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MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER RESOURCES DIVISION
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STAFF REPORT

ALGAL TOXIN MONITORING IN MICHIGAN INLAND LAKES: 2017 RESULTS

Introduction

The term “harmful algal bloom (HAB)” generally describes accumulations of cyanobacteria that are aesthetically unappealing and produce algal toxins. In 2015 the Michigan Department of Environmental Quality (MDEQ), Water Resources Division (WRD), developed the following definition of a HAB (Kohlhepp, 2015a): “An algal bloom in recreational waters is harmful if microcystin levels are at or above the 20 micrograms per liter (µg/L) World Health Organization (WHO) non-drinking water guideline, or other algal toxins are at or above appropriate guidelines that have been reviewed by MDEQ-WRD.” A key concept of this HAB definition is that while high chlorophyll *a* concentration and visible surface/water column algal accumulations can indicate potential problems, the WRD’s focus is on the potential harm that toxins represent. Thus, water samples must be analyzed for the presence of toxins to confirm that a bloom may, in fact, be harmful to humans or wildlife. Visible appearance of blooms cannot be used as a reliable predictor of toxin content.

The WRD receives reports each year about nuisance algal conditions that may or may not be HABs, from district staff, lake associations, and the broader public. These reports can come in as concerns about filamentous algae, cyanobacteria scums, or about suspected pollutants in the water such as “green paint spills,” which upon investigation, turn out to be cyanobacteria. The number of such reports, particularly the occurrence of blue-green algal blooms and concern over the possible presence of toxins such as microcystin, appear to have increased in recent years (Parker, 2014; 2016a; 2016b; and 2018). As a result, the MDEQ-WRD established an internal work group in March 2013 to develop an approach to monitor, assess, and report on nuisance and harmful algal conditions, as well as to improve our understanding of the nature, extent, and frequency of algal blooms in inland waters and nearshore Great Lakes. This report only summarizes microcystin results for inland lakes sampled in 2018. Water samples from beaches along Saginaw Bay and Lake Erie have also been analyzed for microcystins. Results from 2017 Lake Erie samples have been summarized by Parker (2018) and a report on the Saginaw Bay results is pending.

Microcystin concentrations in Michigan inland lakes are not typically very high across lakes that are randomly sampled. Sarnelle and Wandell (2008) found that only 2 of the 77 inland lakes sampled by volunteers in August and September 2006 had microcystin concentrations greater than 20 µg/L. Rediske et al. (2007) also sampled 7 drowned-river mouth lakes in western Michigan in 2006 and did not find any microcystin samples above 20 µg/L. During the United States Environmental Protection Agency’s (USEPA), National Lake Assessments (NLA), in 2007 and 2012, no samples from Michigan exceeded 20 µg/L (Kohlhepp, 2015b).

Recently, the State of Ohio issued a recreational guidance of 6 µg/L for total microcystins (*The link provided was broken and has been removed.*). A revisit of Rediske et al. (2007) revealed 2 of the 7 drowned river mouth lakes sampled had instances where microcystin concentrations were greater than 6 µg/L. Using the State of Ohio guidance value did not change the number of elevated microcystin values found by Sarnelle and Wandell (2008) and in the NLA surveys.

In 2017, algal toxin monitoring occurred in targeted and randomly selected inland lakes, as well as lakes where citizens or staff reported algal blooms. This study was designed to allow the MDEQ to further: (1) evaluate the geographical extent of HABs in Michigan inland lakes (e.g., how widespread is the problem); (2) evaluate how algal toxin concentrations change during a growing season in targeted Michigan lakes; (3) Quantify algal toxin concentrations in lakes with public reports concerning algal blooms; and (4) determine if lake water chemistry parameters correlate with algal toxin concentrations.

Study Design

To achieve the study objectives, WRD biologists collected water quality data at randomly selected lakes, targeted inland lakes, and water bodies that concerned citizens or staff reported to the MDEQ concerning algal blooms. The randomly selected lakes were the 2017 Michigan Department of Natural Resources (MDNR) Inland Lake Status and Trend Program lakes, which are sampled to answer questions about lake conditions across the state (Walterhouse, 2015). The targeted lakes were selected based on high microcystin results from MDEQ monitoring in 2014-16.

Table 1. MDNR, Fisheries Division's (FD), randomly selected lakes sampled twice during summer 2017.

LAKE	County	STORET	Latitude	Longitude	Watershed
Allens Lake	Lenawee	460225	42.05917	-84.18334	Raisin
Au Train Lake	Alger	20167	46.40183	-86.84958	Au Train
Big Fish Lake/Joe's Big Fish Lake	Lapeer	440256	42.88489	-83.39228	Flint
Dead River - Tourist Park	Marquette	520536	46.5693	-87.4181	Dead
Flat Rock Impoundment	Wayne	821596	42.1046	-83.30654	Huron
Four Lake	Gladwin	260065	44.15503	-84.44746	Tittabawassee
Indian Lake	Iosco	350139	44.3475	-83.64945	Au Gres
Lake George	Clare	180056	43.95549	-84.93718	Muskegon
Lake Medora	Keweenaw	420029	47.43806	-87.96806	Montreal
Lake Michigamme	Marquette	520535	46.52542	-88.03174	Michigamme
Little Fish Lake	St. Joseph	750343	41.85362	-85.39628	St. Joseph
Martiny Lake/Big Evans	Mecosta	540206	43.72871	-85.23021	Pine
Michigamme Falls	Iron	360183	45.9726	-88.2017	Michigamme
Mullett Lake	Cheboygan	160050	45.48445	-84.56028	Cheboygan
Round Lake	Iosco	350110	44.33889	-83.65746	Au Gres
Stevenson Lake	Isabella	370163	43.7614	-84.83047	Pine
Tee Lake	Ogemaw	650142	44.20712	-84.35085	Tittabawassee
Wakeley Lake	Crawford	200175	44.6343	-84.5138	Au Sable
Worchester Lake	Schoolcraft	770174	46.4421	-86.2792	Manistique
Sharps Lake	Jackson	380499	42.20365	-84.3949	Upper Grand

The 20 randomly selected inland lakes (Table 1, Figure 1) included in this project were monitored in 2017 utilizing the MDNR-FD's and MDEQ-WRD's status and trends programs. These lakes were sampled for microcystins twice during the 2017 summer growing season; in

July by MDEQ-WRD staff and in August by MDNR-FD staff. On both dates field crews collected up to 4 surface water samples per lake, and used Abraxis (Abraxis, Inc., Warminster, PA) test strips to estimate microcystin concentrations. General lake water chemistry samples were also collected at the center of the lake in July and August.

Mona Lake in Muskegon County, Lamberton Lake in Kent County, and Long Lake in Ionia County were targeted for biweekly monitoring from July to mid-September in 2017. Pontiac Lake in Oakland County was sampled monthly during the same time period. Pontiac Lake was only sampled monthly by the MDEQ because Oakland University was also monitoring microcystin in that lake on a monthly basis from early July to early October and sharing the results with us. Oakland University and the MDEQ arranged sampling schedules so that samples were collected by one of the organizations every 2 weeks. The Oakland University sampling occurred on Camelot Street along the northwestern shoreline.

Mona Lake is a drowned river mouth lake in west Michigan that is a tributary to Lake Michigan with a maximum depth of 27 feet. Lamberton Lake is a 28.5-acre lake located within the city of Grand Rapids with a maximum depth of 15 feet. Lamberton Lake drains into Lamberton Creek, which is a tributary to the Grand River. Long Lake is a 356-acre lake with a maximum depth of 57 feet and is part of the Flat River subwatershed within the Grand River watershed. Pontiac Lake is an impoundment lake in the upper Huron River watershed that is 585 acres in size and has a maximum depth of 34 feet. Finally, lakes were also sampled in response to citizen or staff concerns about observed algae blooms.

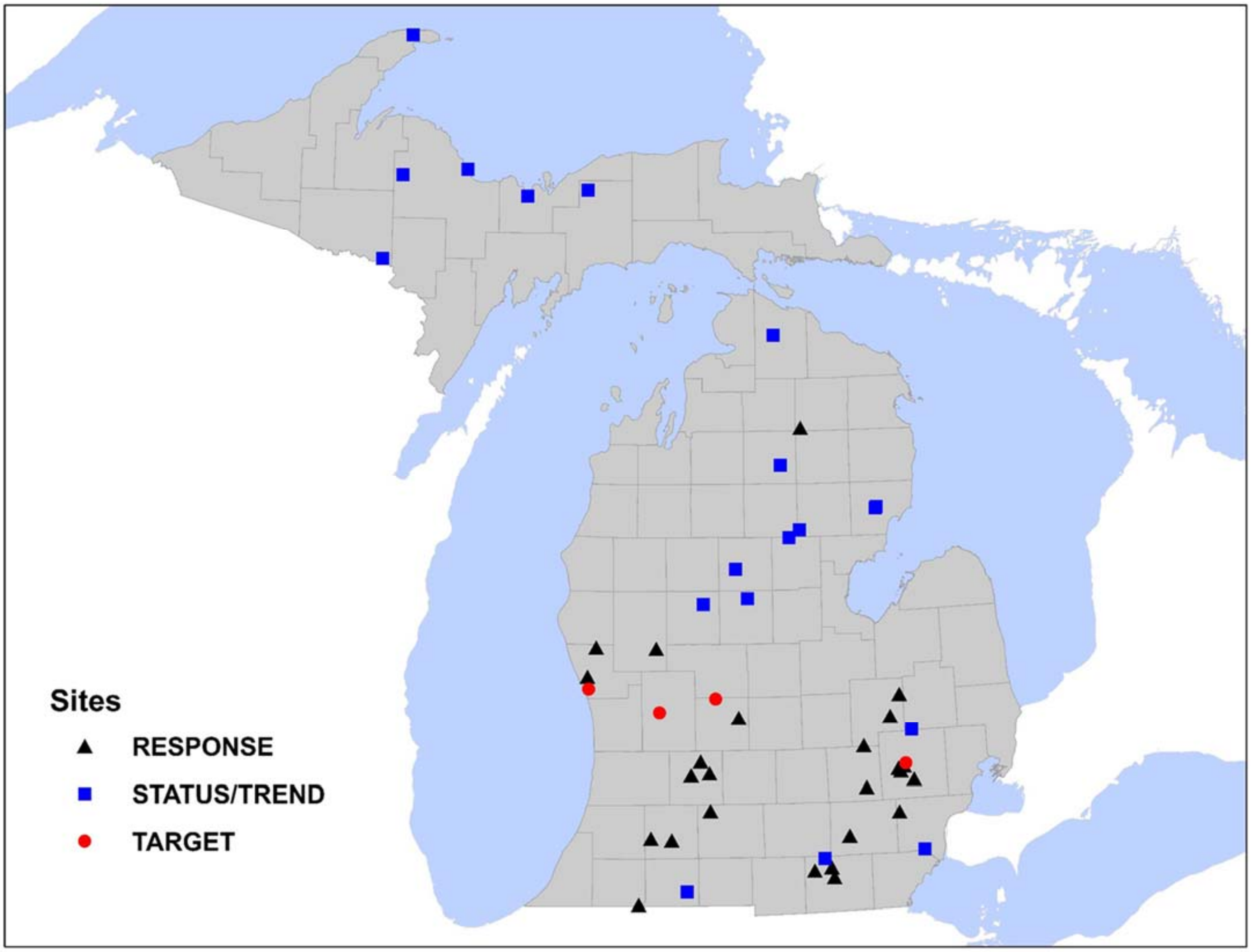

Figure 1. 2017 algal toxin sampling locations.

Field Methods

Sampling occurred between early June and late November, with most monitoring occurring in August and September. During a monitoring event at a lake, MDEQ-WRD staff took pictures of algal conditions, collected general water chemistry in the center of the lake (if accessible by boat), and collected water samples for algal toxin analysis from up to 4 locations around the lake. The algal toxin samples were analyzed using both Abraxis test strips to assess microcystin presence/absence and tandem liquid chromatography mass spectrometry (LC/MS/MS) for quantitative assessment of a suite of algal toxins including microcystins, cylindrospermopsin, and anatoxin-a (Table 2).

Survey Forms

A field sheet was completed during every targeted lake survey to document shoreline algae levels and accumulation.

Water Samples - General Chemistry

Water sample parameters collected at the status and trend lakes, targeted lakes, and some response lakes were generally similar. At all lakes, temperature, dissolved oxygen, conductivity, pH, chlorophyll concentration, chlorophyll relative fluorescence unit, phycocyanin concentration, and phycocyanin relative fluorescence unit were measured using an EXO sonde (YSI Incorporated, Yellow Springs, Ohio). In some cases with the response lakes, the staff who were available to collect the water samples did not have access to an EXO sonde unit. In those cases, only water samples were collected for the purpose of cyanobacteria toxin analysis.

Nutrient surface water samples were collected at approximately 0.5 feet below the water surface using new, 250 milliliter (ml) polypropylene sample bottles that were triple-rinsed with site water. At targeted lakes and response lakes where a boat could be taken to the center of the lake, the following samples were collected: total phosphorus, Kjeldahl nitrogen, nitrate+nitrite, ortho-phosphate, and chlorophyll *a*. The total phosphorus, Kjeldahl nitrogen, and nitrate+nitrite were preserved with sulfuric acid in the field. Chlorophyll *a* samples were collected as an integrated sample of the photic zone (twice the secchi depth) and preserved with magnesium carbonate in the field. If a lake was not accessible by boat, then nutrient and chlorophyll *a* samples were collected at the shoreline. The samples were analyzed at the MDEQ Environmental Laboratory using standard USEPA methods (Table 2). At the status and trend lakes the same nutrient samples were collected, excluding ortho-phosphate.

Following collection, sample bottles were placed on ice or refrigerated for transport and storage prior to delivery to the laboratory. At targeted lakes, the nutrient samples were not collected at every sampling event if sampling occurred several times over a week. The August status and trend water chemistry samples were collected by MDNR-FD staff and analyzed by the Great Lakes Environmental Center.

Water Samples - Algal Toxins

At most lakes that were sampled by boat, 1 mid-lake sample and at least 3 shoreline samples were collected in 250 ml polyethylene terephthalate sample bottles at the water surface. Shoreline samples were typically collected at 1- to 6-foot depths. The shoreline sampling locations were distributed approximately evenly around the shoreline of the lake. However, downwind locations, bays that may be used for recreation, areas impacted by river outlets, or beaches were preferentially targeted. Prior to sampling, bottles were triple-rinsed with site water and samples were collected from an undisturbed area of water. All microcystin samples were collected at the water surface (e.g., the bottles were not submerged under water).

When scum accumulations were present, typically 1 surface scum sample was collected and 1 ambient (non-scum) sample was collected outside of the accumulation. The ambient samples were collected within 5-15 feet from the edge of the scum accumulations. In cases where surface scums were omnipresent either throughout an entire lake, or throughout a very large section of a lake, then only a scum sample was collected.

At response lakes, often only shoreline samples were collected from an area with a cyanobacteria accumulation present, or in an area that previously had high concentrations of microcystins. Most of the samples were collected by MDEQ staff, although in some cases citizens collected water samples and turned them into the MDEQ district offices.

Ambient water and scum samples that were analyzed using qualitative and quantitative methods were kept on ice during transport back to the laboratory. Microcystin presence/absence and relative concentration estimate was determined using test strips. If the initial test strip indicated that microcystins were present in the sample, then it was delivered to the Michigan Department of Human Health and Services (MDHHS) Laboratory for quantitative analysis. Quantitative analysis of anatoxin-a, cylindrospermopsin, and 13 microcystin congeners (Table 2) was performed using LC/MS/MS. If the Abraxis test strips indicated that no microcystin was present in any samples from a lake, then only 1 sample was sent to the MDHHS laboratory for further quantitative analysis.

