Bass Lake Tributary Study

August 22nd, 2024

Tip of the Mitt Watershed Council

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Acknowledgements

Tip of the Mitt Watershed Council (TOMWC) would like to offer our special thanks to the Bass Lake Association of Elk Rapids (BLAER) for their sincere interest in the protection of Northern Michigan's waters and for contracting with us to complete a tributary study for Bass Lake. The following report is intended to be a comprehensive overview of the results from the contract made between TOMWC and BLAER.

Introduction

Bass Lake is situated on the north side of the Village of Elk Rapids, between Elk Lake and Grand Traverse Bay (Figure 1). Being adjacent to the City of Elk Rapids, the southern half of Bass Lake is more heavily developed and impacted by removal of shoreline vegetation (greenbelt loss), shoreline hardening (e.g., seawalls, riprap), and urban stormwater runoff. The northern half of the lake is more intact with vegetated areas in and among the cottages. Bass Lake has an area of 144 acres and a shoreline of 2 miles. Its maximum depth is 24 feet. Bass Lake is a seepage lake, meaning it does not have an inlet or an outlet. The area that was monitored via this project (Figure 7) will be referred to as a 'tributary' throughout this report, for lack of a better term. However, it should be noted that the monitored site is seasonal and has an intermittent flow, so it cannot truly be considered a tributary by definition. The site monitored via this project extends from the northernmost point of Bass Lake (Figure 7).

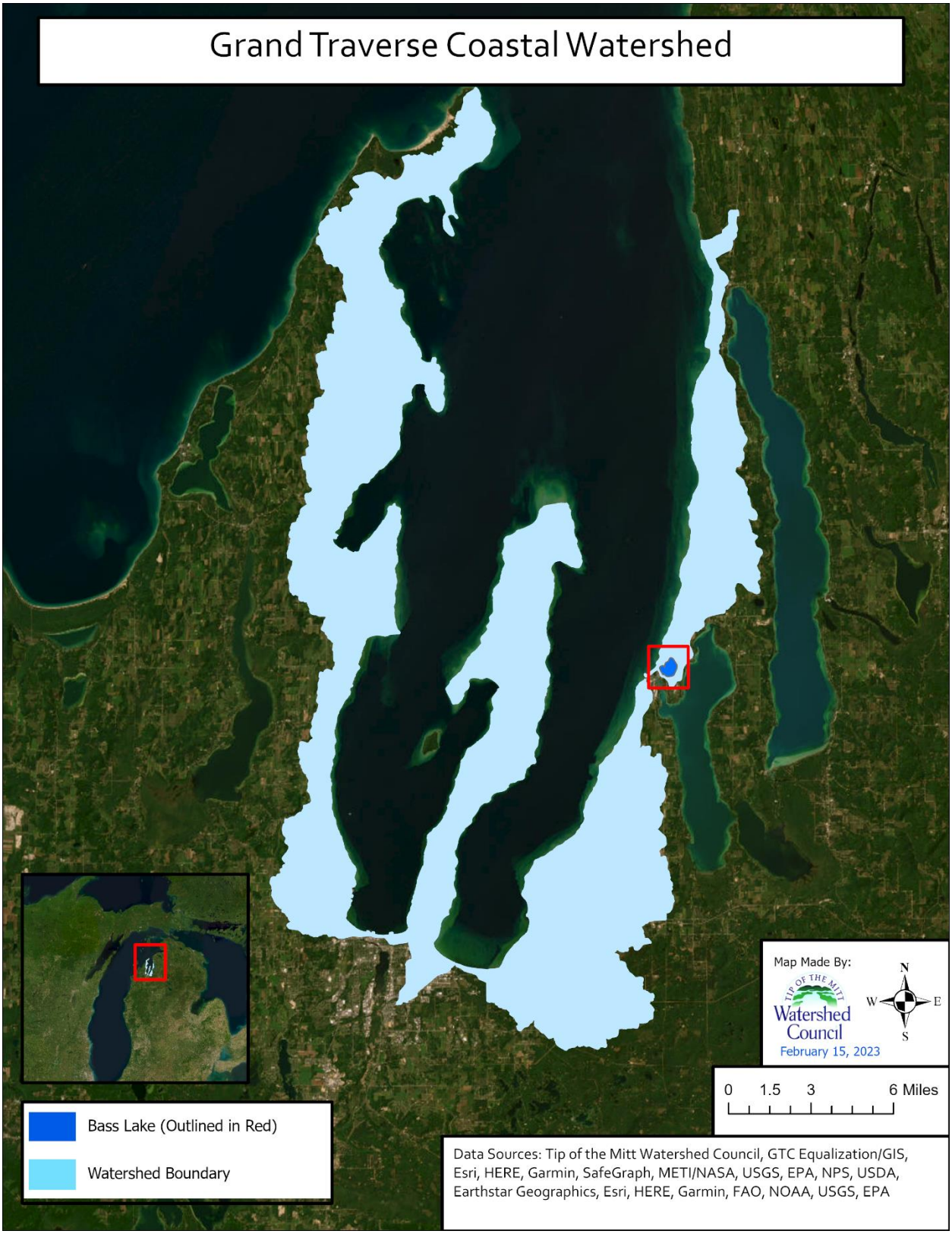


Figure 1. A map of the Grand Traverse Bay watershed with Bass Lake circled in red.

Water Quality

Bass Lake is monitored every three years through the Watershed Council's Comprehensive Water Quality Monitoring (CWQM) Program for dissolved oxygen, specific conductivity, pH, total nitrogen, total phosphorus, and chloride levels. Aquatic nutrients, such as total phosphorus and total nitrogen, are important chemical parameters that form the foundation of all freshwater ecosystems.

