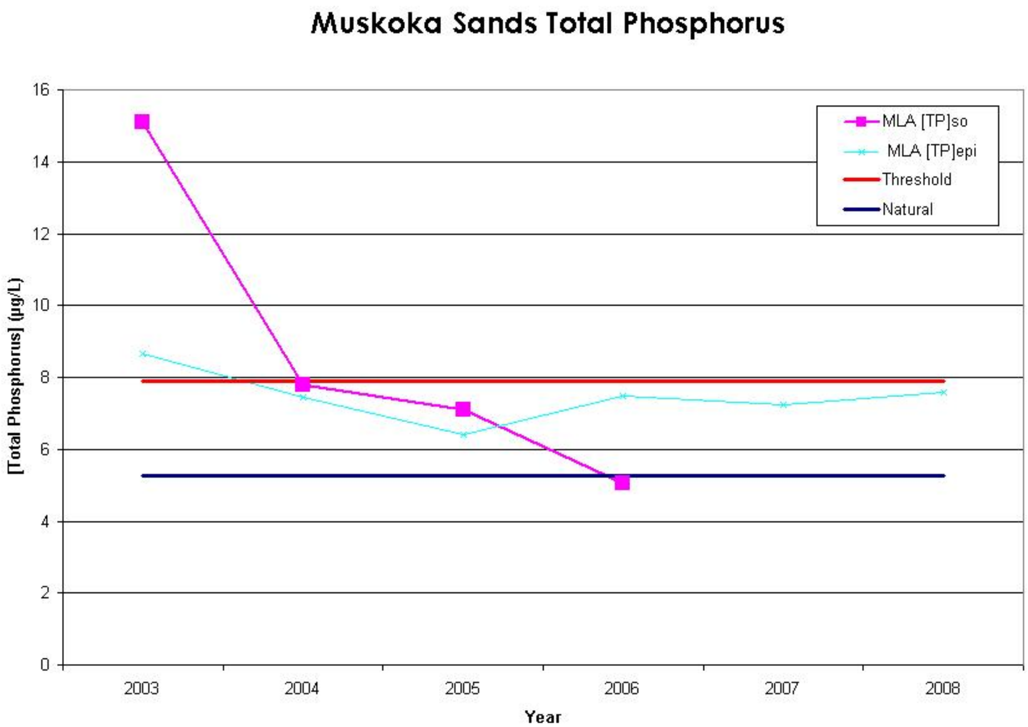

Figure 33. Muskoka Sands Total Phophorus

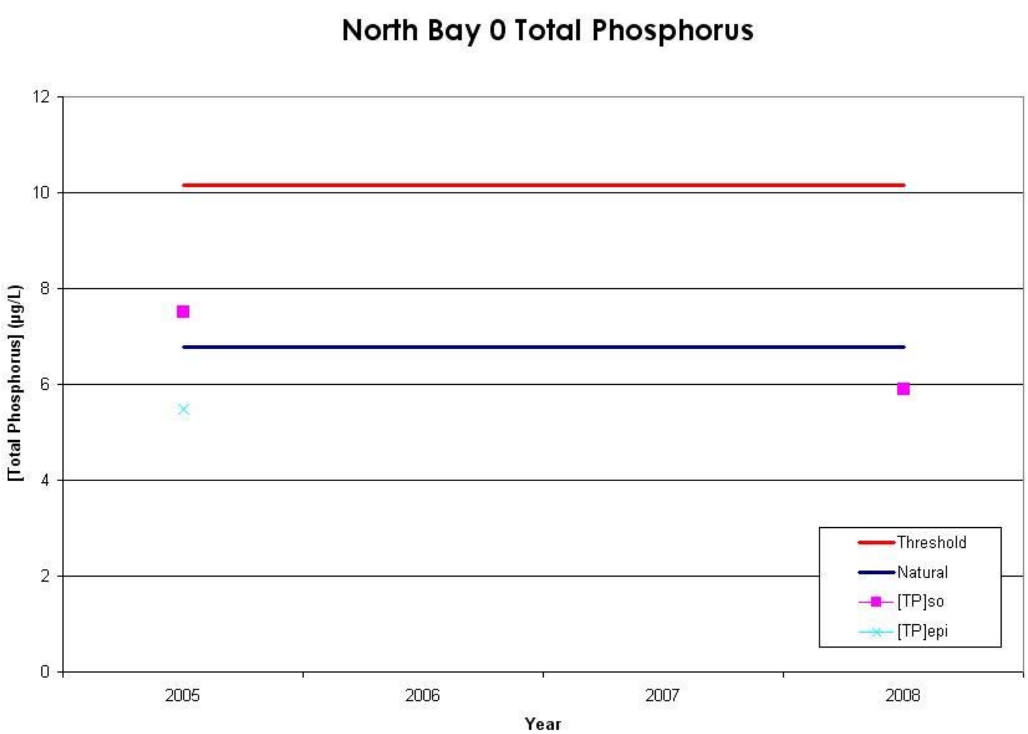

Figure 34. North Bay Total Phosphorus

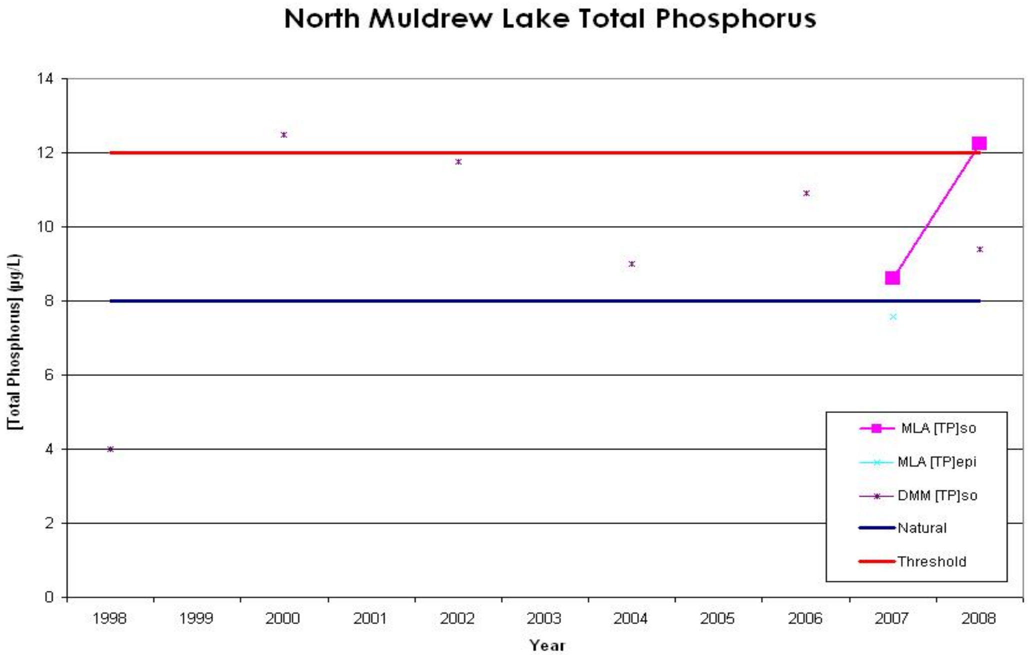