Microcystin samples were held on ice or refrigerated for no more than 48 hours prior to analysis. If microcystin samples needed to be held longer than 48 hours, they were frozen with care taken to reduce volume to allow for expansion. MDEQ-WRD staff analyzed the July status and trend samples and all targeted lake samples using the test strips. The August status and trend samples were analyzed by staff of the Great Lakes Environmental Center and 1 sample from each lake was analyzed by the MDHHS laboratory.

Table 2. Analytical methods and reporting limits.

Parameter	Analytical Method	Reporting Level (ug/L)
Microcystin LR	LC/MS/MS	0.008
Microcystin RR	LC/MS/MS	0.004
Microcystin YR	LC/MS/MS	0.008
Microcystin LA	LC/MS/MS	0.008
Microcystin LF	LC/MS/MS	0.008
Microcystin LW	LC/MS/MS	0.008
Microcystin LY	LC/MS/MS	0.008
Microcystin WR	LC/MS/MS	0.008
Microcystin HILR	LC/MS/MS	0.008
Microcystin HTYR	LC/MS/MS	0.008
Microcystin LR D-ASP3	LC/MS/MS	0.008
Microcystin RR D-ASP3	LC/MS/MS	0.004
Microcystin LR DHA7	LC/MS/MS	0.008
Anatoxin-a	LC/MS/MS	0.02
Cylindrospermopsin	LC/MS/MS	0.02
Qualitative Total Microcystin	Abraxis Test Strips (PN52022)	1
Total Phosphorus	EPA 365.4	10
Kjeldahl Nitrogen	EPA 351.2	100
Ammonia	EPA 350.1	10
Nitrate+Nitrite	EPA 353.2	10
Ortho-phosphate	EPA 365.1	10
Chlorophyll a	10200H (Standard Methods)	1

Data Analysis

Trophic status indices (TSI) were calculated using the TSI equation from Fuller and Minerick (2008) for lakes that were sampled at the maximum lake depth via boat, using the total phosphorus (milligrams per liter [mg/l]), chlorophyll *a* (µg/l; integrated samples), and mid-lake Secchi depth (meters) values. Because Lamberton Lake was not accessible by boat, and only shoreline samples could be collected, TSI values were not calculated. The TSIs were calculated to summarize the amount and variation of chlorophyll *a*, total phosphorus, and Secchi depth in the lakes that were frequently sampled. The targeted lakes were sampled multiple times throughout 2017. This frequency of sampling is different from what the State of Michigan uses for lake water quality assessments under Section 305(b) of the federal Clean Water Act. Therefore calculated TSIs in this report are not used for determining designated use attainments or impairments under Section 303(d) of the Clean Water Act.

To evaluate the effect of observed chemical/physical parameters measured at the time microcystin samples were collected, a principal components analysis (PCA) was performed. The PCA was used to reduce the dimensionality of the correlated, independent, chemical/physical variables, into a single value, or PC 1 score. The first PC score often represents the degree of anthropogenic disturbance that a system is experiencing. High PC 1 scores typically represent more disturbed systems, whereas low PC 1 scores often represent less disturbed environments (Uzarski et al., 2005). Pearson correlations between the PC 1 scores, acting as a surrogate for disturbance, and microcystin values ($\log_{10}$-transformed to homogenize variances) were performed to assess whether overall site conditions could explain observed toxin concentrations. Chemical/physical data for the above analyses were only used from specific sites where samples were sent to the laboratory for nutrient and microcystin analyses.

Linear regressions were also performed on total phosphorus (collected in the center of the lake) and microcystin concentrations (averages of quantified microcystin) in the targeted lakes. Xie et al. (2012) reported a positive relationship between total phosphorus and microcystin concentrations in Mona Lake in 2006 and MDEQ staff have found a similar relationship (Parker, 2017). We wanted to evaluate whether the same relationship existed in Mona Lake, or any other lakes, in 2017. Linear regressions were performed on site latitude and mean lake microcystin concentrations and site latitude versus maximum lake microcystin concentrations. A Welch 2-sample t-test was performed on all microcystin concentration values that originated from scum samples versus all ambient/non-scum water samples collected throughout the state. A separate Welch 2-sample t-test was also performed on scum and ambient samples that were taken side-by-side on 23 separate occasions.

RESULTS

Water samples were collected and analyzed for microcystin from 49 different inland water bodies throughout the state in 2017. Out of 153 individual samples that were analyzed in the laboratory, 48 (31%) were above the State of Ohio’s recreational guidance of 6 µg/l microcystin. Of those 48 samples, 24 (16% of the original 153 samples) contained ≥ 20 µg/l microcystin (WHO recreational guidance; WHO, 1999). Four lakes had detectable amounts of anatoxin a, but none of the concentrations were greater than the State of Ohio’s recreational guidance of 80 µg/l. No cylindrospermopsin was found in any samples taken throughout 2017.

All microcystin results were shared with the MDHHS who then shared those results with the appropriate county health departments. Results from lakes that were sampled because of a complaint were shared with the complainants. In situations where elevated microcystin concentrations were detected, the MDHHS also communicated results with the appropriate lake association, if one existed.

Latitude and Microcystin Concentrations

Microcystin concentrations were highly variable in the southern Lower Peninsula, but consistently low in the northern Lower and Upper Peninsula. Linear regressions of average and maximum microcystin concentrations revealed significant, but weak inverse relationships between microcystin and latitude in Michigan (Figures 2 and 3).

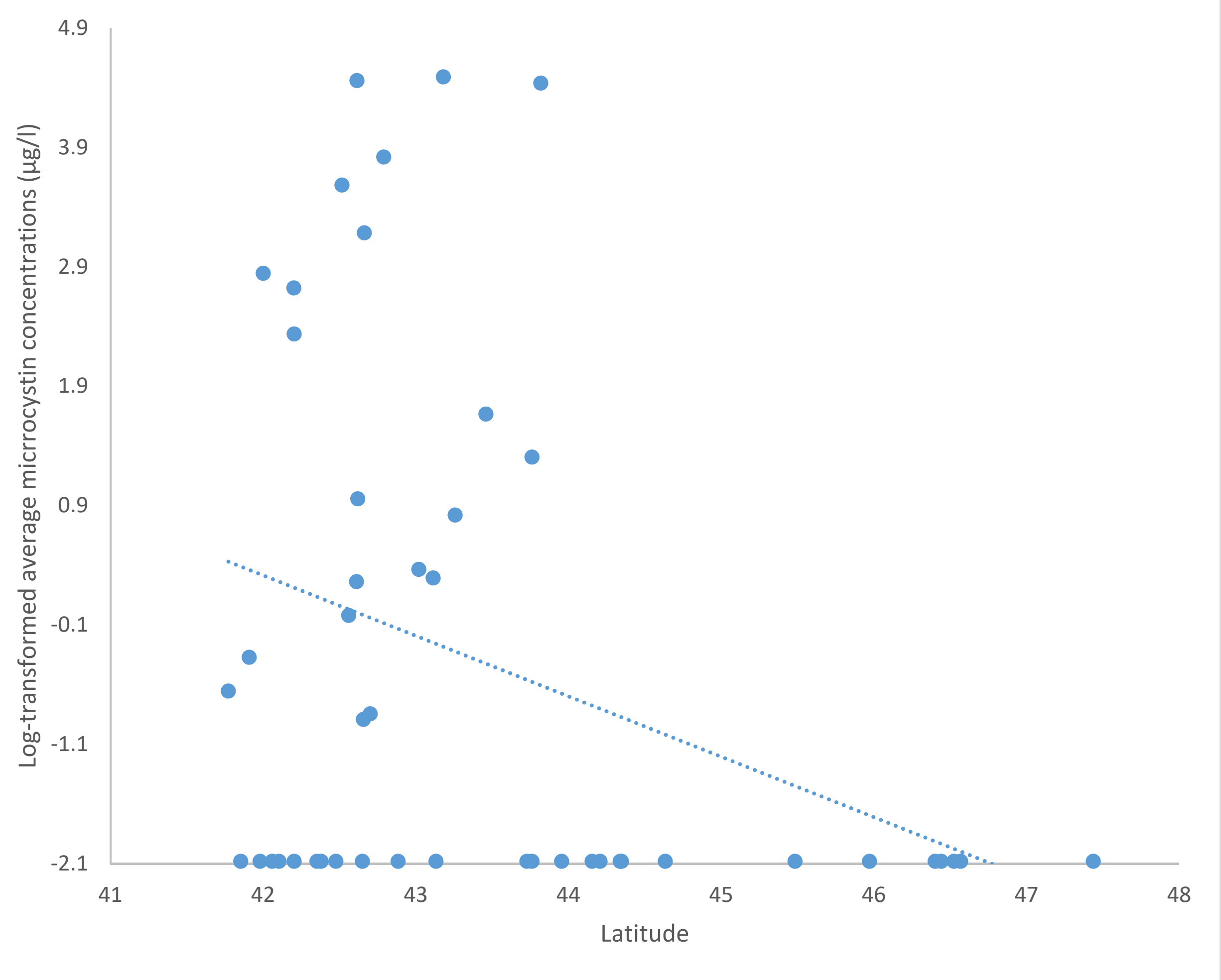

Figure 2. Regression of log-transformed, average microcystin site concentrations and site latitude ($R^2 = 0.11$, $p = 0.02$).

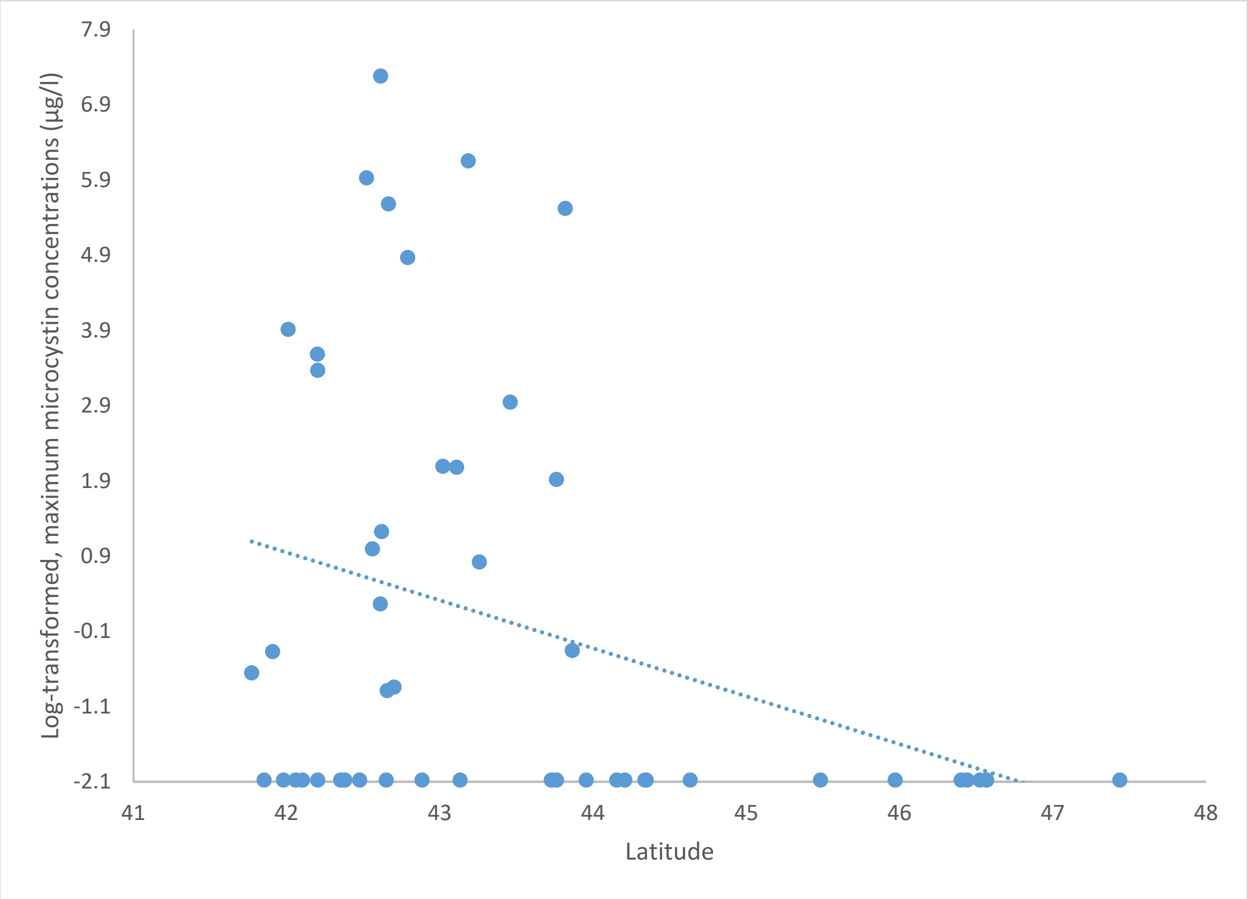

Figure 3. Regression of log-transformed, maximum microcystin site concentrations and site latitude (R^2 = 0.10, p = 0.026).

Chemical/Physical Predictors of Observed Microcystin Concentrations

The PCA bi-plot representing all of the lakes sampled across the state in 2017 revealed that lakes representing a wide range of conditions were assessed. The first principal component, which is best explained as a gradient of anthropogenic disturbance (increasing nutrients, chlorophyll *a* (integrated samples), and phycocyanin; Uzarski et al., 2005) explained 36% of the variability in the chemical/physical matrix (Figure 4). A linear regression of PC 1 scores versus $\log_{10}$-transformed microcystin concentrations showed no relationship between PC 1 scores and microcystin concentrations (R^2 = 0.00, p = 0.91; Figure 5).

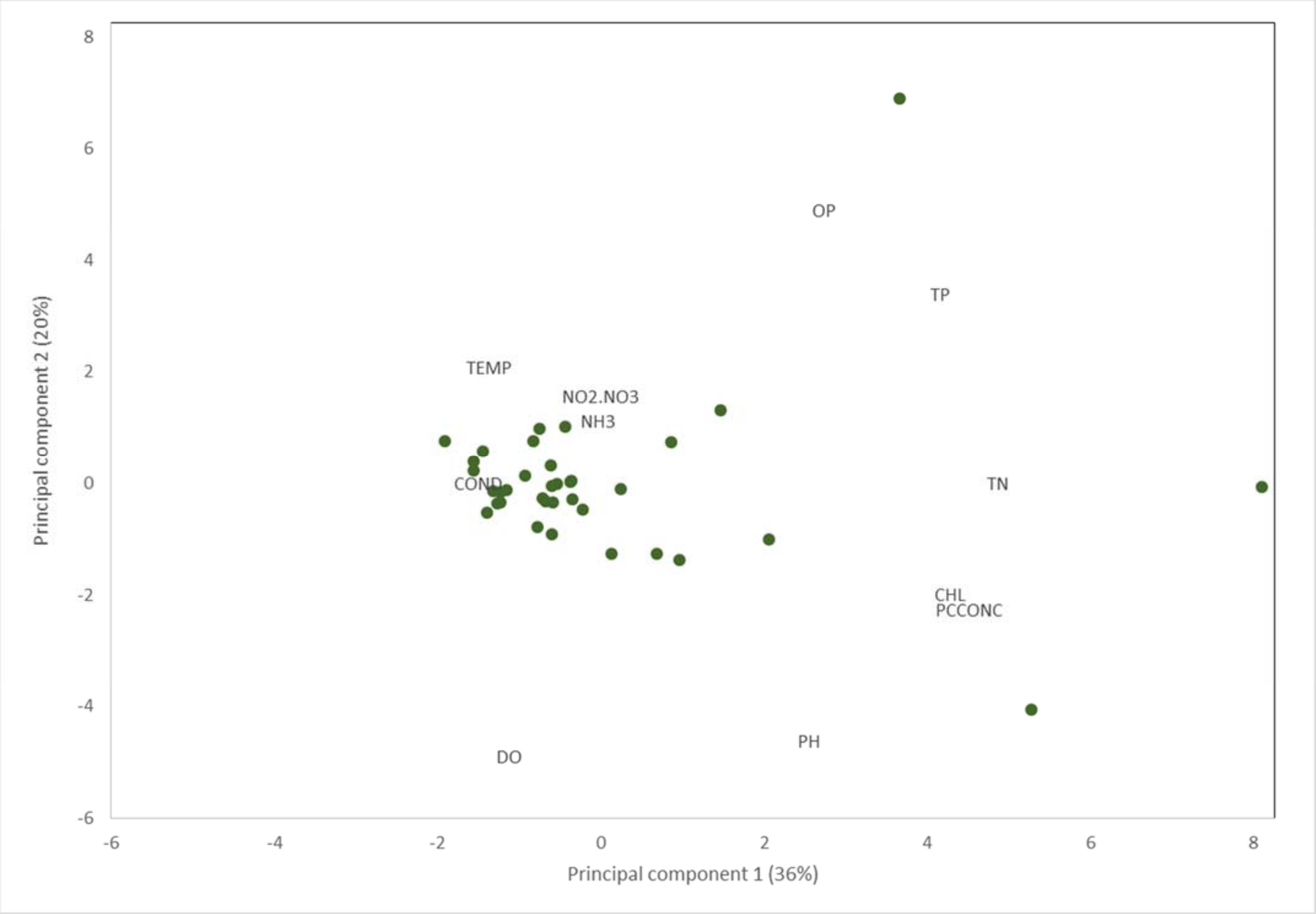

Figure 4. Principal component analysis bi-plot of chemical physical variables in Michigan lakes that were sampled in 2017.