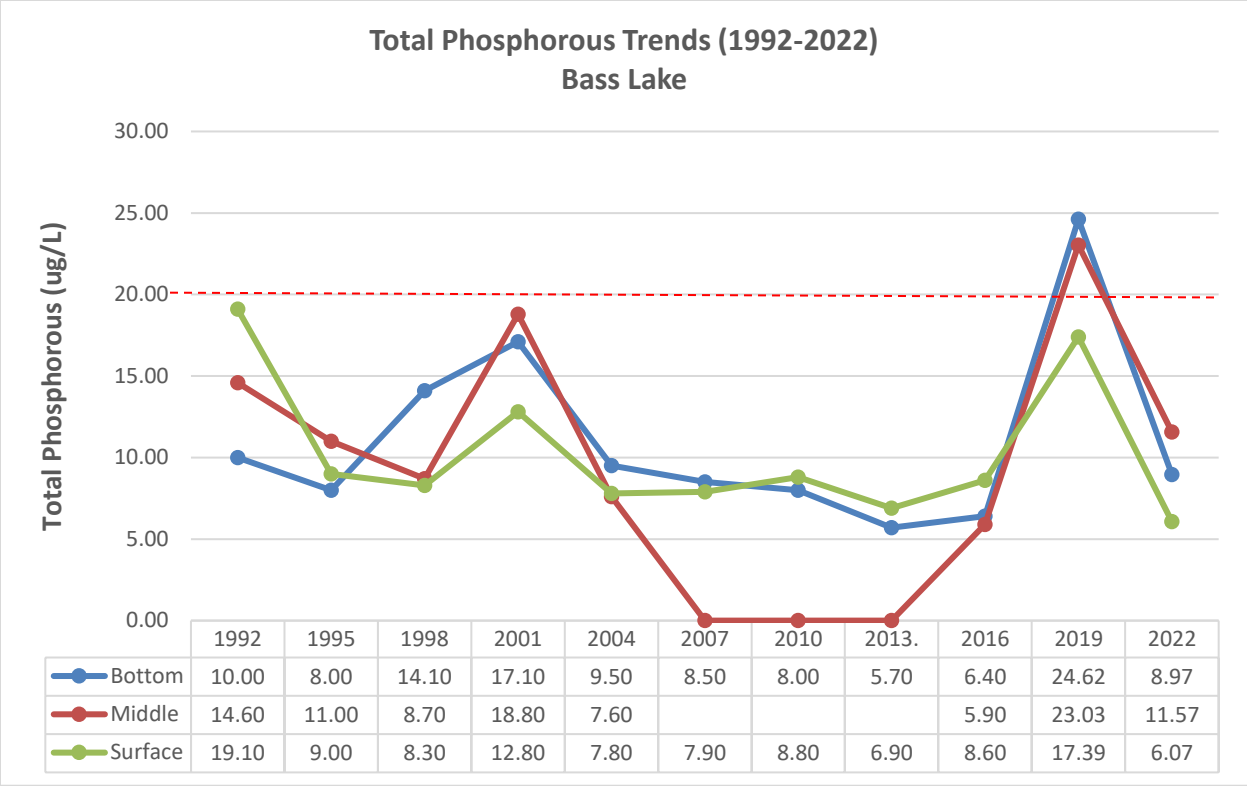
Total phosphorus is an essential aquatic nutrient required by algae and rooted aquatic plants to facilitate their growth and reproduction. Total phosphorus predicts both biological productivity and current trophic states of freshwater bodies. It can be used to determine whether nutrient pollution is occurring, and to what extent. Nutrient pollution can not only cause increased aquatic plant and algal growth, but can contribute to decreased water clarity, depleted levels of dissolved oxygen, mucky lake bottoms, unstable food chains, hypoxic zone formation, and death of benthic organisms.

Total nitrogen is another essential nutrient found in aquatic ecosystems. Nitrogen contributes to the growth of algae and plants, which provide wildlife habitat. Similar to total phosphorus, excess levels of nitrogen are indicative of a eutrophic ecosystem. Nitrogen-heavy waters may reflect environmental disturbances or anthropogenic activities, such as fertilizer use, stormwater runoff, or wastewater leakage from malfunctioning septic systems.

Below are the assessment criteria used for nutrient parameters sampled through the Watershed Council's CWQM program (Table 1). The assessment criteria are derived from the United States Environmental Protection Agency's (EPA) ambient water quality recommendations. Standard parameter values vary based on classification of waterbodies (i.e. lake or stream), type of parameter (i.e. type of nutrient, type of physical parameter, etc.), and EPA ecoregions and subecoregions. An ecoregion refers to specific areas where ecosystems are generally similar. A subecoregion refers to an ecoregion, but on a smaller geographic scale. Bass Lake falls into subecoregion 51.