Figure 35. North Muldrew Lake Total Phosphorus

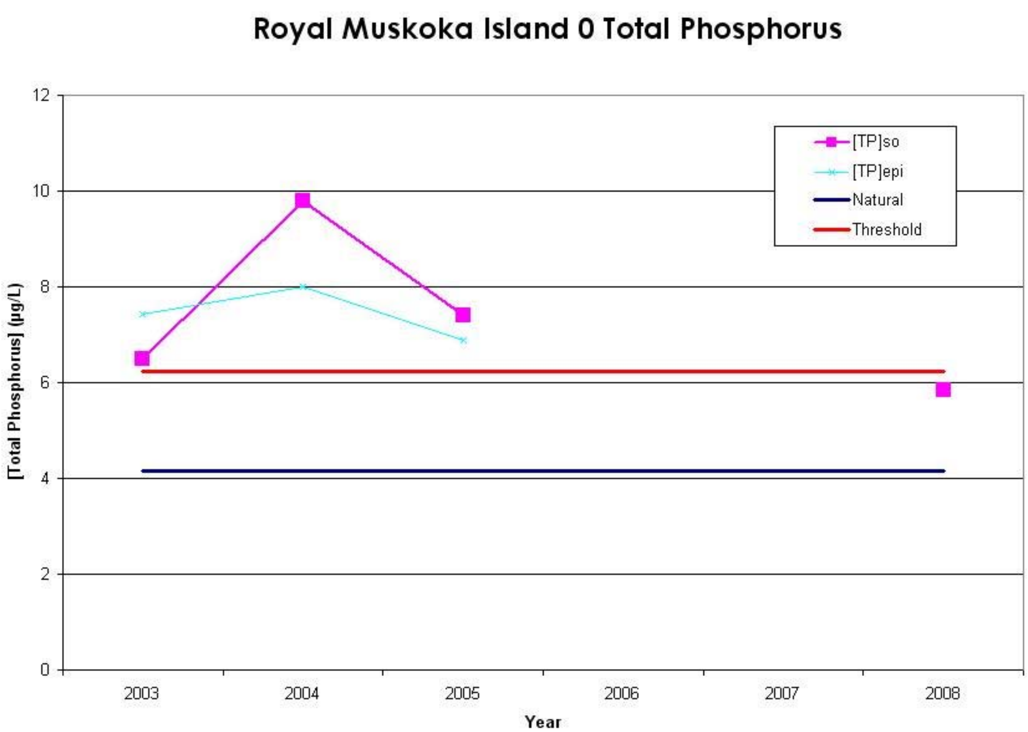

Figure 36. Royal Muskoka Island Total Phosphorus

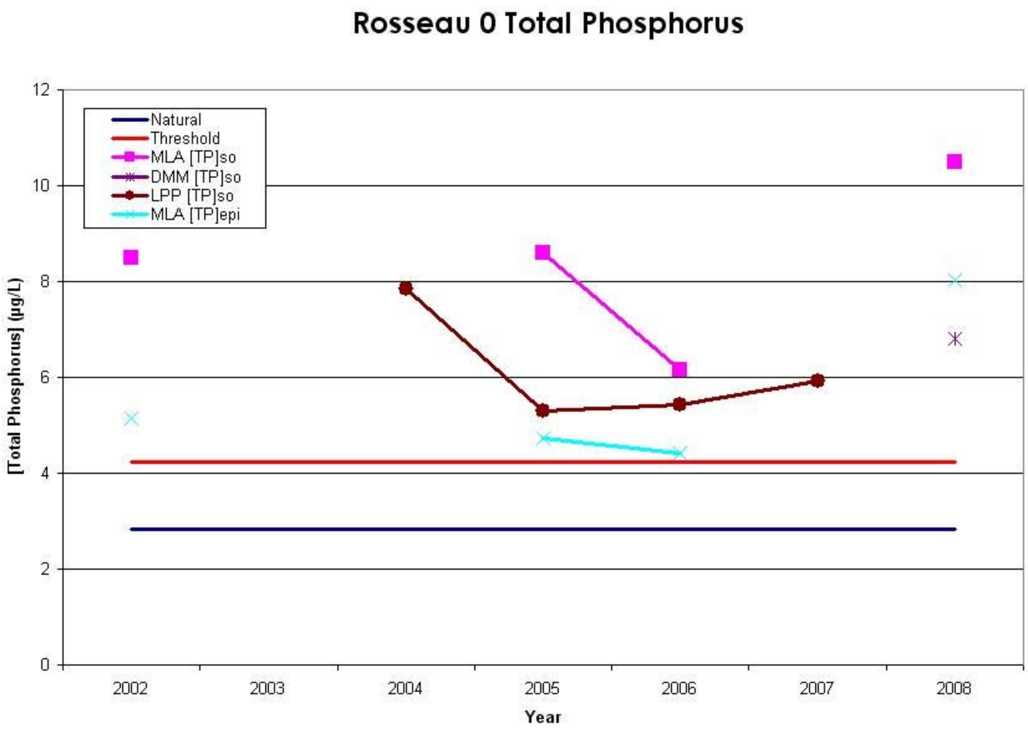