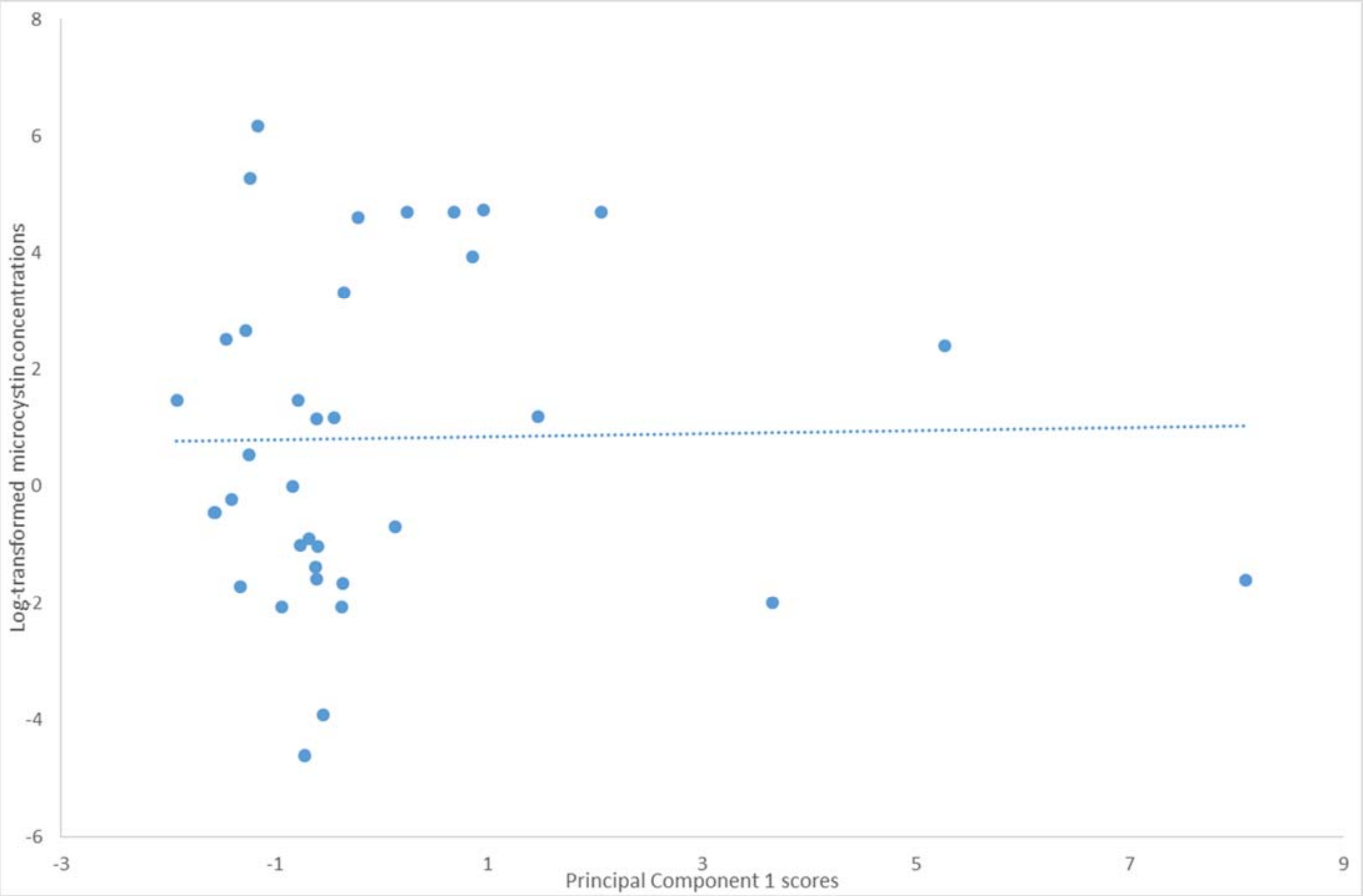

Figure 5. Linear regression of log10-transformed microcystin concentrations and PC 1 scores for each lake.

Status and Trend Lakes

Over the course of the July and August 2017 sampling, 208 microcystin test strips were run on discrete samples from the status and trend lakes. Those initial test strip results indicated that one of the lakes had microcystin present. Laboratory analysis of the one lake, Stevenson Lake in Isabella County, found that it had 6.8 µg/l microcystin in a July sample. A follow-up sample in Stevenson Lake revealed no microcystins. No microcystins were detected in the July or August samples of the other 25 lakes. No anatoxin-a or cylindrospermopsin were detected in any of the status and trend lakes.

Targeted Lakes

Mona Lake

Mona Lake was visited on 10 separate occasions. In Mona Lake, the highest recorded microcystin concentrations were both 430 µg/l recorded on September 15 and 25, 2017 (Figure 6). Large, concentrated cyanobacteria blooms formed starting in mid-August and persisted until late September. The area of Mona Lake with the highest average microcystin concentrations was on the eastern side of the lake (Figure 7). Areas near Highgate Road and the public boat launch in Muskegon Heights had the most persistent blooms (Figure 10).

Mona Lake's average TSI values ranged from 52 to 67.6 (which are in the eutrophic to hypereutrophic range with an average TSI of 60.8.

No relationship between microcystin and total phosphorus concentrations were revealed throughout the entire year ($R^2 = 0.044$; $p = 0.59$; Figure 8). However, this relationship was largely driven by data collected on October 2, 2017, which had a high total phosphorus concentration of 0.1 mg/l, but low average microcystin concentrations. A review of the depth-temperature and dissolved oxygen-depth profile data from the deepest part of the lake on that date showed that Mona Lake was in a fall turnover at the time. Because the abnormally high total phosphorus value was likely from nutrient-rich, hypolimnetic water circulating throughout the lake (Steinman et al., 2009), a second linear regression of the phosphorus-microcystin relationship was performed without the October data. A marginally significant relationship between microcystin and total phosphorus concentrations was revealed only using data from the summer stratification period ($R^2 = 0.49$; $p = 0.055$; Figure 9). Low amounts of anatoxin-a were found in Mona Lake from mid-September to early October ranging from 0.51-4.4 µg/l.

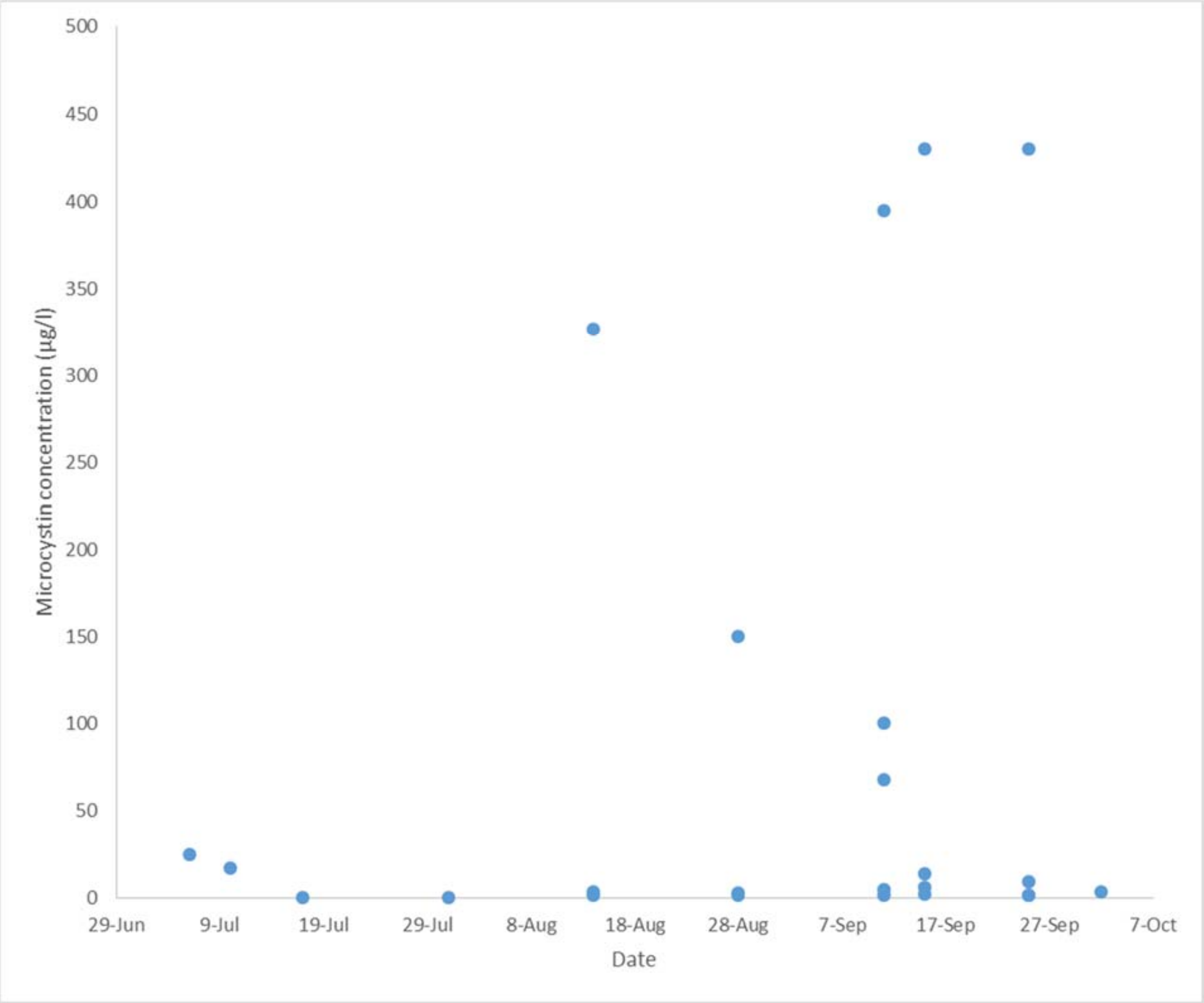

Figure 6. Microcystin concentrations from early July through early October 2017 in Mona Lake, Muskegon County.

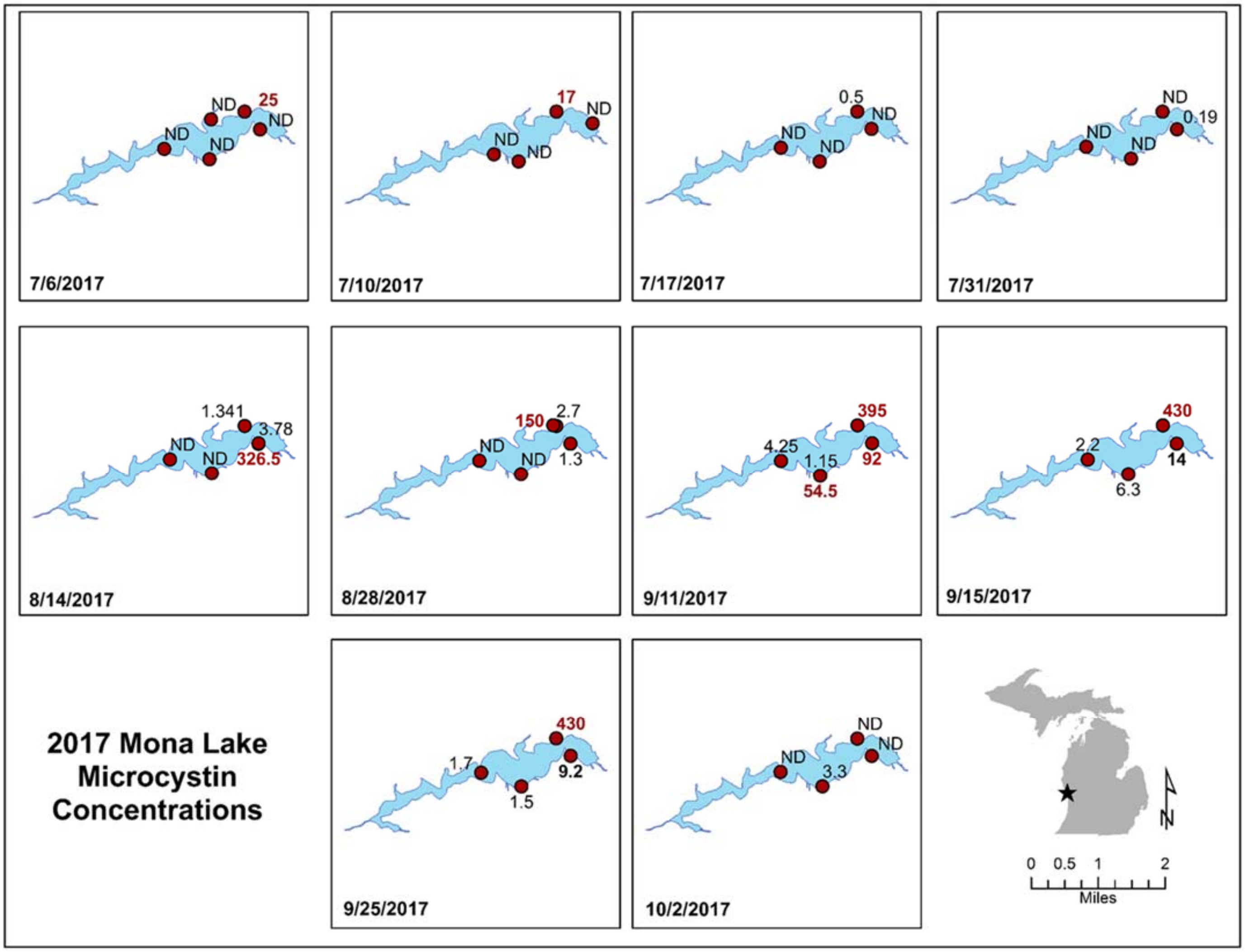

Figure 7. Microcystin concentrations (µg/l) at different sampled areas of Mona Lake, Muskegon County in 2017 (ND = non-detection). Two values that are close to one point (i.e., 326.5 and 3.78 µg/l microcystin on August 14, 2017) represent areas of a scum accumulation where a sample was collected within the scum (high values) and a sample was collected in ambient (clear) water (low values), typically within 5-15 feet of the scum accumulation.