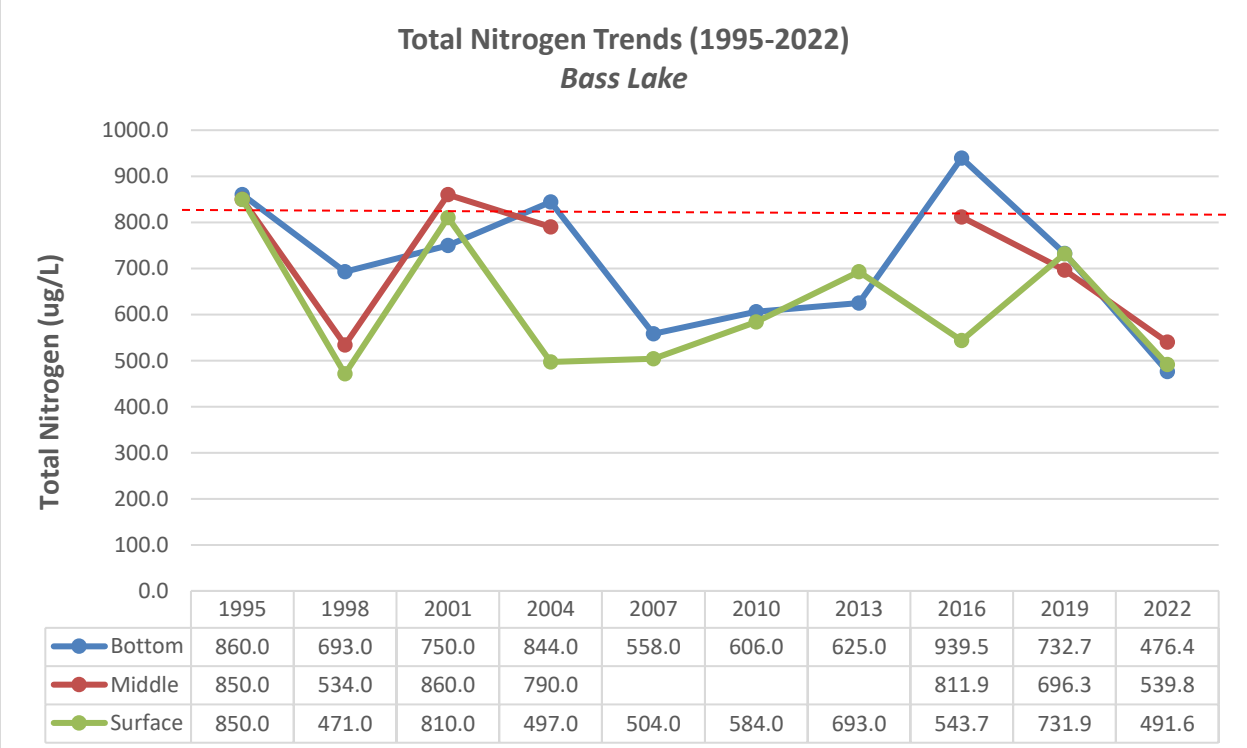
Table 1. Aquatic parameters measured as part of the Watershed Council's CWQM program.

Parameter	Standard Value(s)
Total Phosphorus (ug/L)	**Subecoregion 51:** 28.75 ug/L streams, 20 ug/L lakes
Total Nitrogen (ug/L)	**Subecoregion 51:** 710 ug/L streams, 810 ug/L lakes



	1992	1995	1998	2001	2004	2007	2010	2013.	2016	2019	2022
Bottom	10.00	8.00	14.10	17.10	9.50	8.50	8.00	5.70	6.40	24.62	8.97
Middle	14.60	11.00	8.70	18.80	7.60				5.90	23.03	11.57
Surface	19.10	9.00	8.30	12.80	7.80	7.90	8.80	6.90	8.60	17.39	6.07

*Figure 2. Phosphorus trends in Bass Lake from 1992-2022, collected through the Comprehensive Water Quality Monitoring Program. Note: Red dashed line indicates EPA recommended maximum value (20 ug/L). NOTE: The 3 readings in 2007, 2010, and 2013 do **not** indicate total phosphorus levels of zero. Rather, they indicate that only surface and bottom-level total phosphorus samples were collected during those years, and that there is no middle-level total phosphorus data in 2007, 2010, and 2013.*



	1995	1998	2001	2004	2007	2010	2013	2016	2019	2022
Bottom	860.0	693.0	750.0	844.0	558.0	606.0	625.0	939.5	732.7	476.4
Middle	850.0	534.0	860.0	790.0				811.9	696.3	539.8
Surface	850.0	471.0	810.0	497.0	504.0	584.0	693.0	543.7	731.9	491.6

Figure 3. Nitrogen trends in Bass Lake from 1995-2022, collected through the Comprehensive Water Quality Monitoring Program. Note: Red dashed line indicates EPA recommended maximum value (810 ug/L).

Water clarity (i.e. Secchi depth), chlorophyll-*a*, and water temperature are also monitored in Bass Lake each summer by volunteers as part of the Watershed Council's Volunteer Lake Monitoring (VLM) Program. Secchi disks are used to measure water clarity, or transparency, of a lake. Water clarity relates to overall nutrient levels and biological productivity (i.e. the clearer the water, the more nutrient-poor), and thus, Secchi disks are used for general assessment of lakes worldwide. For example, clear, nutrient-poor lakes may have Secchi disk depths reaching up to 50 feet or more, and nutrient-heavy lakes with excess algal blooms may be invisible just a few feet below the water's surface.

Chlorophyll-*a* is a photosynthetic pigment found in all green plants, including algae. Chlorophyll-*a* concentrations can be used as a measure of algal biomass in freshwater ecosystems, and can provide an estimate of overall biological productivity, and thus, trophic state. Trophic state essentially refers to the level of biological productivity, and overall nutrient levels, observed in waterbodies. Trophic state is commonly classified into four distinct categories: oligotrophic (nutrient-poor), mesotrophic (moderate nutrient levels), eutrophic (nutrient-enriched), and hypereutrophic (extreme nutrient enrichment). The median value of the summer chlorophyll-*a* monitoring results is used to calculate the Carlson Trophic Status Index (TSI) value for the lake, which is compared with the Secchi disk and total phosphorus TSI values for trophic status determination. The Carlson TSI uses an equation to calculate overall biological productivity and trophic state for any given waterbody (Table 3). Below are the assessment criteria used for all aquatic parameters sampled through the Watershed Council's VLM program (Table 2).