Figure 37. Rosseau (Lake Rosseau North Basin) Total Phosphorus

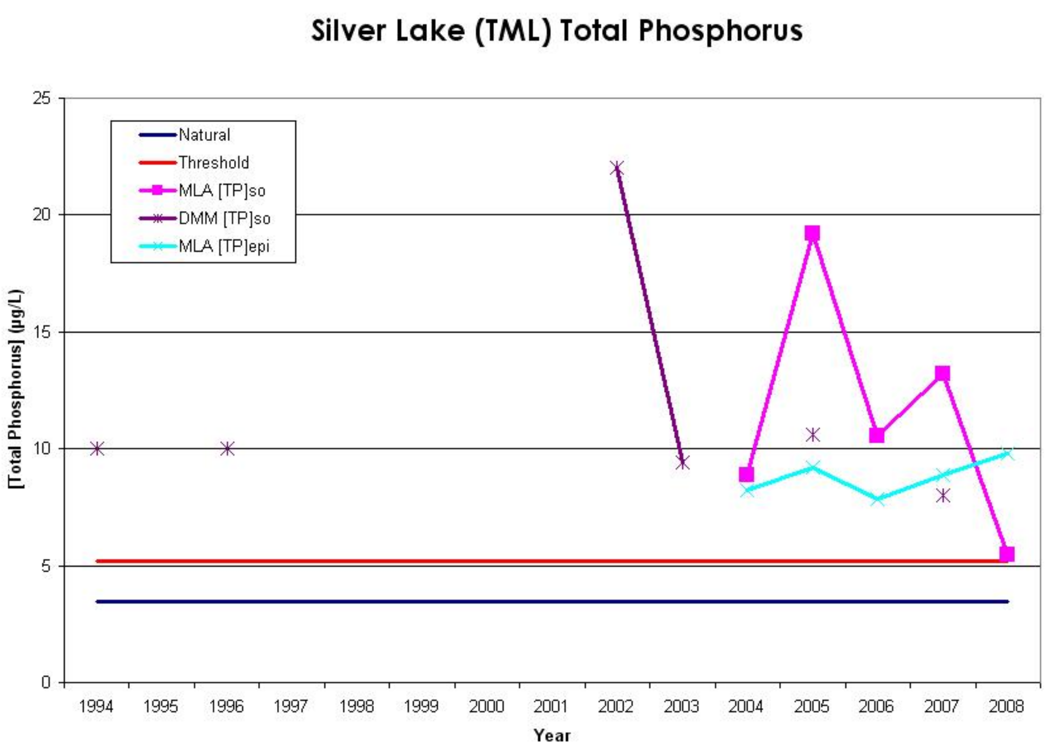

Figure 38. Silver Lake (Muskoka Lakes) Total Phosphorus

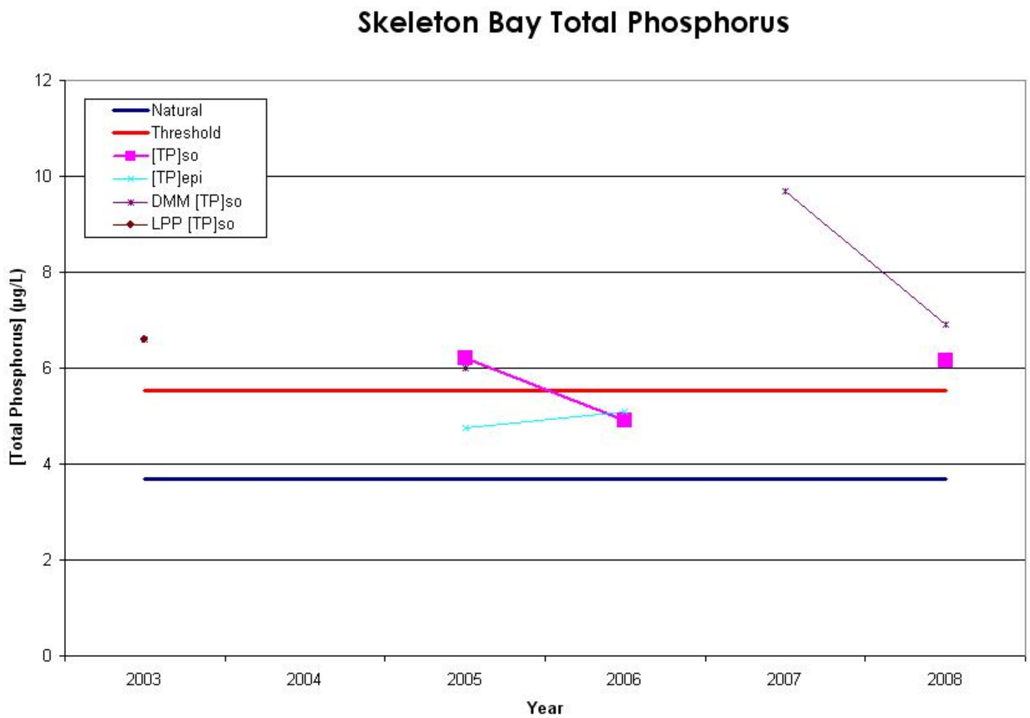