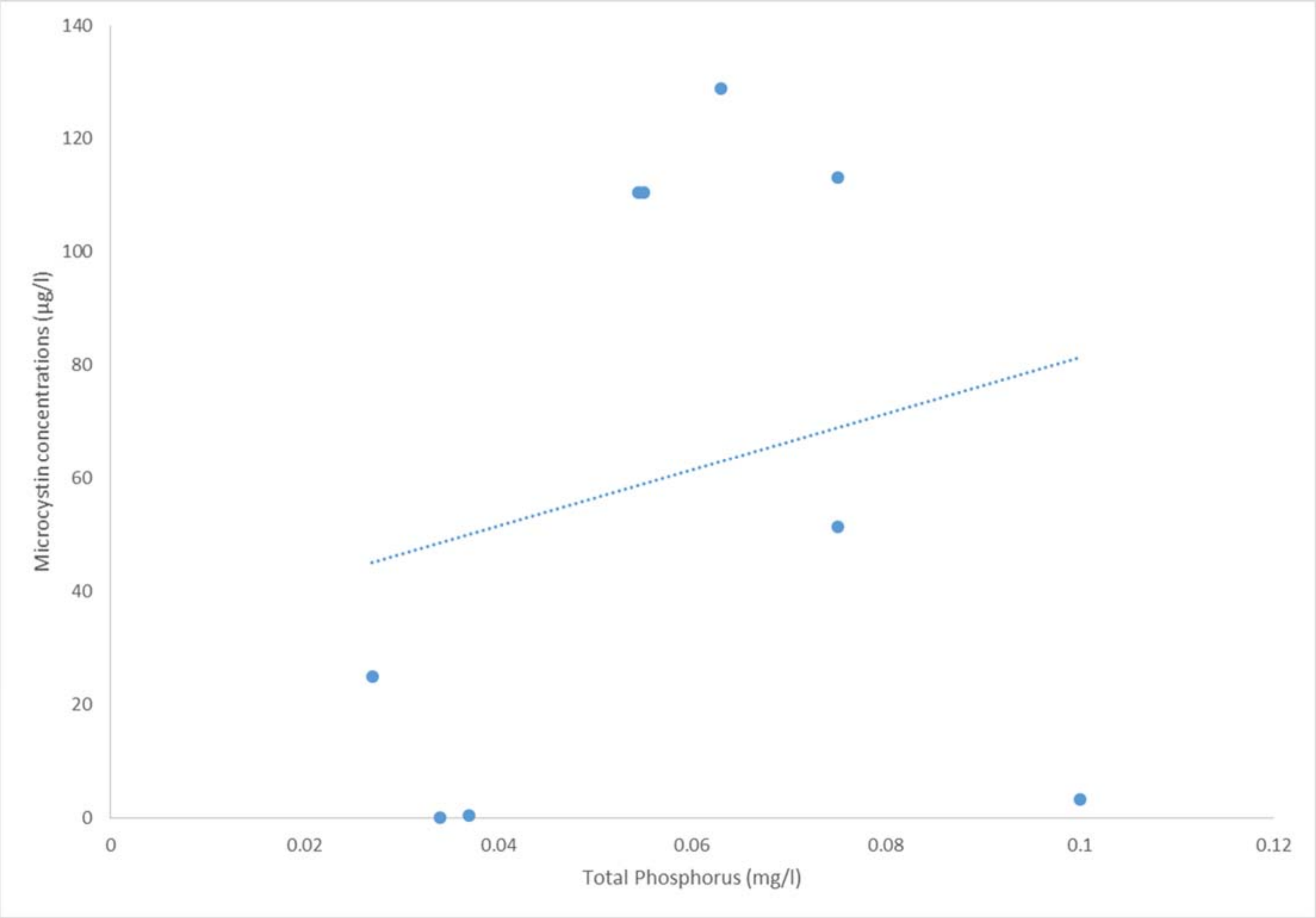

Figure 8. Linear regression of total phosphorus-average microcystin relationship in Mona Lake from July 6 to October 2, 2017.

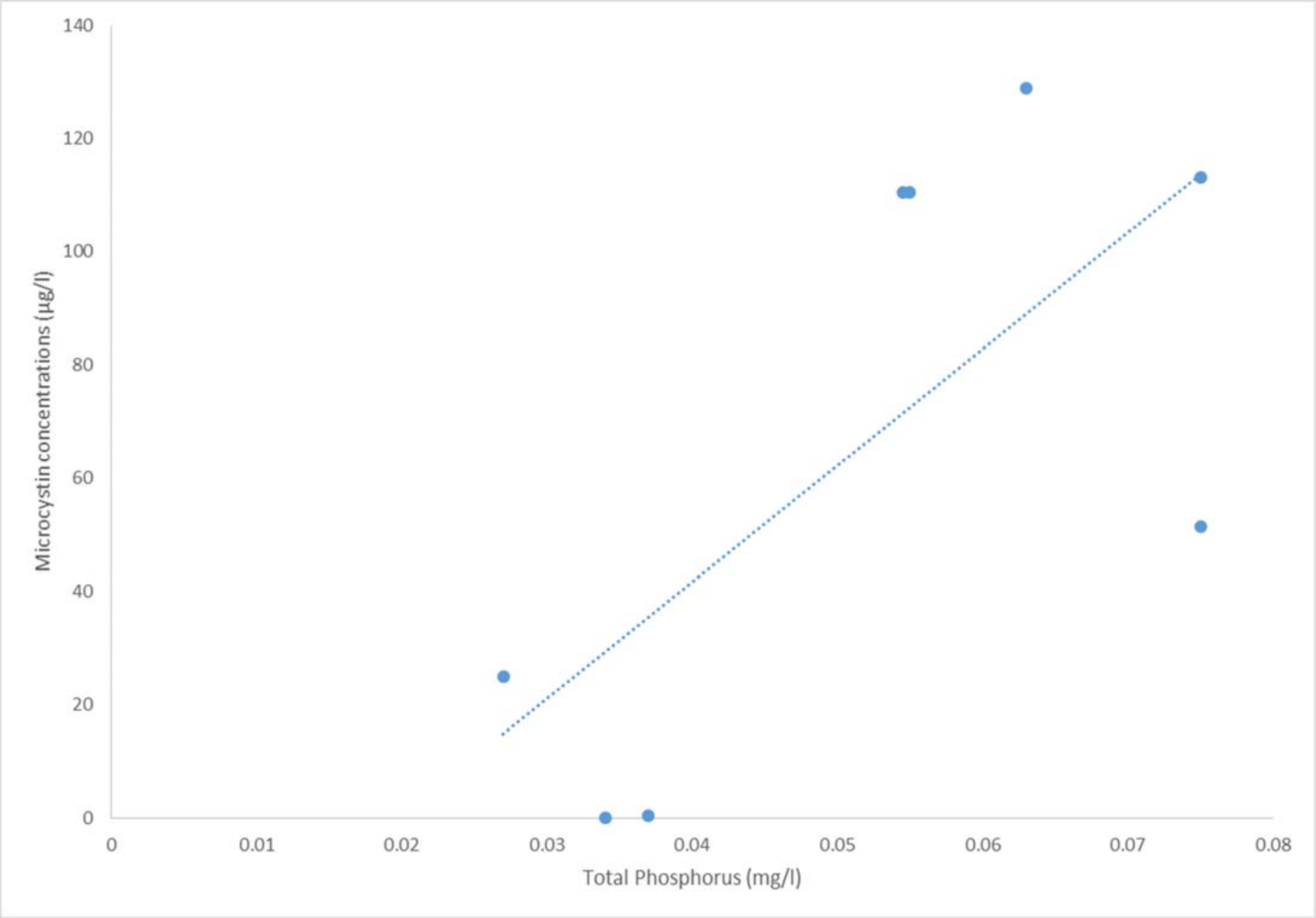

Figure 9. Linear regression of total phosphorus-average microcystin relationship in Mona Lake from July 6 to September 25, 2017.

Figure 10. Cyanobacteria blooms in Mona Lake at the Muskegon Heights boat launch on September 15, 2017 (left) and near Highgate Drive on September 11, 2017 (right).

Lamberton Lake

Lamberton Lake was visited on 8 separate dates. Lamberton Lake had relatively low microcystin concentrations throughout the 2017 sampling period. Only 2 samples were greater than the State of Ohio's recreational guidance of 6 µg/l and none of the samples were greater than the WHO recreational guidance of 20 µg/l. The highest microcystin concentration recorded was 10.6 µg/l on July 6, 2017 (Figure 11). Microcystin was only detected along the northeast shoreline of Lamberton Lake (Figure 12). There was no relationship between total phosphorus and microcystin concentrations in the lake ($R^2 = 0.06$; $p = 0.60$).

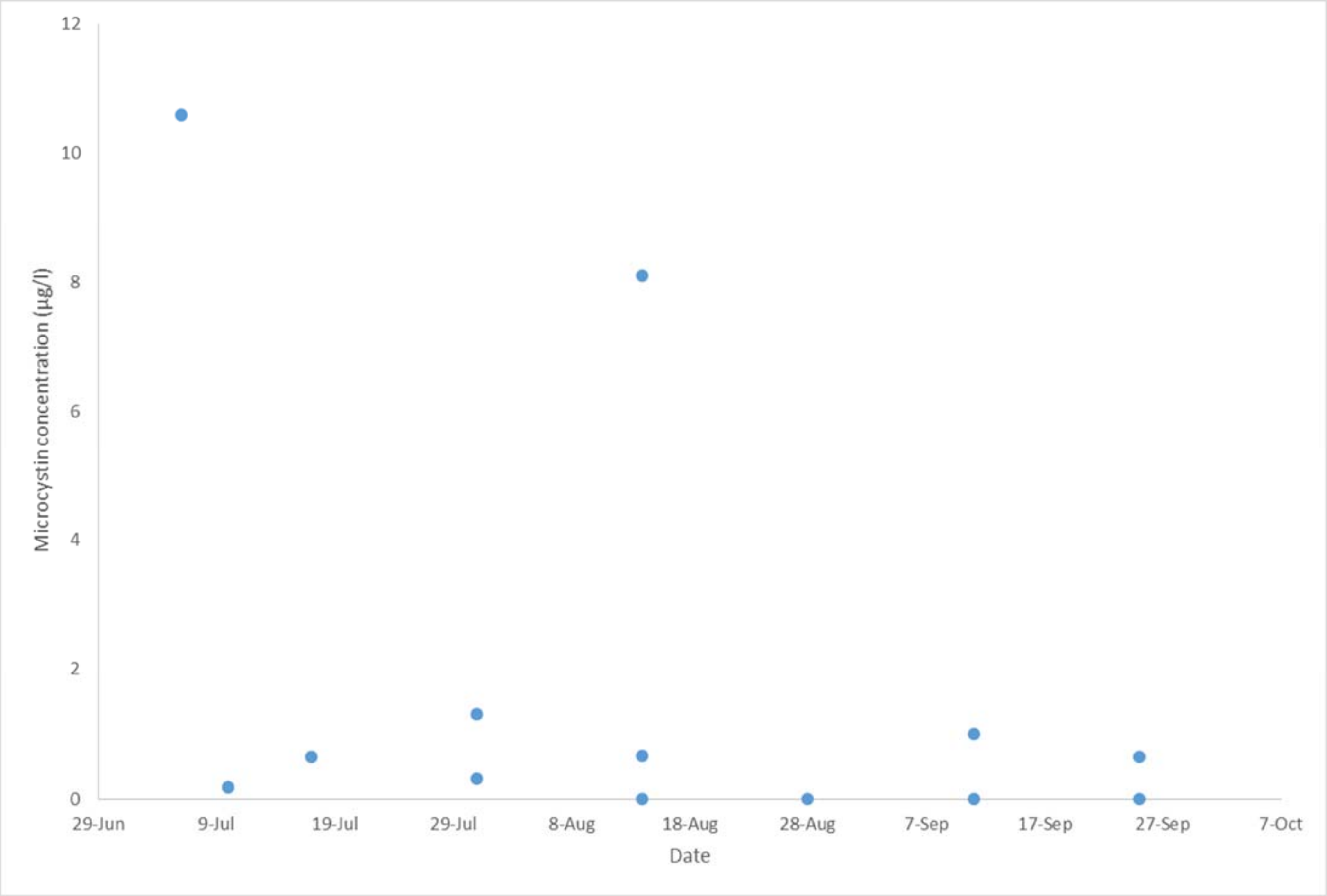

Figure 11. Microcystin concentrations from early July through late September 2017 in Lamberton Lake, Kent County.

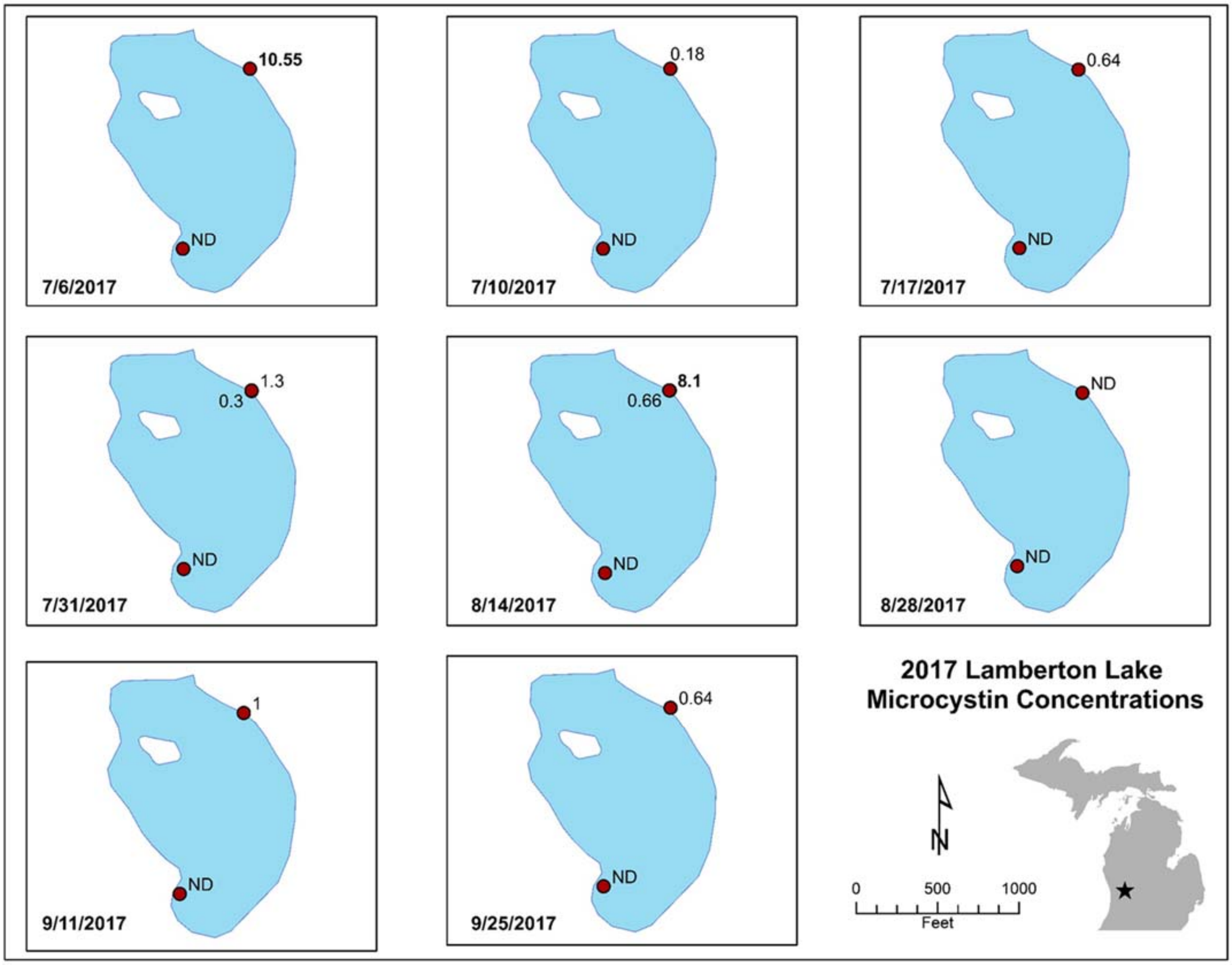

Figure 12. Microcystin concentrations (µg/l) at different sampled areas of Lamberton Lake, Kent County in 2017 (ND = non-detection). Two values that are close to one point (i.e., 8.1 and 0.66 µg/l microcystin on August 14, 2017) represent areas of a scum accumulation where a sample was collected within the scum (high values) and a sample was collected in ambient (clear) water (low values), typically within 5-15 feet of the scum accumulation.