Table 2. Aquatic parameters measured as part of the Watershed Council's VLM program.

Parameter	Standard Value(s)
Chlorophyll-*a* (maximum value reported, in ug/L)	Oligotrophic = < 2.2 ug/L Mesotrophic = 2.2 - 6.0 ug/L Eutrophic = 6.0 - 22.0 ug/L Hypereutrophic = >22.0 ug/L
Water Clarity (Carlson Trophic Status Index (TSI))	Oligotrophic = ● Secchi disc depth: > 15.0 ft ● Chlorophyll-*a*: < 2.2 ug/L Mesotrophic = ● Secchi disc depth: 7.5 - 15.0 ft ● Chlorophyll-*a*: 2.2 - 6.0 ug/L Eutrophic = ● Secchi disc depth: 3.0 - 7.5 ft ● Chlorophyll-*a*: 6.0 - 22.0 ug/L Hypereutrophic: = ● Secchi disc depth: < 3.0 ft ● Chlorophyll-*a*: > 22.0 ug/L

Table 3. Trophic State and Corresponding Carlson TSI Values.

Trophic State	Carlson TSI
Oligotrophic	<38
Mesotrophic	38-48
Eutrophic	48-61
Hypereutrophic	>61

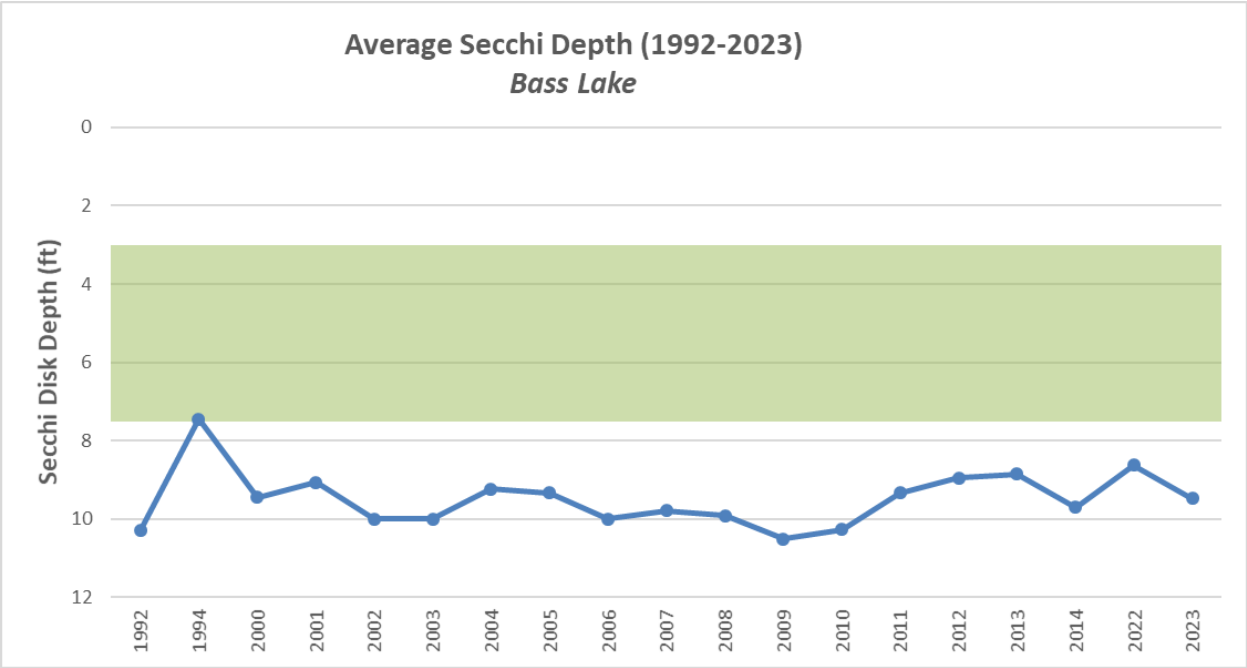


Figure 4. Secchi disk depth trends in Bass Lake from 1992-2023, collected through the Volunteer Lake Monitoring Program. Note: Green shaded region indicates a eutrophic ecosystem (Secchi depth readings of 3.0 feet to 7.5 feet). Readings less than 3.0 feet are indicative of a hypereutrophic ecosystem.