Figure 39. Skeleton Bay Total Phosphorus

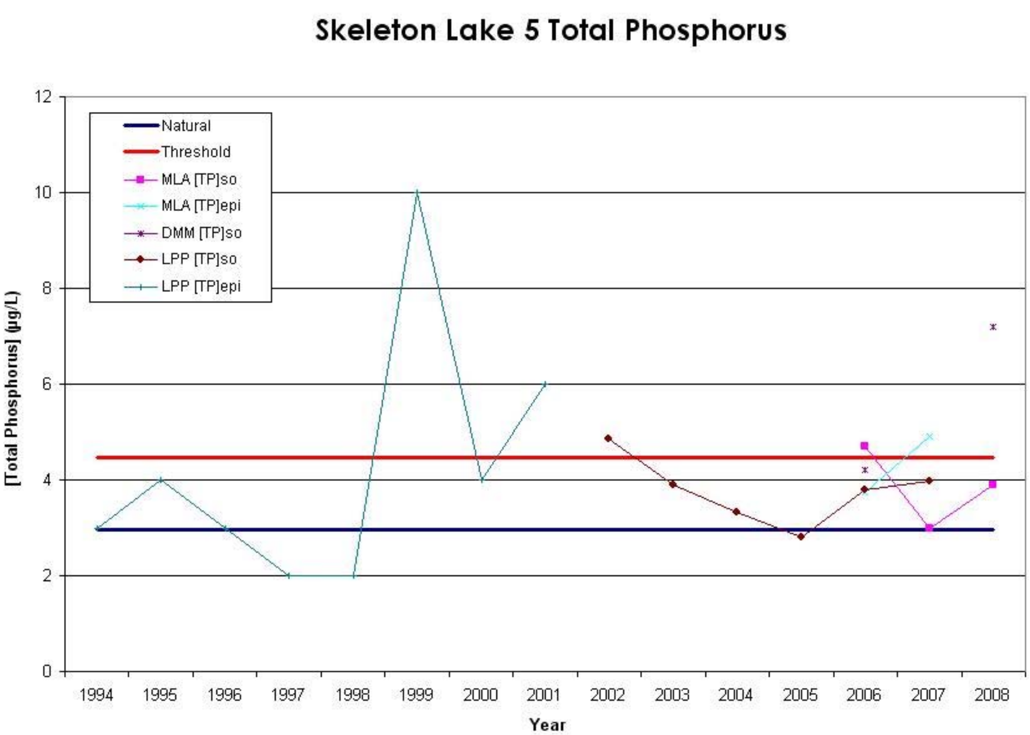

Figure 40. Skeleton Lake Total Phosphorus

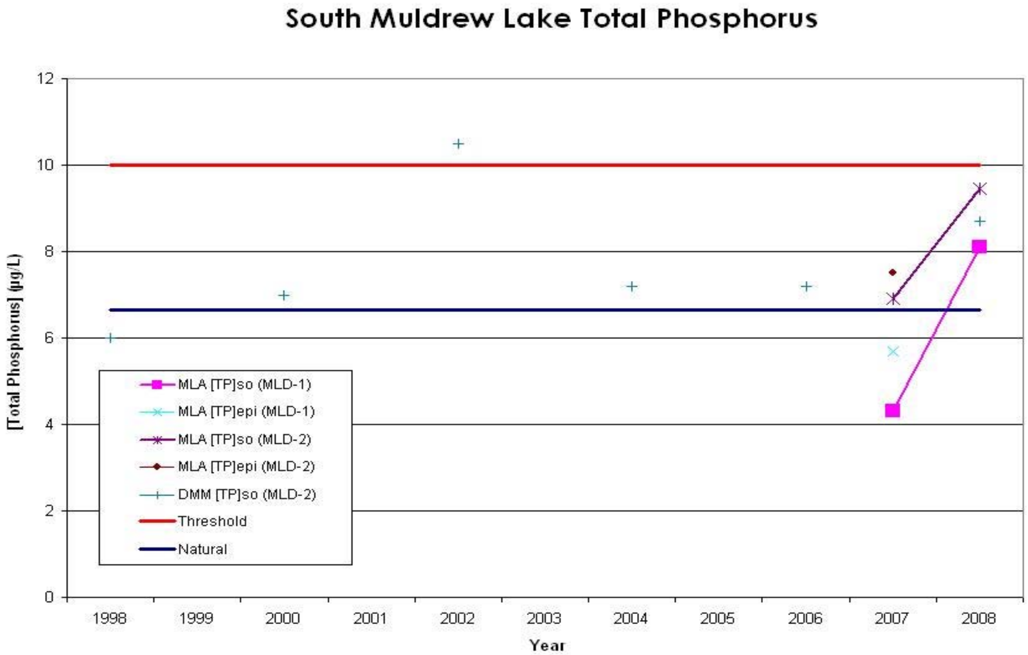