Long Lake

Long Lake was visited on 9 separate occasions. Long Lake had relatively low microcystin concentrations throughout 2017. The highest microcystin concentrations were 8 and 6.2 µg/l found in scum samples on September 11 and September 15, respectively (Figure 13). The scum samples with the highest microcystin concentrations were in the southwest section, at the MDNR boat launch on September 11 and in the middle of the lake on September 15 (Figure 14). Long Lake's average TSI values ranged from 38.8 to 47.1 with an average TSI of 42.9 (mesotrophic). There was no relationship between total phosphorus and microcystin concentrations in the lake ($R^2 = 0.13$; $p = 0.42$). On August 14 a low amount of anatoxin-a was detected in Long Lake (1 µg/l).

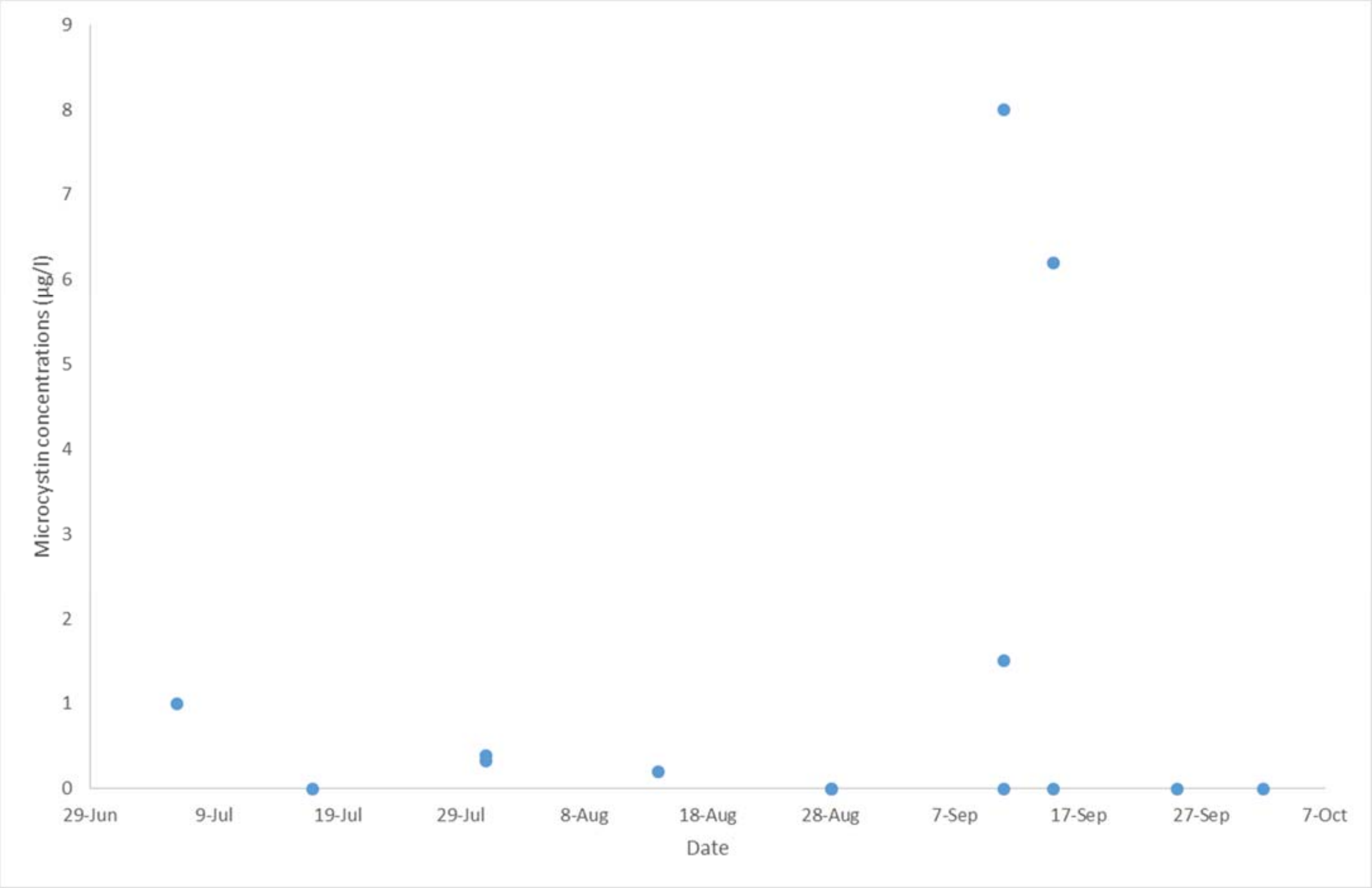

Figure 13. Microcystin concentrations from early July through late September 2017 in Long Lake, Ionia County.

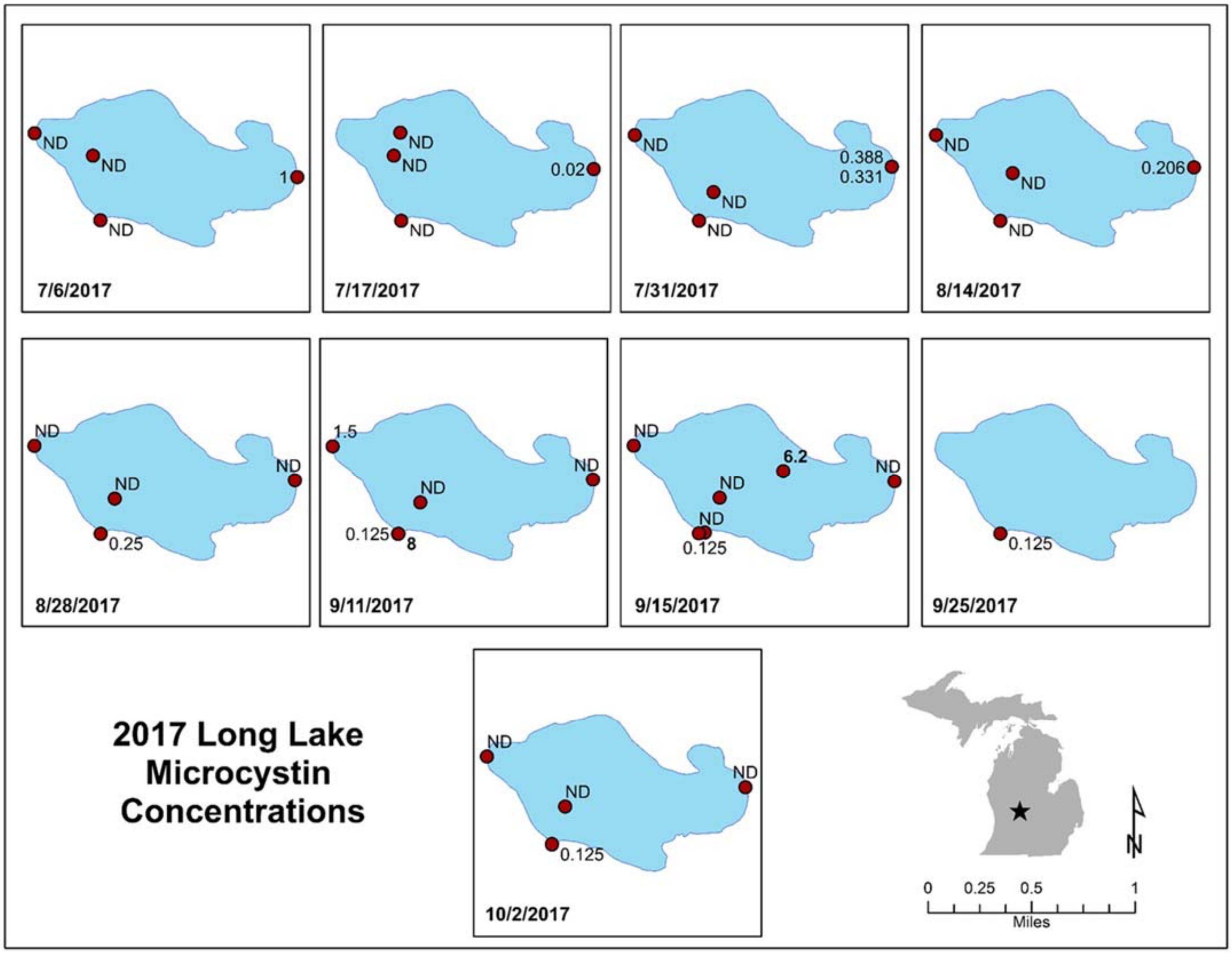

Figure 14. Microcystin concentrations (µg/l) at different sampled areas of Long Lake, Ionia County in 2017 (ND = non-detection). Two values that are close to one point (i.e., 8 and 0.125 µg/l microcystin on September 11, 2017) represent areas of a scum accumulation where a sample was collected within the scum (high values) and a sample was collected in ambient (clear) water (low values), typically within 5 to 15 feet of the scum accumulation.

Pontiac Lake

Pontiac Lake was visited by MDEQ staff on 6 separate occasions either as part of regularly-scheduled monitoring or in response to citizen complaints about cyanobacteria blooms. Pontiac Lake had relatively low microcystin concentrations throughout July and August, but had cyanobacteria blooms in September with high associated microcystin concentrations. The highest microcystin concentrations were 265 and 78 µg/l found in a scum samples on September 13 and September 21, respectively (Figure 15). The scum samples with the highest microcystin concentrations were in an embayment in the southern part of the lake (Figures 16 and 17). Samples collected during the first weeks of July, August, September, and October by Oakland University along the northwest shoreline, near Camelot Street, ranged from 0.39 to 1.49 µg/l.

Pontiac Lake's average TSI values ranged from 51 to 56 with an average TSI of 53.9 (eutrophic). A strong, but non-significant relationship existed between total phosphorus and microcystin concentrations ($R^2 = 0.88$; $p = 0.06$). The lack of statistical significance was likely a result of the low number of samples.

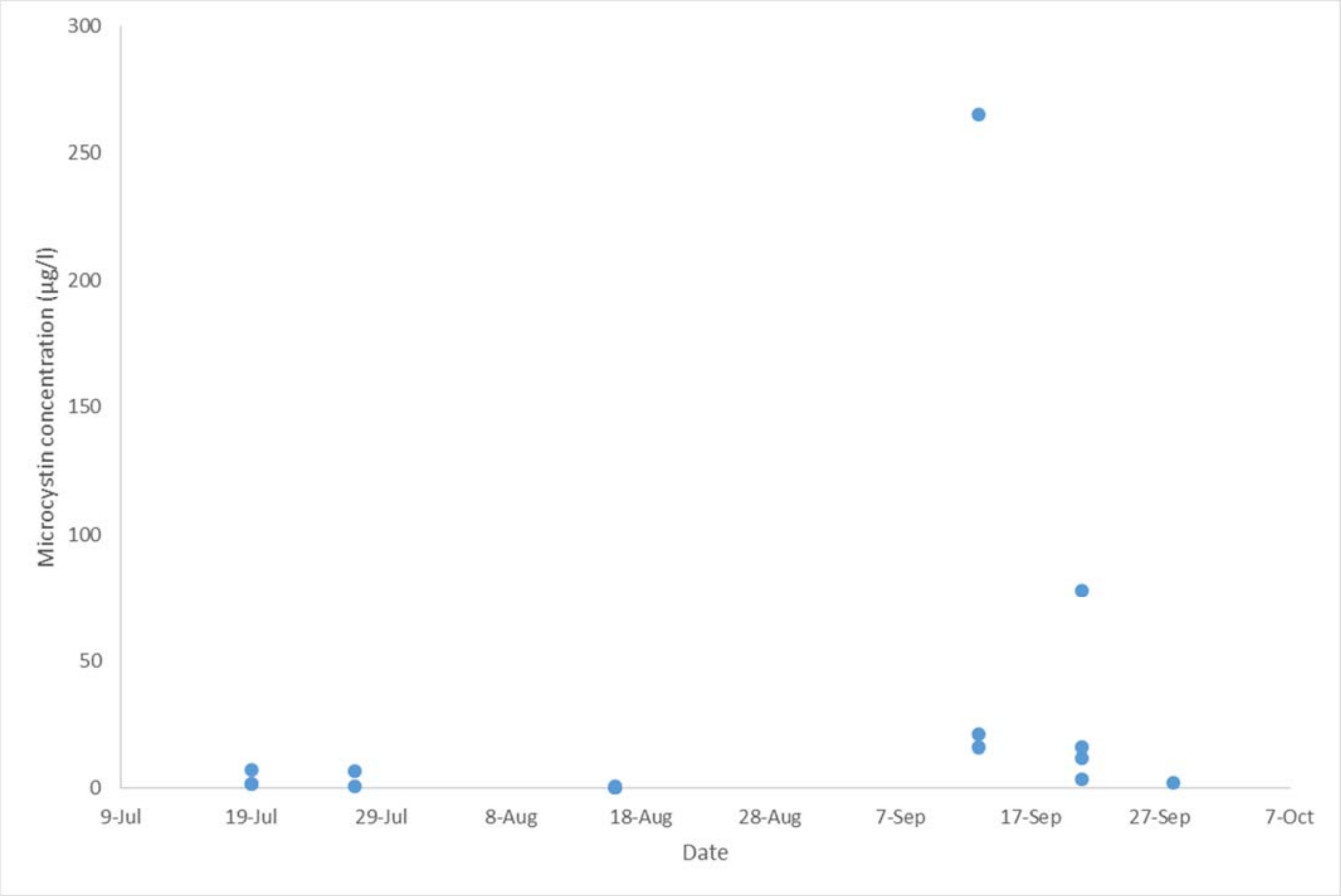

Figure 15. Microcystin concentrations from mid-July through late September 2017 in Pontiac Lake, Oakland County.