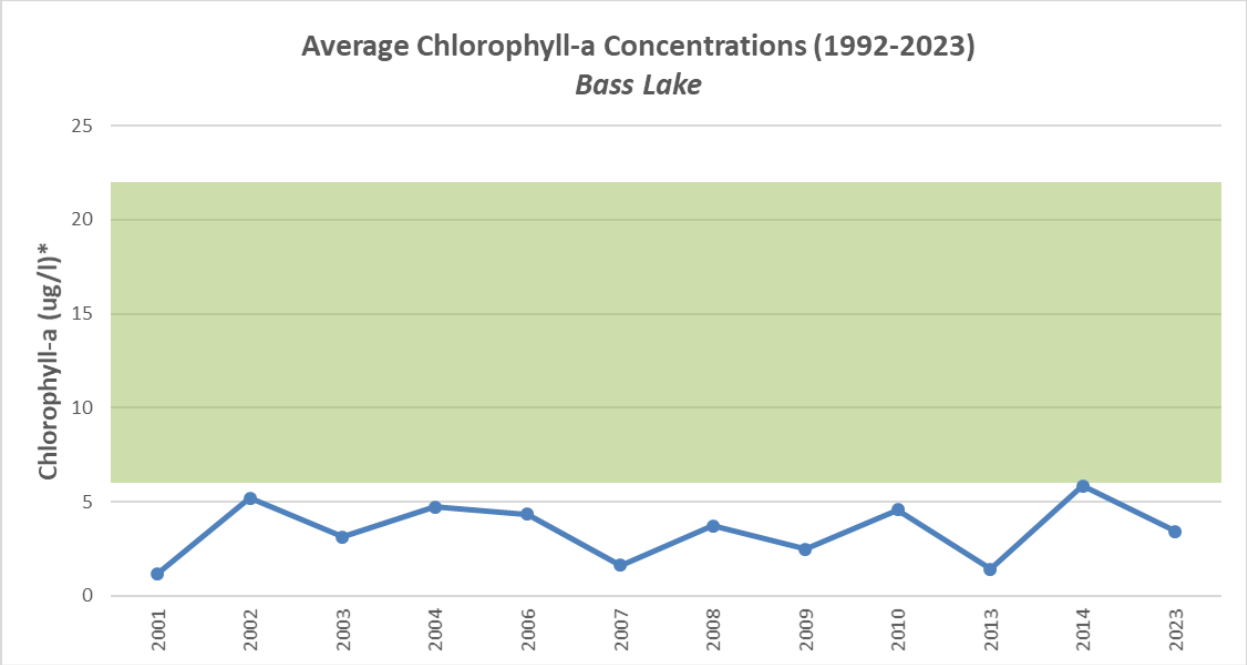


Figure 5. Chlorophyll-a trends in Bass Lake from 2001-2023, collected through the Volunteer Lake Monitoring Program. Note: Eutrophic conditions are indicative of chlorophyll-a concentrations at 6.0 ug/L and above. Levels do not exceed this threshold for this lake in the data reflected above.

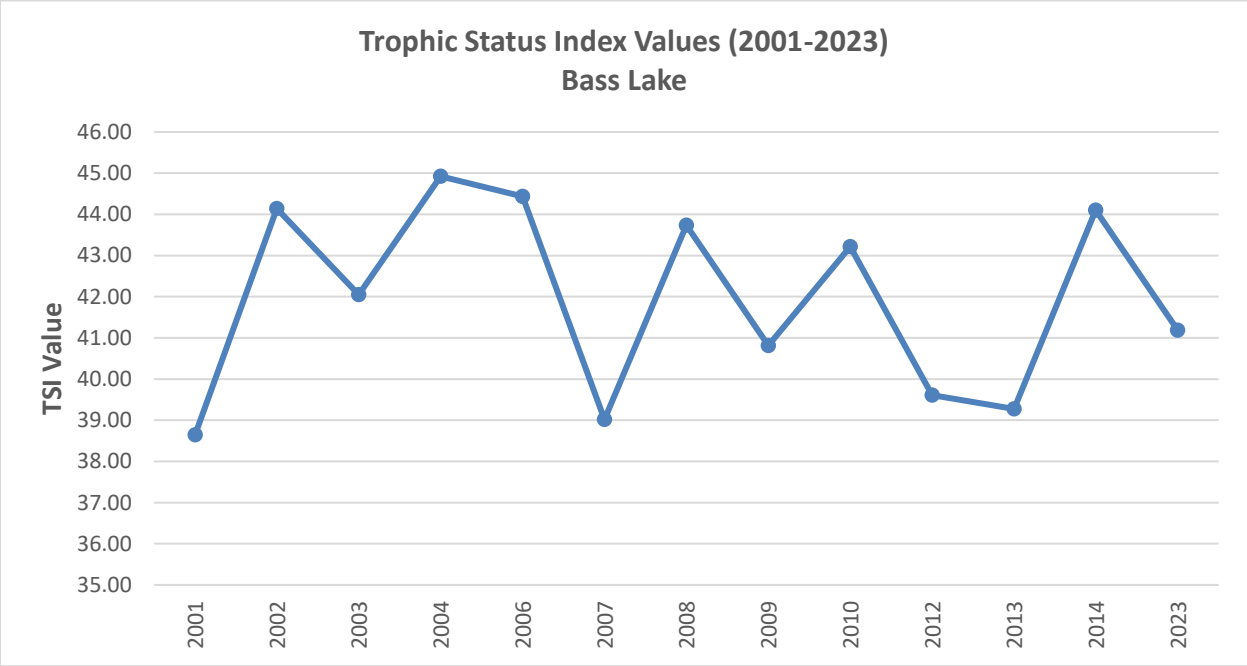


Figure 6. Trophic status index trends in Bass Lake from 2001-2014, collected through the Volunteer Lake Monitoring Program. Note: Eutrophic conditions are associated with a Trophic Status Index value of 48 or higher. Levels do not exceed this threshold for this lake in the data reflected above.

Based on the above nutrient data, we see that phosphorus levels in Bass Lake did not follow a concrete trend during the years of data collection. Levels slightly breached the EPA recommended maximum in 2019, going above 20 ug/L (Figure 2). Nitrogen levels in Bass Lake did not exhibit a concrete trend. Levels breached the recommended maximum of 810 ug/L periodically throughout the years, but levels were only notably higher around 2016 (Figure 3). In relation to Secchi depths, water clarity was lowest around 1994, where eutrophic conditions were briefly observed (Secchi disc reading of about 7.5 feet, Figure 4). Chlorophyll-*a* concentrations exhibited no concrete trend throughout the years, but did not demonstrate eutrophic conditions (levels were all under 6.0 ug/L, Figure 5). Finally, trophic status index values for Bass Lake did not surpass the value associated with eutrophic conditions (TSI ≥ 48), and no concrete trend was detectable (Figure 6).