Figure 41. South Muldrew Lake Total Phosphorus

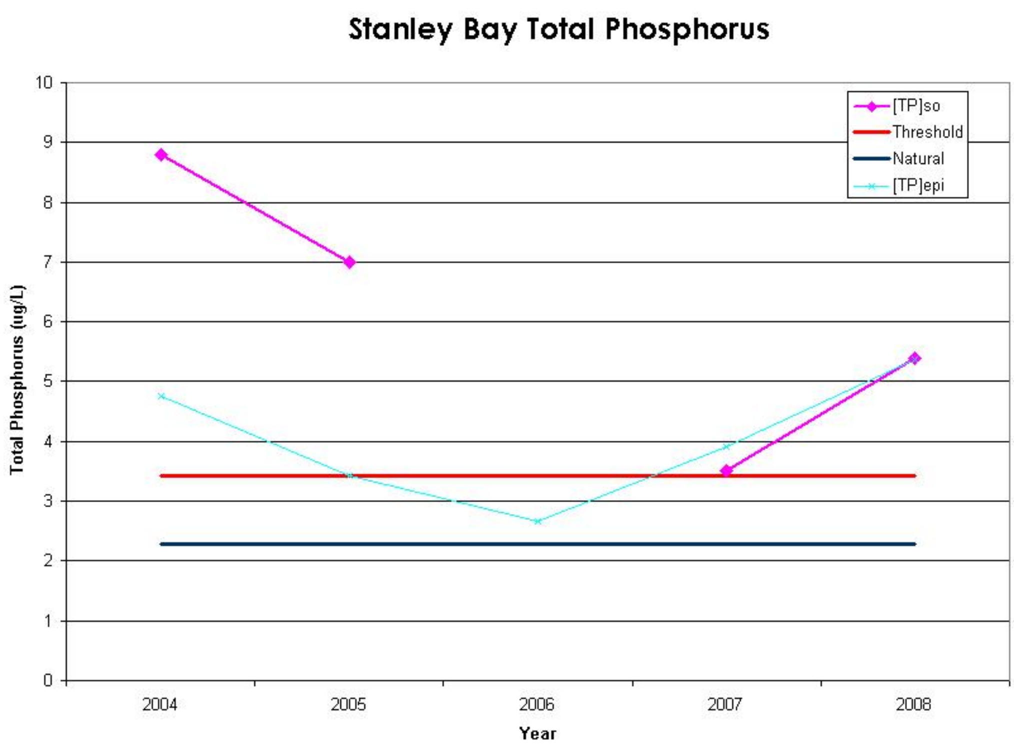

Figure 42. Stanley Bay Total Phosphorus

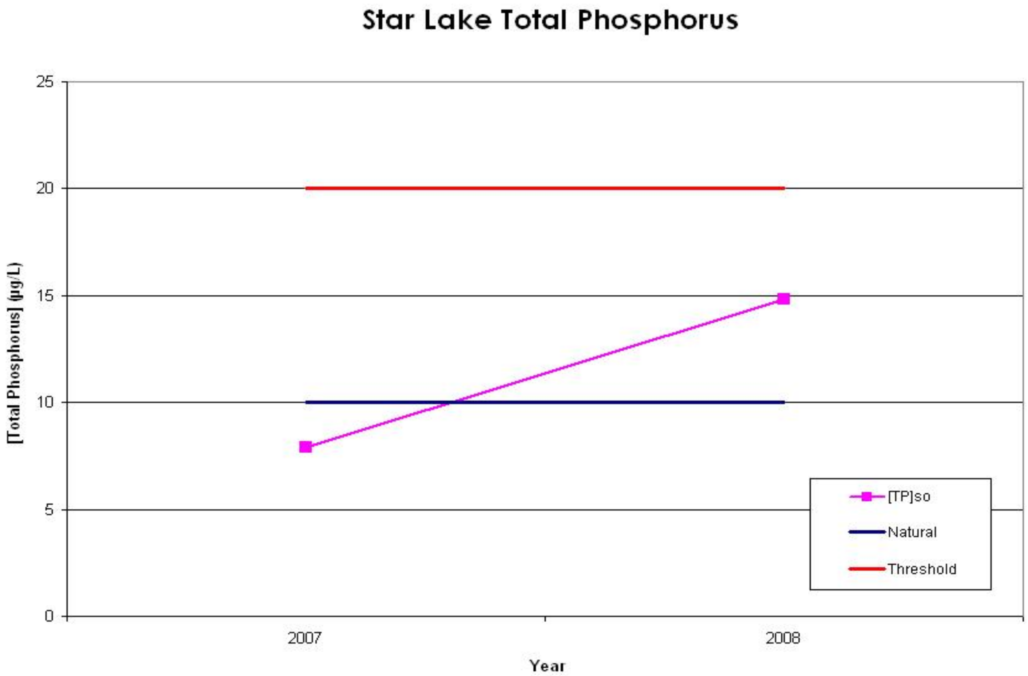

Figure 43. Star Lake Total Phosphorus