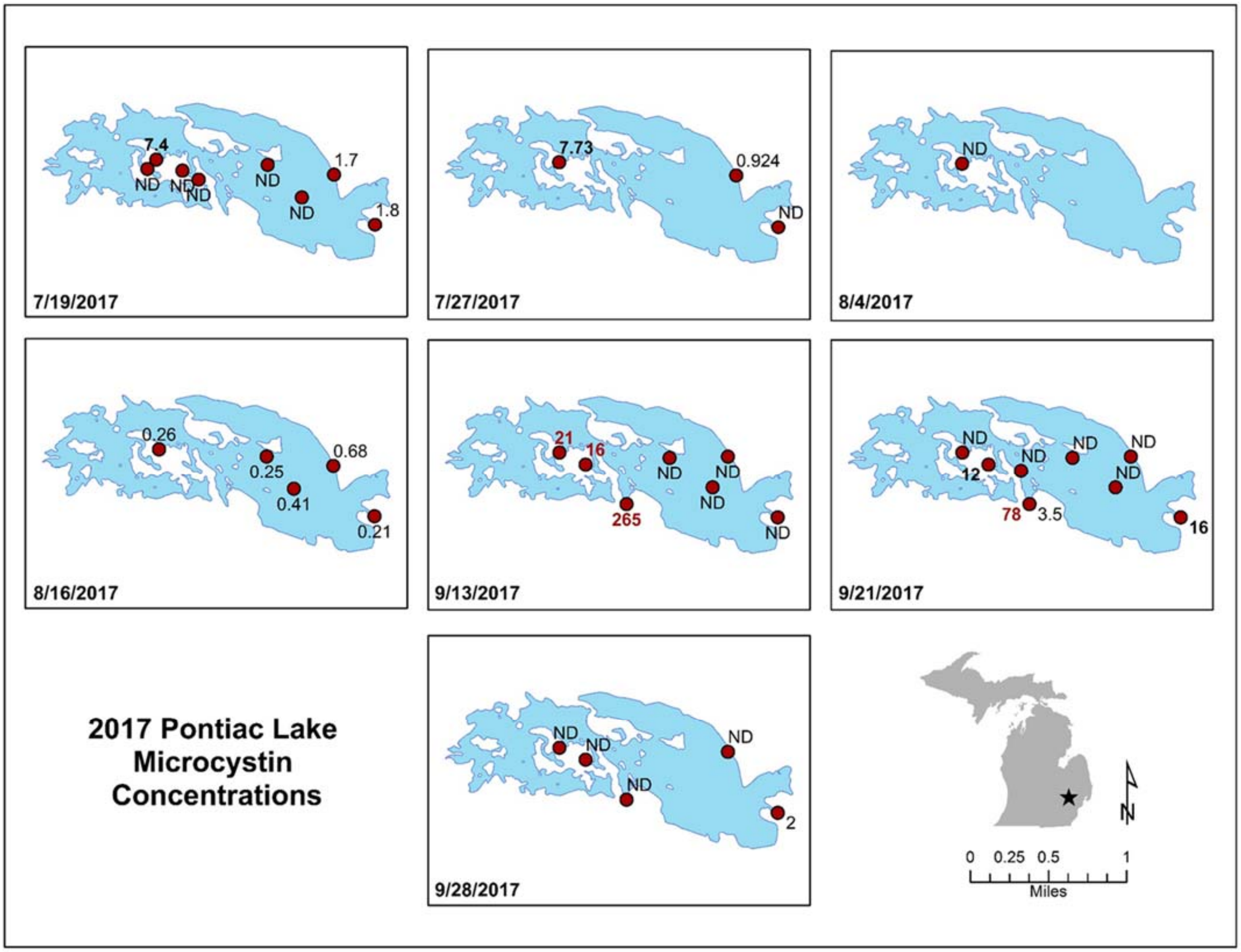

Figure 16. Microcystin concentrations (µg/l) at different sampled areas of Pontiac Lake, Oakland County in 2017 (ND = non-detection). Two values that are close to one point (i.e., 78 and 3.5 µg/l microcystin on September 21, 2017) represent areas of a scum accumulation where a sample was collected within the scum (high values) and a sample was collected in ambient (clear) water (low values), typically within 5 to 15 feet of the scum accumulation.

Figure 17. Cyanobacteria bloom in Pontiac Lake in an Embayment near Kingston Street and Pontiac Lake Road on September 13, 2017.

Sugden Lake

Sugden Lake was first visited in mid-July in response to citizen concerns about a large cyanobacteria bloom (Figure 18). Persistent blooms and high microcystin concentrations required follow-up responses through late September. Sugden Lake was visited on 9 separate occasions. Sugden Lake had a bloom with extremely high microcystin concentrations in July. Microcystin concentrations then fluctuated widely throughout August and September (Figure 19). The highest microcystin concentration was 1,450 µg/l found in a scum sample on the south side of the lake in late July (Figure 20). After the initial responses to the bloom concerns, cyanobacteria accumulations with high microcystin concentrations continued to occur on different shorelines, largely as a function of wind direction (Figure 20). Sugden Lake's average TSI values ranged from 33.3 to 38.3 with an average TSI of 35.3 (oligotrophic). There was no relationship between total phosphorus and microcystin concentrations ($R^2 = 0.33$, $p = 0.31$). On August 16 a low amount of anatoxin-a was found in Sugden Lake (1.2 µg/l).

Figure 18. Cyanobacteria bloom on the east side of Sugden Lake in July 2017 (photo taken by Jill Anulewicz and used with permission).

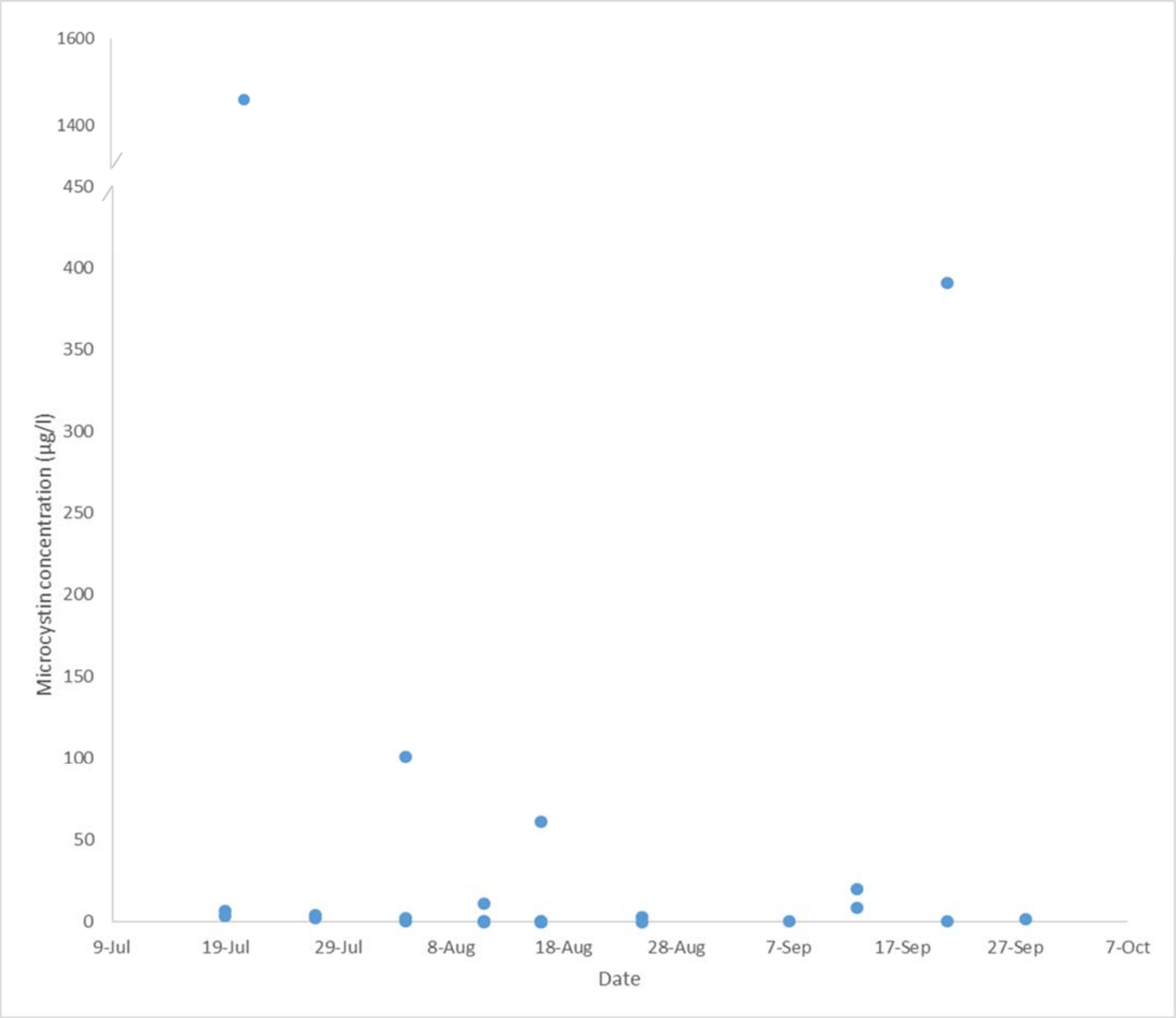

Figure 19. Microcystin concentrations from mid-July through late September 2017 in Sugden Lake, Oakland County. Note: y axis is broken from 450 to 1400 µg/l microcystin.

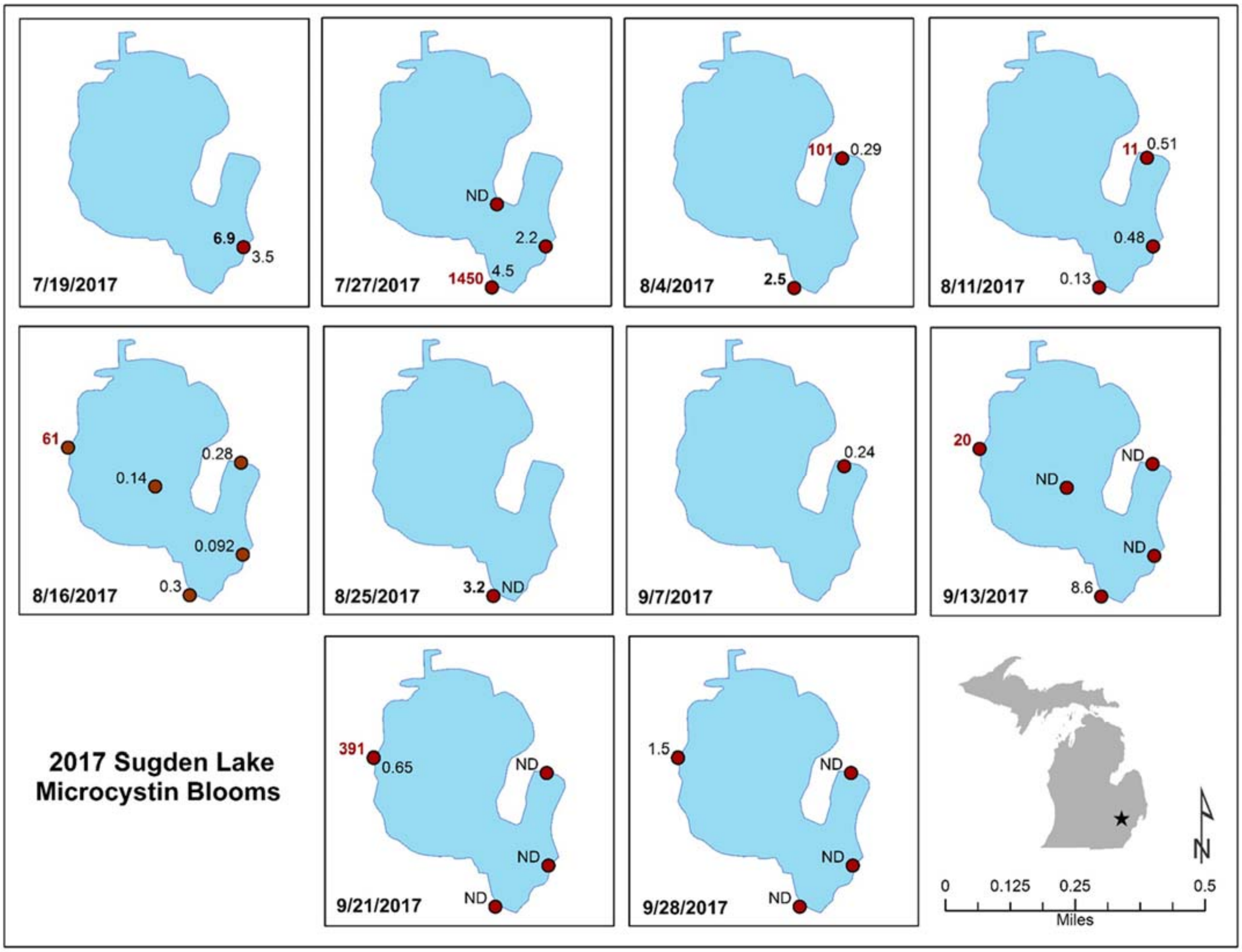

Figure 20. Microcystin concentrations (µg/l) at different sampled areas of Sugden Lake, Oakland County in 2017 (ND = non-detection). Two values that are close to 1 point (i.e., 1,450 and 4.5 µg/l microcystin on July 27, 2017) represent areas of a scum accumulation where a sample was collected within the scum (high values) and a sample was collected in ambient (clear) water (low values), typically within 5 to 15 feet of the scum accumulation.

Response Lakes

In 2017, WRD staff were contacted either by private citizens or MDEQ staff about algae blooms occurring in 49 different water bodies throughout the state (39 inland lakes, 10 rivers/streams [Parker, 2018]). Algal bloom complaints began in mid-May and continued into late November 2017. The majority of the complaints were in the southern half of the Lower Peninsula (Parker, 2018). Response efforts were made at 29 different water bodies, from which water samples were collected and at the very least analyzed for microcystin using test strips. Five water bodies were clear when they were sampled and the test strips indicated that no microcystin was present. In those cases, water samples were not sent to the MDHHS laboratory for further analysis. At 13 of the water bodies, microcystin concentrations were less than 1 µg/l. At the remaining response water bodies, 3 of the water bodies did not exceed 6 µg/l microcystin and 8 had maximum concentrations ranging from 19 to 1,450 µg/l (Table 3).

Table 3. Concentration ranges in response lakes with >1 µg/l microcystin. ND = non-detect.

Response Lake	County	Microcystin range (µg/l)
Podunk Lake	Barry	1.3
Thornapple Lake	Barry	0.21 - 3.4
West Bloomfield Lake	Oakland	ND - 2.7
Big Blue Lake	Muskegon	ND - 19
Pleasant Lake	Washtenaw	ND - 29
Crooked Lake	Kalamazoo	1.3 - 36
Loch Erin	Lenawee	ND - 50
Lobdell Lake	Genesee/Livingston	ND - 130
Wixom Lake	Gladwin	0.7 - 250
Brighton Lake	Livingston	ND - 375
Sugden Lake	Oakland	ND - 1450

Scum vs ambient samples

The highest microcystin concentrations were from surface scum samples, although even within the scum samples, concentrations ranged from non-detect to 1,450 µg/l. In total, 51 different scum samples were taken from the 12 different lakes. In 4 lakes of the 12 lakes where surface scum samples were collected (Haas Lake in Oakland County; Quail Run Pond in Wayne County; West Bloomfield Lake in Oakland County; Thornapple Lake in Barry County) all microcystin concentrations were less 6 µg/l. When comparing all ambient and scum samples, the mean microcystin concentration within scum samples was higher than concentrations in ambient water ($t_{50} = -3.17$, $p = 0.002$; Figure 21). When comparing the scum and ambient samples that were collected side-by-side, the mean scum samples also contained greater microcystin concentrations ($t_{22} = 2.22$, $p = 0.037$; Figure 22).

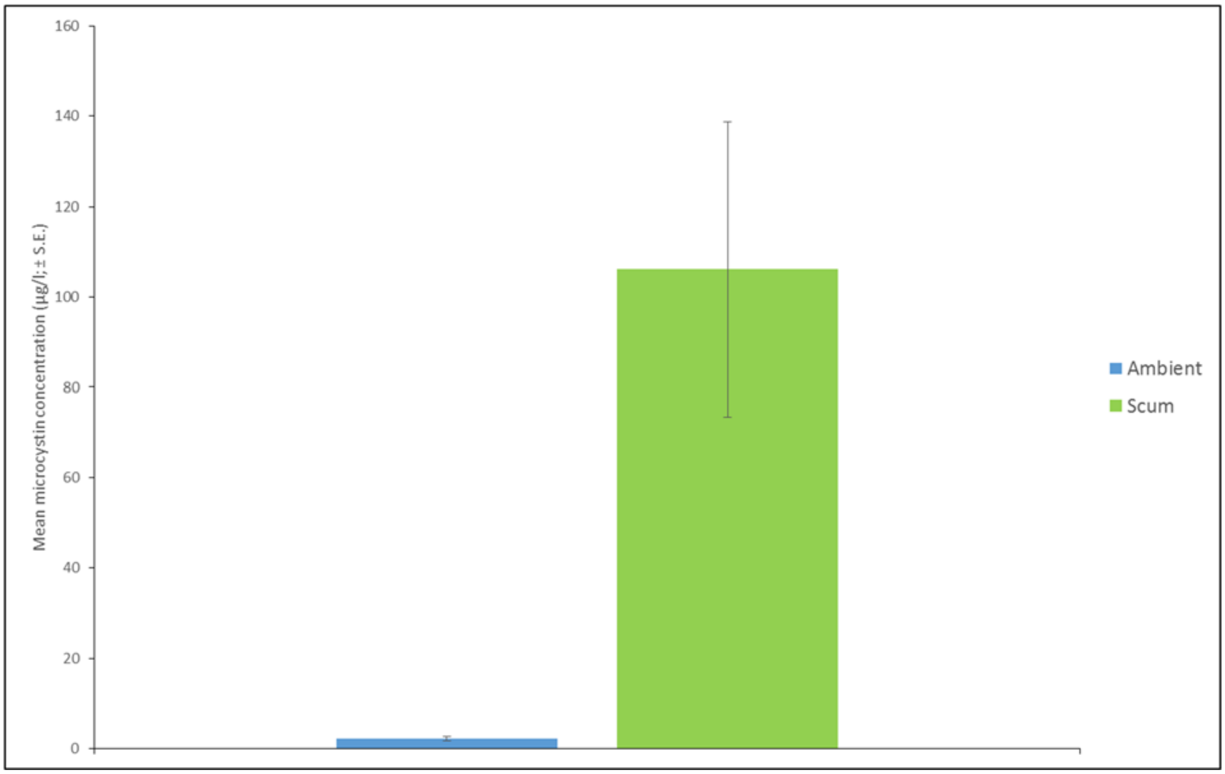

Figure 21. Mean microcystin concentrations (± S.E.) in all ambient and scum samples.