Tributary Monitoring

Bass Lake Association of Elk Rapids initially approached the Watershed Council with the suggestion of tributary monitoring based on their concerns regarding excess plant growth. As mentioned above, Bass Lake has had instances of both total phosphorus and total nitrogen exceedances throughout the course of CWQM monitoring. Total phosphorus levels in Bass Lake (middle and bottom-level samples) exceeded the recommended maximum in 2019 (reaching almost 25 ug/L), and total nitrogen levels in Bass Lake peaked in 2016, falling around 950 ug/L (exceedance of the maximum value of 810 ug/L). To further investigate potential sources of nutrient influx, and to rule out the single tributary as a source of nutrient pollution, BLAER pursued sampling the tributary for both total phosphorus and total nitrogen. Below is a map depicting the location of the Bass Lake tributary in relation to the lake and its surrounding watershed (Figure 7).

Figure 7. A map of Bass Lake and the unnamed tributary that was sampled for nutrients in accordance with the BLAER contract.

Methodology

Sample collection was completed by the TOMWC Monitoring Coordinator, Anna Watson. Two water samples, to be analyzed for total phosphorus (in milligrams per liter of water, or mg/L), and total nitrogen (mg/L), were collected on March 7th, 2024. Sampling procedures involved using acid-washed bottles from the Great Lakes Environmental Center (GLEC). The sample bottles were lowered into the tributary at mid-depth. However, it should be noted that the tributary itself is both seasonal and shallow, so collection of the water sample was more similar to collecting a surface water sample (rather than a mid-depth sample). The sample bottles were *not* rinsed prior to collection due to the presence of a preservative in each of the bottles from GLEC. After collection, the bottles were stored on ice in a cooler and delivered immediately to GLEC for subsequent analysis.

Results

Below are the results for the total Phosphorus and total Nitrogen sample collected by TOMWC and analyzed by GLEC (Table 4). All tests were performed within the maximum holding times and met or exceeded QC criteria. Test results are in compliance with the NELAC Institute Standards.

Table 4. Results for total phosphorus and total nitrogen from the GLEC laboratory in mg/L.

Sample Description	Parameter ID	Results	Units	Analysis Method	Analysis Date	Sample Date
Bass Lake Tributary	Total Phosphorus	0.0234	mg/L	SM 4500-P F	3/22/2024	3/7/2024
Bass Lake Tributary	Total Nitrogen	0.318	mg/L	SM 4500-N C	3/28/2024	3/7/2024

For discussion purposes, it should be noted that the Watershed Council interprets nutrient (total phosphorus and total nitrogen) values in micrograms per liter of water, or ug/L. Test results provided in mg/L (as above) can be easily converted to ug/L by multiplying the mg/L value x 1000. The results for the Bass Lake Tributary in ug/L are as follows:

Table 5. Results for total phosphorus and total nitrogen from the GLEC laboratory, converted from mg/L to ug/L.

Parameter ID	Results	Units
Total Phosphorus	23.4	ug/L
Total Nitrogen	318	ug/L

From the results of the nutrient analysis, we see that total phosphorus levels were at 23.4 ug/L (Table 5). The recommended maximum level for total phosphorus concentrations in the subecoregion that contains Bass Lake (subecoregion 51) is 20 ug/L. The data indicates that **total phosphorus**

concentrations are exceeding the recommended maximum. Total nitrogen levels were at 318 ug/L (Table 5). The recommended maximum level for total nitrogen concentrations in the subecoregion that contains Bass Lake (subecoregion 51) is 810 ug/L. The data indicates that **total nitrogen concentrations are *not* exceeding the recommended maximum.**

Discussion

Of the two parameters analyzed, only one (total phosphorus) is present in excess in the Bass Lake tributary. This indicates that Bass Lake may be susceptible to and/or experiencing water quality issues, particularly since the tributary monitored is the only area providing Bass Lake with some degree of connectivity to the surrounding landscape. Potential sources of excess phosphorus to the Bass Lake tributary, and to Bass Lake itself, include the following:

Nutrient Runoff

Runoff occurs in all watersheds and can be from agricultural or urban sources. Increasingly higher levels of development in formerly natural areas (such as most of Northern Michigan's landscape) increase the risk of nutrient runoff entering previously undisturbed waterbodies. Phosphorus is a component of many fertilizers, and is commonly used in many agricultural practices. It can be carried from agricultural fields via runoff water or can attach to soil particles via erosion.

Malfunctioning Septic Systems

Improperly maintained or failing septic systems can pose a problem to inland lakes. In Michigan, 35% of residents rely on septic systems. However, Michigan is the only state in the nation without uniform standards for how on-site septic systems are designed, built, installed, and maintained. Poorly functioning and failing septic systems may introduce excess nutrients and bacteria to ground and surface waters that can be harmful to human health (via pathogen exposure) and to ecosystems (via contribution to cultural eutrophication – see page 16 for more details).

Shoreline Hardening

Shoreline hardening is the process by which the natural features of a waterbody's shoreline may be gradually replaced with more artificial structures as the lakefront undergoes development. These artificial structures may include seawalls (composed of steel, concrete, or wood), perpendicular groins (strip of rock that extends perpendicularly from the shoreline), rip-rap (collections of boulder and rock), mowing of grass, and removal of natural, native vegetation strips (known as 'greenbelts').