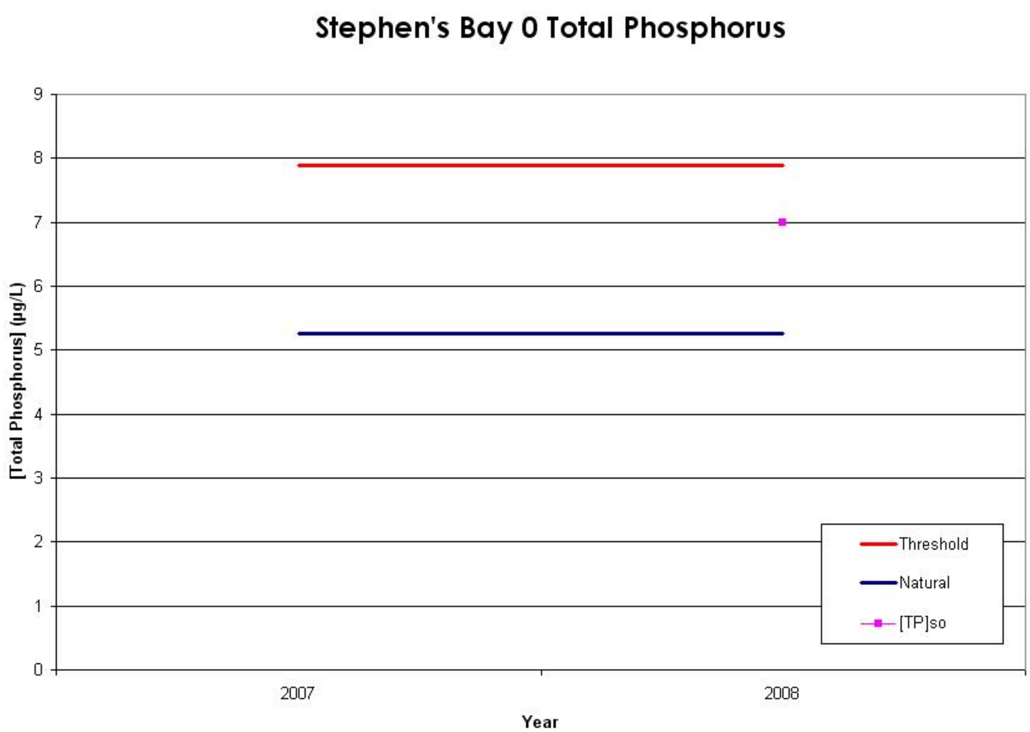

Figure 43 - Stephen's Bay Total Phosphorus

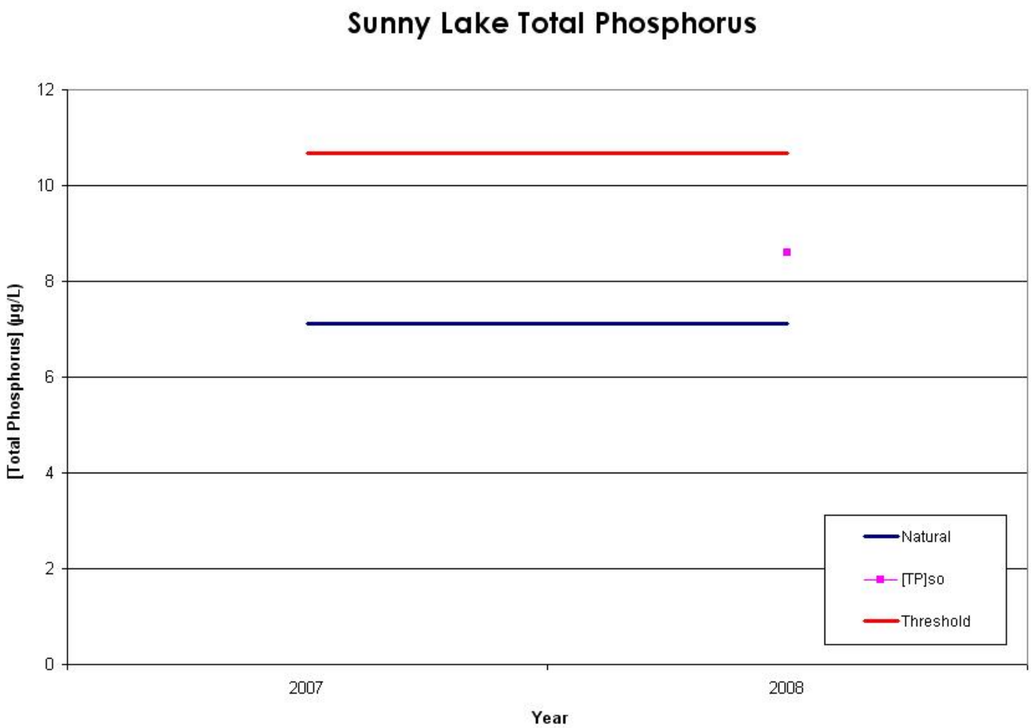

Figure 44. Sunny Lake Total Phosphorus

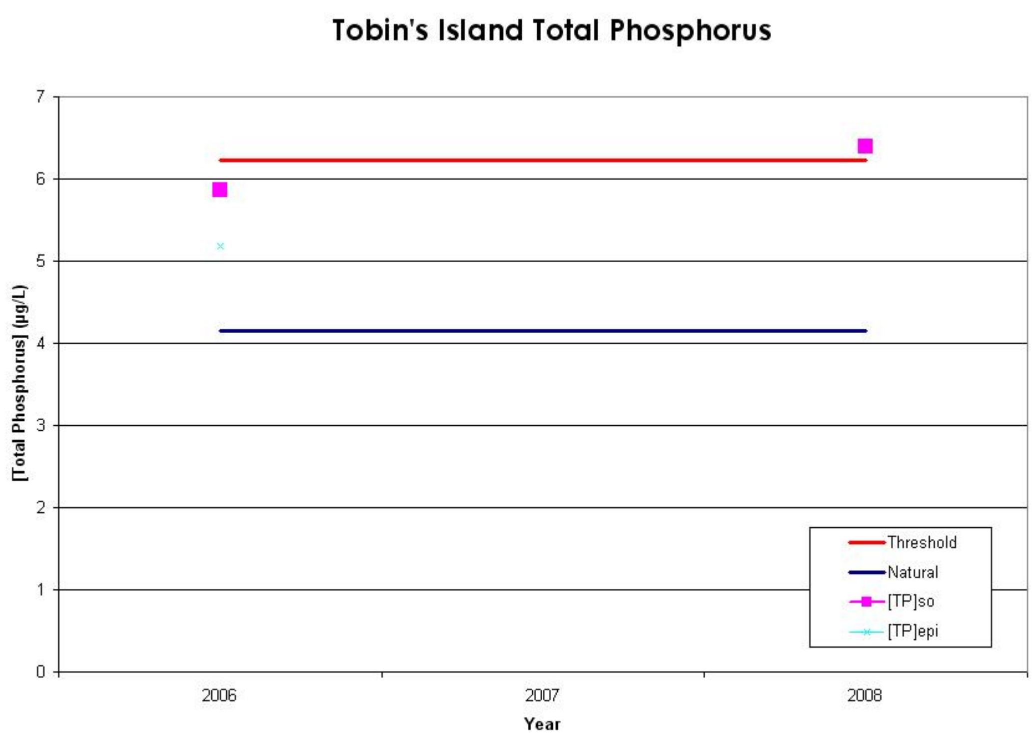