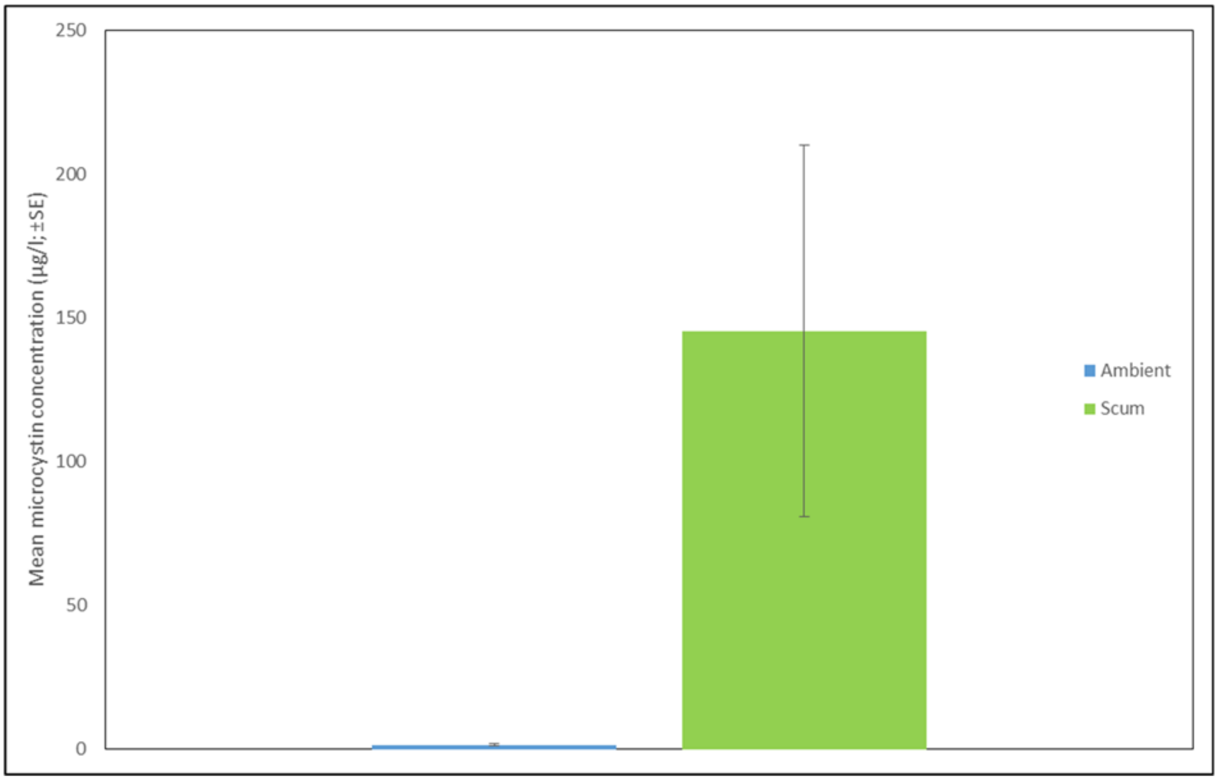

Figure 22. Mean microcystin concentrations (± S.E.) in side-by-side ambient and scum samples.

Discussion

In 2017, MDEQ staff received more complaints about algal blooms than in previous years (Parker, 2018). Microcystin concentrations in some lakes were greater than we have previously recorded, with multiple lakes containing microcystin concentrations greater than the State of Ohio’s recreational guidance of 6 µg/l and the WHO’s recreational guidance of 20 µg/l.

Discerning whether the increased number of reports was the result of actual increases in cyanobacteria blooms or increased awareness by citizens and MDEQ staff is difficult. Some cyanobacteria blooms received local media coverage, which in some cases prompted citizens to contact the MDEQ about cyanobacteria blooms in other lakes. In 2017, an increased number of samples were also collected largely as a result of increased sampling capacity by MDEQ District staff. The sampling by local District staff also shortened the time between when complaints were received and when samples were collected. This may have resulted in higher microcystin concentrations being detected since the blooms were often still present when staff arrived. In previous years by the time staff from Lansing arrived at some of the complaint lakes, the blooms had dissipated. In 2017, cyanobacteria blooms persisted for much longer than we have observed in previous years, particularly in Mona and Sugden Lakes.

Mona Lake

The calculated TSIs for Mona Lake throughout 2017 ranged from eutrophic to hypereutrophic, which is consistent with what others have found in Mona Lake (Steinman et al., 2006; Steinman et al., 2009; Xie et al., 2012). Although the 2017 TSI values were higher than in 2016 (Parker, 2017).

The Mona Lake watershed has a long history of anthropogenic degradation. Prior to the 1970s, Mona Lake received wastewater discharges from the cities of Muskegon Heights and Norton Shores. However, a large wastewater diversion plant has reduced the amount of nutrients entering Mona Lake (Evans, 1992; Steinman et al., 2006). Little Black Creek, a tributary to Mona Lake drains a heavily urbanized and industrial area of Muskegon Heights. Within the Little Black Creek watershed is a petroleum refinery, foundries, metal finishing plants, a plating facility superfund site, and an abandoned landfill that did not contain a leachate collection system (Walker, 2000; Steinman et al., 2006; Cooper et al., 2009). Most of the Mona Lake watershed is natural; however, development is high, particularly around Mona Lake (Table 4; Steinman et al., 2009). Steinman et al. (2009) found that the majority of the summer phosphorus input (68 to 82%) is from internal loading during thermal stratification.

Table 4. 2005 Mona Lake watershed land use data (from Steinman et al., 2009).

Natural	Developed	Agriculture
46.60%	37.80%	15.60%

Microcystin production in Mona Lake has fluctuated over the years, with maximum concentrations ranging from <1 to 430 µg/l (Figure 23). Assessments of the phytoplankton community in Mona Lake have found that cyanobacteria tend to be the dominant taxa during the late summer (Xie et al., 2012; Gillett et al., 2015), which includes an invasive species of *Cylindrospermopsis* (Hong et al., 2006).

In 2017, microcystin concentrations were higher than what had previously been reported (Rediske et al., 2007; R. Rediske personal communication in Gillett et al. [2015]; Rediske et al. 2011; Holden, 2016; Parker 2017). During the first sampling event in early July, a sample collected from the Muskegon Heights boat launch contained 25 µg/l microcystin, which is greater than the WHO’s recreational guidance of 20 µg/l microcystin. After the initial sampling event, microcystin concentrations declined through the end of July. However, when Mona Lake was revisited in mid-August, a dense cyanobacteria bloom was present on the east side of the lake near Highgate Drive, which had very high microcystin concentrations. In late August, a cyanobacteria bloom was present near the Muskegon Heights boat launch and had high microcystin concentrations. Throughout the month of September, cyanobacteria was visible at all sites that were visited, including the middle of the lake. All sites that were sampled in September had some microcystin present, although the east side of the lake had the densest cyanobacteria accumulations and the highest microcystin concentrations, particularly near Highgate Drive and the Muskegon Heights boat launch. During the last sampling event, in early October, the cyanobacteria blooms had dissipated and microcystin concentrations decreased.

Similar to Xie et al. (2012), microcystin production in Mona Lake was correlated to total phosphorus. Xie et al. (2012) proposed that low dissolved inorganic nitrogen in Mona Lake coupled with high amounts of phosphorus may give N_2-fixing cyanobacteria a competitive advantage over other phytoplankton (Smith, 1983; Kahru et al., 2000). During 2015 and 2017 the average total phosphorus that we recorded was 0.06 and 0.053, respectively, which are considered hypereutrophic concentrations (Fuller and Minnerick, 2008). In 2016, when no obvious cyanobacteria blooms were evident and microcystin concentrations were low, the average total phosphorus concentration was 0.033 mg/l (eutrophic; Fuller and Minnerick, 2008).

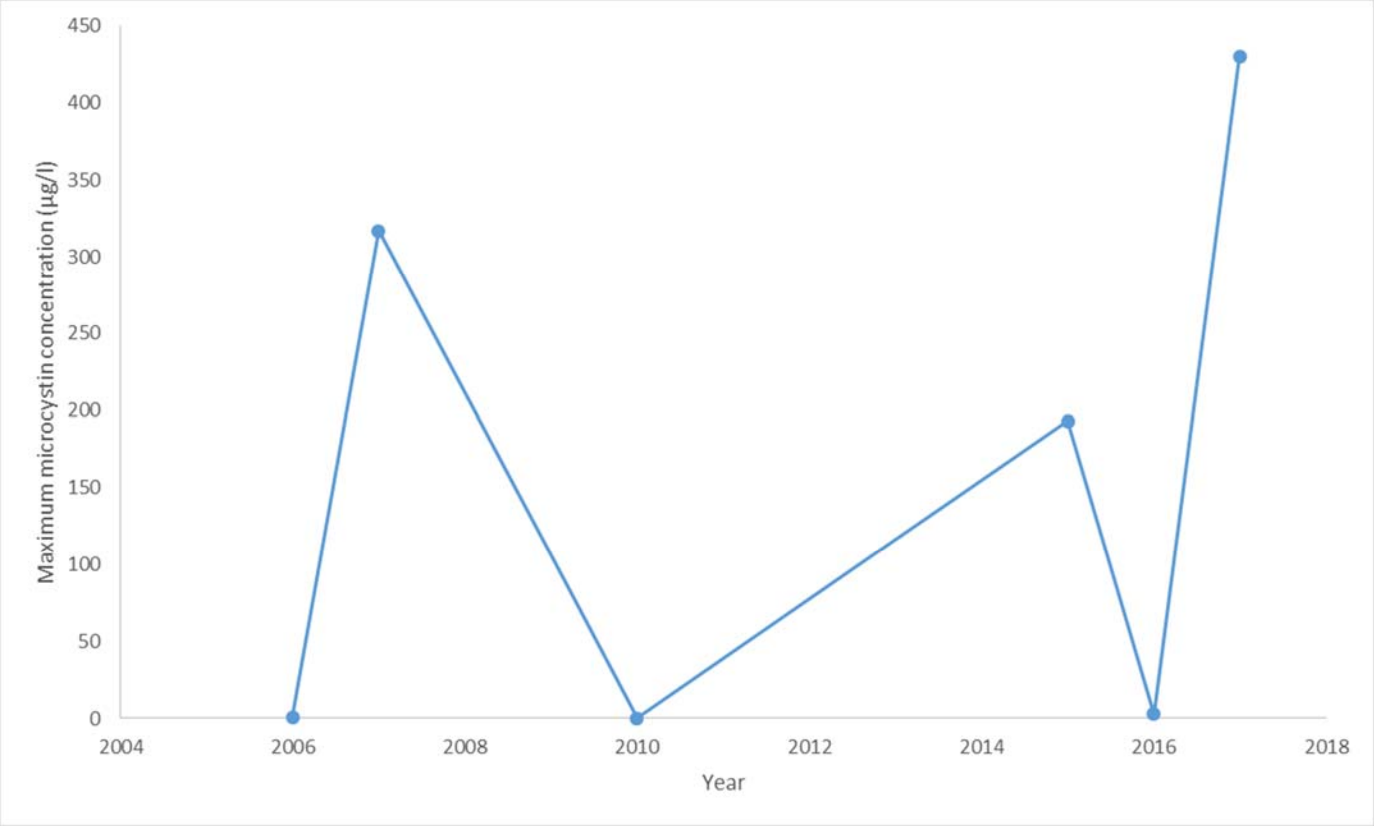

Figure 23. Maximum microcystin concentrations detected in Mona Lake. Microcystin concentration data are from the following sources: 2006: Rediske et al. (2007), 2007: R. Rediske personal communication in Gillett et al. (2015), 2010: Rediske et al. (2011), 2015: Holden (2016), 2016: Parker (2017) and 2017: this report.

Lamberton Lake

Lamberton Lake is in the upper reaches of the Lamberton Creek watershed, which is a tributary to the Grand River. Lamberton Lake is located within the city of Grand Rapids near Plainfield Avenue NW and Interstate 96. Land use in the Lamberton Creek watershed is highly developed (Table 5a). MDEQ staff first visited Lamberton Lake in early August 2016 in response to a cyanobacteria bloom on the north side of the lake. A scum sample from that bloom had a microcystin concentration of 10.59 µg/l. Subsequent sampling in mid-August found a concentration of 1.4 µg/l and no microcystins were detected in late August (Parker, 2017).

Table 5a. Land use data for Lamberton Creek watershed.

Developed	Forest	Wetland	Agriculture	Other
76%	11%	4%	4%	5%

Because the scum sample from 2016 had one of the highest microcystin concentrations recorded that year, we decided to sample Lamberton Lake more intensively in 2017. The highest microcystin concentration in 2017 was 10.6 µg/l, which was recorded in early July during the first sampling event. Microcystin concentrations remained low through the remainder of July but in mid-August a sample had 8.1µg/l of microcystin. Samples in late August and all of September were all ≤ 1 µg/l microcystin.

In Lamberton Lake, the 2 elevated microcystin concentrations were within scum samples that accumulated on the north side of the lake. The site that we sampled on the south side of the lake was consistently clear and no microcystin was ever detected there. When we visited Lamberton Lake, the wind direction often appeared to blow towards the north, which sometimes caused accumulations of cyanobacteria. The scum accumulations that were present were not very extensive (< 3 square feet).

Long Lake

Long Lake is located in the upper Flat River watershed. Land use in the Long Lake subwatershed is mostly forest and wetland although agricultural land use is also high (Table 5b). Long Lake was sampled in 2016 as part of the random Lake Status and Trend fish and water quality sampling conducted by the MDNR-FD and MDEQ. Two microcystin samples collected in July 2016 had concentrations of 1 and 4.3 µg/l. Because Long Lake was randomly chosen for sampling in 2016, yet had 2 detections of microcystin, we decided to sample it more extensively in 2017 to evaluate whether cyanobacteria blooms and subsequent microcystin production were common in Long Lake.

Table 5b. Land use data for Lamberton Creek watershed.

Developed	Forest	Wetland	Agriculture	Other
7%	21%	28%	38%	6%

Based on calculated TSIs, Long Lake maintained mesotrophic conditions throughout the entire sampling season. Microcystin concentrations were low throughout July and August. During a short period of time in mid-September some cyanobacteria was observed and elevated concentrations of microcystin were measured in the scums. The 2 scums that were observed were not densely concentrated, but rather consisted of numerous small aggregations that appeared to be organized in windrows (Figure 24). The values of 6.2 and 8 µg/l were greater than the State of Ohio's recreational guidance of 6 µg/l, but not greater than the WHO guidance of 20 µg/l. Water samples from subsequent sampling in late September and early October did not contain measurable amounts of microcystin.

Figure 24. Surface cyanobacteria scums in Long Lake, Ionia County. Left: Near MDNR boat launch on September 11, 2017. Right: In center of lake on September 15, 2017.