Comparison to Bass Lake Shoreline Survey (2022)

Shoreline hardening and sources of excess nutrients can be more thoroughly examined through shoreline surveys. Shoreline surveys look for erosion, *Cladophora* growth, shoreline hardening and alterations, and parcel development. In 2022, a shoreline survey was conducted on Bass Lake that found approximately 82% of shoreline properties on Bass Lake were considered to be developed or partially developed, with the vast majority of these being developed (Figure 8). Furthermore, 29% of Bass Lake parcels had no greenbelt, and 44% of parcels had at least one shoreline alteration (i.e. rip-rap, seawall, beach sand, etc.).

Lack of greenbelts, increased property development, and artificial shoreline alterations may all increase Bass Lake's degree of susceptibility to excess nutrient runoff. For example, removal or lack of greenbelt vegetation prevents absorption and/or filtration of pollutants from stormwater runoff. Development that involves an increase in impervious surfaces (roofs, driveways, roads) allows for greater inflow of runoff into the surrounding watershed.

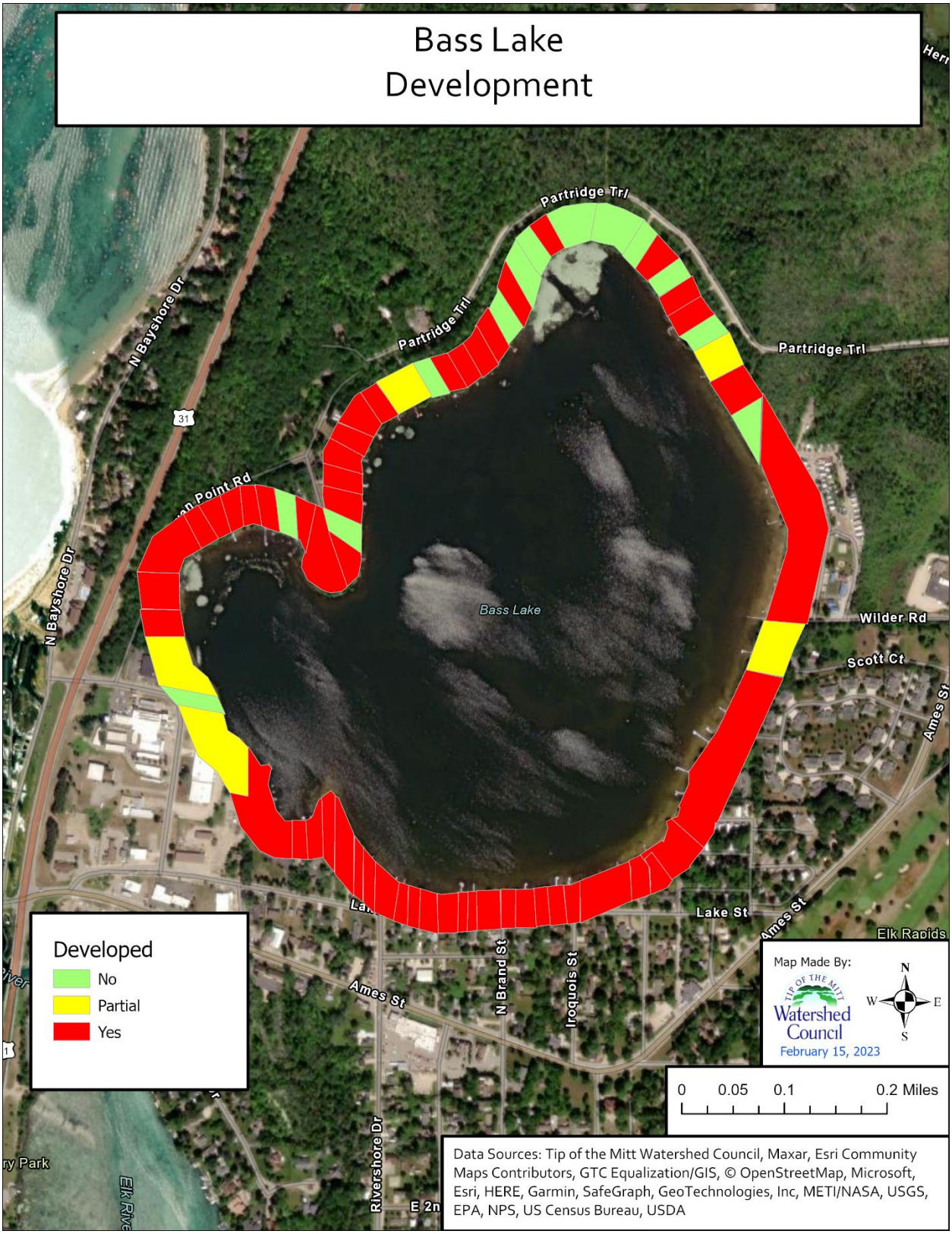


Figure 8. A map of the degree of development ('no', 'partial', 'yes') on Bass Lake from the 2022 Shoreline Survey.

While nutrient runoff, malfunctioning septic systems, and shoreline hardening are all significant ways that excess phosphorus could enter a lake or tributary, it is important to note that the excess nutrient sources are not limited to the aforementioned causes. Nutrients may enter freshwater ecosystems in a variety of ways. Furthermore, the process of nutrient influx is natural within aquatic ecosystems to a certain degree.