Figure 45. Tobin’s Island Total Phosphorus

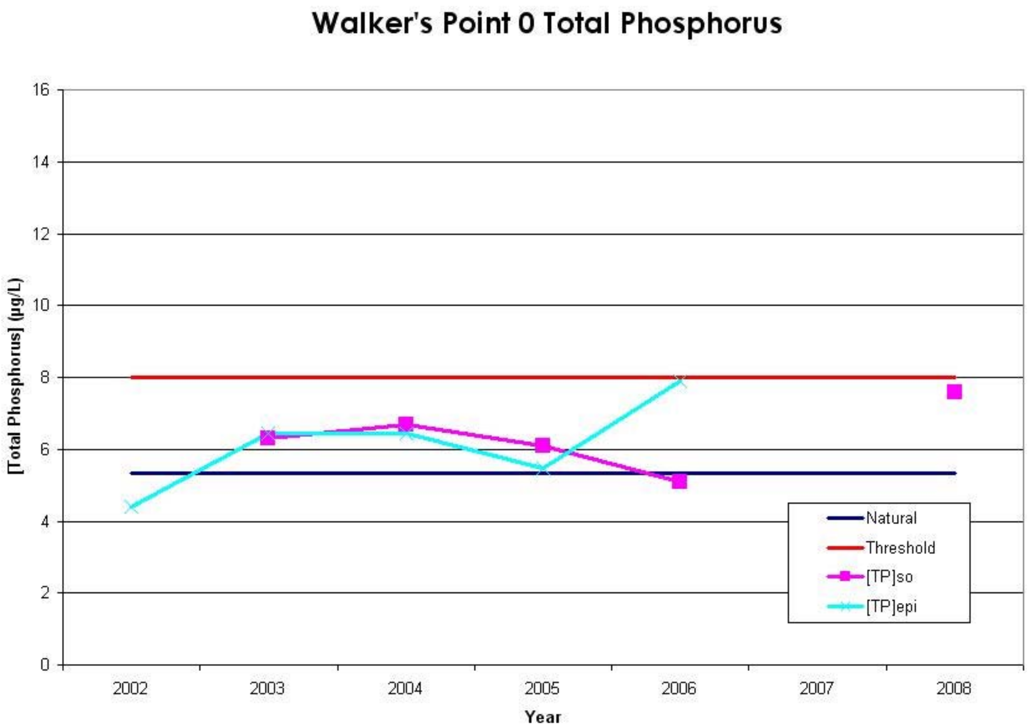

Figure 46. Walker's Point Total Phosphorus

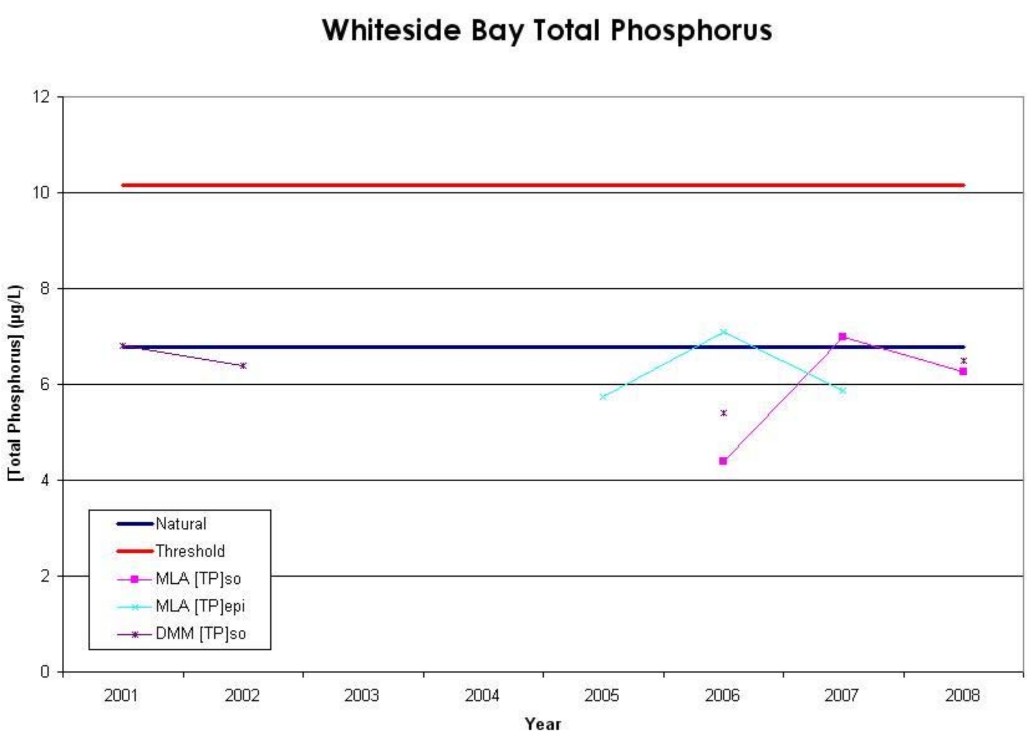