Effects of Excess Phosphorus

High levels of total phosphorus may introduce a plethora of water quality issues within the Bass Lake watershed, and its larger counterpart (the Grand Traverse Bay Watershed). These issues include, but are not limited to, eutrophication and harmful algal blooms (HABs), pathogen exposure (i.e. bacteria such as *E. coli*), unsuitable habitat for wildlife, excessive plant and algal growth (i.e. *Cladophora,* a filamentous alga that proliferates in response to excess nutrients) and issues with recreation and human access to water resources.

'Eutrophic' is the term used to refer to a water body with excessive nutrients, which leads to issues like increased aquatic plant and algal growth, decreased water clarity, depleted dissolved oxygen levels (unsuitable wildlife habitat), mucky lake bottoms, unstable food chains, hypoxic zone formation (habitat degradation), and death of benthic organisms. 'Cultural eutrophication' is pollution occurring as a result of excess nutrients, specifically from anthropogenic activities, that causes a waterbody to reach the aforementioned eutrophic state. This high level of eutrophication may facilitate the formation of HABs, which are algae blooms containing cyanotoxins that can produce a variety of health issues, or in extreme cases, fatalities, for humans and pets.

In terms of pathogen exposure, excess plant growth, and recreational issues, we know that the impact of a failing septic system may be especially noticeable in the form of increased plant and algae growth (*Cladophora*) in the nearshore area, which can make boating and swimming undesirable recreational activities. Failing septic systems can also make it unsafe for swimming due to the introduction of disease-causing bacteria, viruses, parasites, and other pathogens to freshwaters.

Comparison to the Coastal Grand Traverse Bay Watershed Plan

When considering the impacts of excess phosphorus in the Bass Lake tributary, it is critical to understand both landscape and water quality conditions at a larger scale – that is, the Coastal Grand Traverse Bay Watershed. According to 2016 land use/land cover data, the landscape surrounding Bass Lake is predominantly urban on the southern half of the lake, and consists of forested wetlands around the northern half. Sources of excess phosphorus are potentially entering the Bass Lake tributary via stormwater runoff from an increasingly urbanized landscape. Additionally, lands around Bass Lake were found to have low drainage soils in combination with 32+ housing units per square mile. These factors combined increase the risk of septic pollution in the areas surrounding Bass Lake and its tributary.

Additionally, sites of environmental contamination, and sites with leaking underground storage tanks, have been identified in proximity to Bass Lake.

Based on the above potential sources of excess phosphorus in the Bass Lake tributary, it is crucial to note that the Watershed Plan identified 'nutrients' as a known environmental stressor/pollutant within watershed itself – with identifiable sources of these nutrients (i.e. total phosphorus) being the following:

(1) Urban/agricultural/rural stormwater runoff
(2) Septic systems
(3) Lack of riparian buffers (i.e. greenbelts or vegetation buffers along streambanks)
(4) Wetland reduction
(5) Residential or commercial fertilizer use
(6) Air Deposition
(7) Decomposition
(8) Animal Waste

These known sources of nutrient pollution, along with potential sources like low drainage soils and environmental contamination sites, were considered when writing and prioritizing implementation tasks (i.e. action items to combat water quality or environmental issues in the watershed) for the Coastal Grand Traverse Bay Watershed Plan. Bass Lake is adjacent to both low-priority and medium-priority areas that have been identified by the Watershed Plan as needing 'protective actions' to maintain high environmental quality and high water quality. The landscape also has identified 'critical areas' (areas in need of restoration actions to rectify poor environmental/water quality) since it is near an urban area and has wetlands that need to be protected. Based on the identified critical and priority areas, implementation tasks were established, some of which are listed below in the 'Recommendations' section.

The 'Recommendations' section below is designed to list potential action items that can be taken to further combat the issue of excess phosphorus and nutrient pollution within Bass Lake, the unnamed tributary, and the Coastal Grand Traverse Watershed as a whole.

Recommendations

(1) Pursue a second round of total phosphorus testing in the tributary. Sampling at multiple locations may provide helpful information as to the source of the nutrient influx.
(2) Pursue a greenbelt or bioengineering contractual service with TOMWC for interested residents. Greenbelts and natural shoreline alterations may decrease the level of nutrients entering Bass Lake and its tributary.
(3) Continue to monitor Bass Lake as part of the CWQM and VLM programs through TOMWC. Long-term trend data is extremely useful when it comes to interpreting environmental changes.

(4) Share the nutrient results of this tributary study with Bass Lake Association and Bass Lake lakefront property owners so they can be aware of the issues that come with excess nutrient concentrations.
(5) Continue to promote and adopt implementation tasks from the Coastal Grand Traverse Bay Watershed Plan. These tasks include, but are not limited to, installation of green infrastructure, riparian buffers, coastal resiliency projects, adoption of local ordinances that aim to protect high quality waters, in-stream habitat improvement installation, and much more. For full details on the implementation tasks, and the Watershed Plan in general, visit the following link: GRAND TRAVERSE BAY WATERSHED (watershedcouncil.org)
(6) Education should be provided to property owners, and potential buyers, about septic systems. The United States EPA has a SepticSmart program that includes education on septic systems and how to properly maintain them. Additionally, the Watershed Council has a publication on proper septic system maintenance. Property owners should be encouraged to educate themselves, as well as friends and family, on what exactly happens once you "dispose" of something down the drain.
(7) Further action items may be developed from discussions between BLAER and TOMWC. Remember, there are numerous ways that nutrient pollution can be addressed in order to maintain the high quality waters of Northern Michigan.

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