Figure 47. Whiteside Bay Total Phosphorus

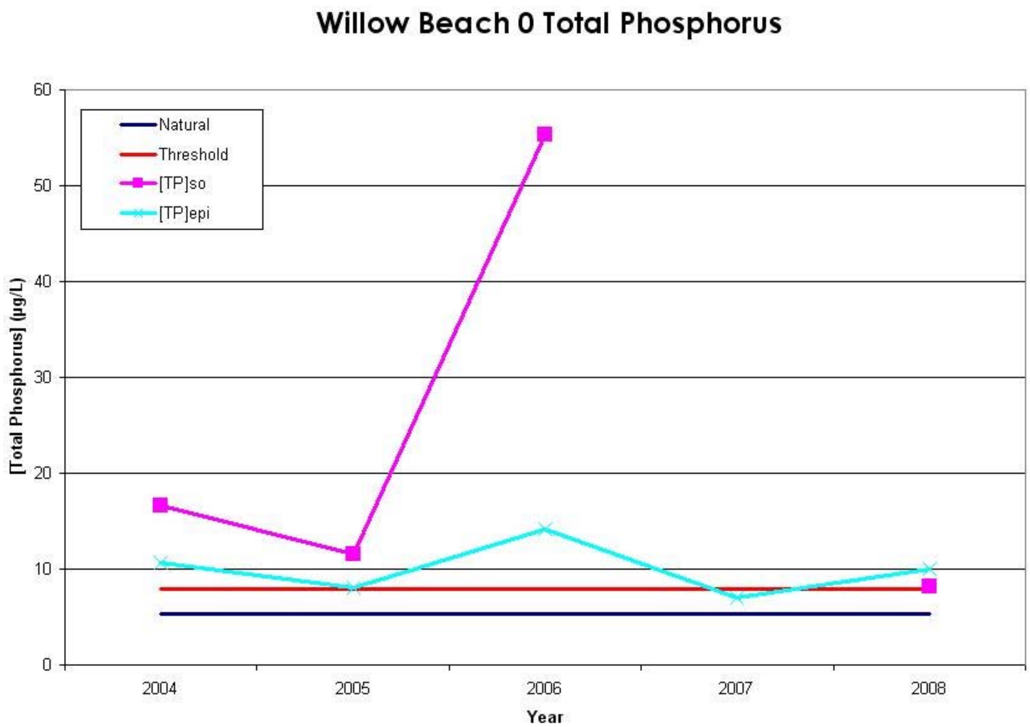

Figure 48. Willow Beach Total Phosphorus

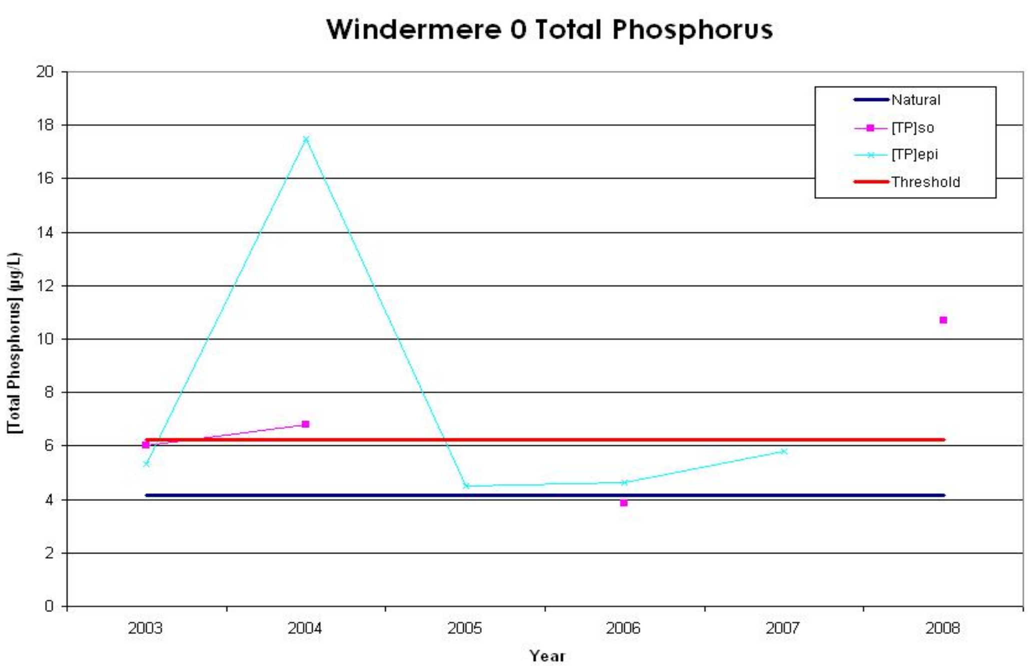

Figure 49. Windermere Total Phosphorus