Pontiac Lake

Pontiac Lake is located in the Huron River watershed and is an impoundment that was created in 1926 when a smaller lake was dammed (Thomas, 1993). Land use in the immediate Pontiac Lake watershed is mostly forest and wetland (Figure 25; Table 6). Although development is a relatively small percentage of the lake watershed (20.2%), a lot of the development is along the immediate shoreline of the lake, including 2 large peninsulas that extend into it (Thomas, 1993; personal observation). In 2016, MDEQ biologists who were performing an aquatic invasive species survey in the lake reported a cyanobacteria bloom near the MDNR boat launch in late September. During a subsequent response sampling effort on September 23, 2016, the cyanobacteria bloom near the boat launch was still present and had a microcystin concentration of 122 µg/l, the highest concentration of microcystin detected in 2016 (Parker, 2018). Because of the high amount of microcystin that was observed in 2016, targeted sampling occurred in 2017.

Table 6. Land use data in the Pontiac Lake watershed. Data provided by David Szlag, Oakland University (personal communication). These data were collected as part of MDEQ-funded research being performed by Oakland University, which includes Pontiac Lake.

Lake	Watershed area (km$^{2)}$	Water (%)	Developed (%)	Barren (%)	Forest (%)	Shrubs (%)	Herbaceous (%)	Agriculture (%)	Wetlands (%)
Pontiac	54.5	7.1	20.2	0.4	36.6	0.3	4.5	10.1	20.9

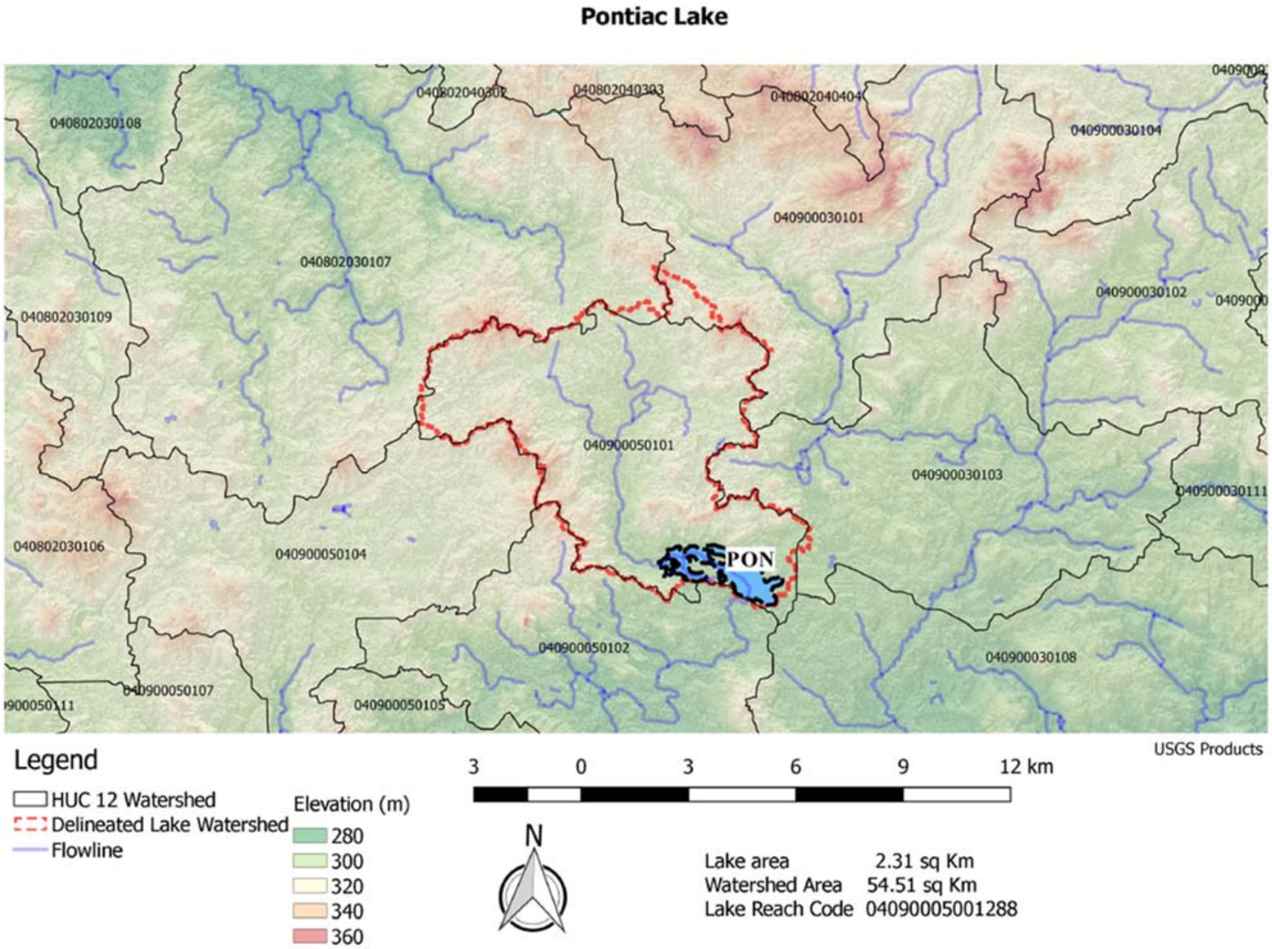

Figure 25. Watershed map of Pontiac Lake. Map provided by David Szlag, Oakland University (personal communication). Map produced as part of MDEQ-funded research being performed by Oakland University, which includes Pontiac Lake.

Calculated TSIs consistently indicated that Pontiac Lake is a eutrophic lake. Microcystin concentrations of 7.4 and 6.9 µg/l were found in mid- and late July, respectively. Those concentrations were greater than the State of Ohio's recreational guidance of 6 µg/l. In August no elevated concentrations of microcystin were present; however, in mid-September we began receiving complaints from concerned citizens about cyanobacteria blooms in Pontiac Lake, particularly within the numerous embayments along the south peninsula. Two samples in mid-September contained microcystin concentrations of 265 and 78 µg/l, which is higher than the WHO recreational guidance of 20 µg/l. The last sample collected in late September had a low amount of microcystin in it. The period of time that we observed the most dense cyanobacteria blooms and highest microcystin concentrations was also at the same time of year that we responded to a bloom in 2016 and found the elevated microcystin concentration.

Stable, warm water conditions can be conducive to buoyant, surface-dwelling cyanobacteria (i.e., Paerl et al., 2001). Cyanobacteria and associated microcystin concentrations were low to non-detectable in the more open, wind-exposed areas of Pontiac Lake such as the State Park beach and off Skull Island. However, the numerous embayments along the southern peninsula were often calm and protected from the wind, which may create favorable conditions for cyanobacteria.

Sugden Lake

Although Sugden Lake was not a targeted lake in 2017 we sampled it enough times, from mid-July through September because of persistent blooms, that further analysis could be performed on it. Sugden Lake is located in the Huron River watershed. A similar size lake, Bogie Lake, is upstream of Sugden Lake and drains to Sugden via a small channel. Sugden Lake then drains into the main stem Huron River through a small channel. Fine-scale, land use data for the immediate Bogie and Sugden Lake watersheds revealed developed land and forest predominate, with minimal agricultural land use (Figure 26; Table 7).

Table 7. Land use data in the Bogie and Sugden Lake watersheds. Data provided by David Szlag, Oakland University (personal communication). These data were collected as part of MDEQ-funded research being performed by Oakland University, which includes Bogie and Sugden Lakes.

Lake	Watershed area ($km^{2)}$	Water (%)	Developed (%)	Barren (%)	Forest (%)	Shrubs (%)	Herbaceous (%)	Agriculture (%)	Wetlands (%)
Bogie	2.3	12.6	44.2	1.7	29.2	0.0	1.4	0.0	10.8
Sugden	0.9	27.4	31.1	0.6	22.9	0.7	0.0	5.6	11.5

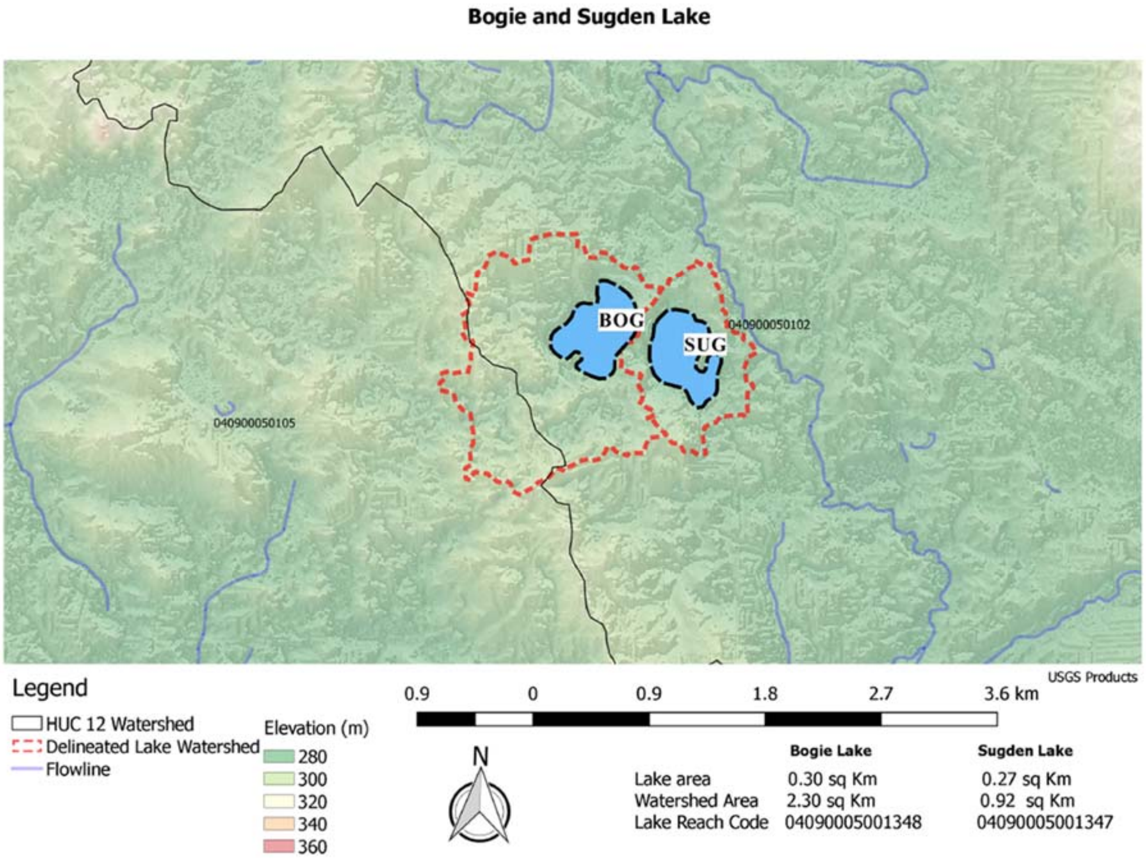

Figure 26. Watershed map of Bogie and Sugden Lakes. Map provided by David Szlag, Oakland University (personal communication). Map produced as part of MDEQ-funded research being performed by Oakland University, which includes Bogie and Sugden Lakes.

MDEQ staff were contacted in mid-July 2017 by residents who were concerned about a large cyanobacteria bloom occurring in the lake (i.e., Figure 18). Because of the unusual coloration of the cyanobacteria (dark yellow, as opposed to green) in the Sugden Lake bloom, the MDEQ also received calls about a possible sewage spill/unknown pollution in the lake. In late July, a dense bloom accumulated along the south shore of the lake and had an extremely high microcystin concentration of 1,450 µg/l in the surface scum. After the high microcystin concentration was detected in July, Sugden Lake was sampled frequently. The bloom persisted and moved around the lake to different shorelines, most likely as a function of wind direction. Although never as high as the late July sample, microcystin concentrations in the surface scum samples in August and September ranged from 20 to 391 µg/l.

Interestingly, the calculated TSIs of Sugden Lake indicate that it is an oligotrophic lake. Total phosphorus concentrations in Sugden Lake were extremely low, ranging from 0.004 to 0.01 mg/l. Therefore, nutrient enrichment was most likely not the cause of the cyanobacteria blooms in Sugden Lake in 2017.

During our sampling events, MDEQ staff observed dreissenid mussels (zebra mussels [*Dreissena polymorpha*] and/or quagga mussels [*Dreisenna bugensis*]) in the lake. Several residents consistently said that they first began to observe dreissenid mussels in Sugden Lake around 3 to 4 years ago (2013-2014). The residents that we spoke with also all consistently indicated that blooms such as the ones that occurred in 2017 had never been observed in the lake before.

The recent invasion by dreissenid mussels followed by cyanobacteria blooms in an oligotrophic lake leads us to suspect that the invasive mussels may be responsible for the blooms in Sugden Lake. *Dreissena*-induced cyanobacteria blooms in oligotrophic and mesotrophic lakes have been well documented in Michigan (Raikow et al., 2004; Knoll et al., 2008; Woller-Skar, 2009; White et al., 2017; Gaskill and Woller-Skar, 2018). Woller-Skar (2009; personal communication) reported that in oligotrophic, *Dreissena*-invaded lakes in Leelanau County, that the cyanobacteria blooms also had a yellow/pollen-like hue. Those cyanobacteria were identified as *Microcystis aeruginosa*, which is a very common cyanobacteria.

Dreissenid mussels are capable of filtering large quantities of water and will selectively consume diatoms and green algae, which can reduce resource competition for cyanobacteria and allow them to achieve bloom proportions (Bykova et al., 2006; Woller-Skar, 2009). Vanderploeg et al. (2001) found that zebra mussels would selectively feed on non-toxic algae and would even feed on cyanobacteria that were not producing microcystin. However, if cyanobacteria were producing microcystin, then the zebra mussels would partially ingest, and then reject it (e.g., they will feed on cyanobacteria, including those that are capable of producing microcystins, but will not necessarily feed on cyanobacteria that are actively producing microcystin). Thus, selective feeding by dreissenid mussels appears to lead to disproportionate populations of toxin-producing cyanobacteria. Furthermore, dreissenid mussel excretions may alter the nitrogen/phosphorus ratios in lake water such that they are more favorable to cyanobacteria growth (Bykova et al., 2006).

Response Lakes

The majority of complaints were in the southern half of the Lower Peninsula, which is consistent with previous years (Parker, 2018). In several cases, MDEQ staff were able to determine that the algae were non-toxin producing green algae (i.e., *Cladophora*), or that the cyanobacteria blooms had dissipated by the time staff could respond. In some cases, samples were collected and only a test strip analysis was necessary because the strip indicated that microcystin was not present. Holden (2016) and Parker (2017) have shown that the microcystin test strips are effective at detecting elevated concentrations of the toxin. Holden (2016) found that the test strips may over-estimate the amount of microcystin in a water sample. Overall, the test strips have provided rapid screening information, sometimes within hours of collection, which is valuable for providing information to the MDHHS and the public.

MDEQ staff received complaints from concerned citizens and staff about 49 different water bodies throughout the state. The number of complaints received in 2017 was nearly double the number received in previous years (Parker, 2018). It is difficult to determine whether the increased number of complaints was the result of greater incidences of algal blooms in the state, an increased awareness/concern about algal blooms by citizens and staff, as well as a centralized reporting outlet (algaebloom@michigan.gov) that made reporting algal blooms easier, or a combination of factors. In 2017, algal blooms that occurred in west Michigan and southeast Michigan received coverage by local media outlets. After the media coverage, the MDEQ would often be contacted by concerned citizens about algal blooms that were occurring in other water bodies. In 2017, cyanobacteria blooms did persist in several lakes for a longer period of time than we had previously observed, and the microcystin concentrations that were detected were greater than we have seen before. Thus, the increase in citizen and staff complaints is likely a combination of both increased awareness/concern about cyanobacteria blooms and an actual increase in the occurrence, magnitude, and intensity of cyanobacteria blooms in 2017.

Chemical/Physical Predictors of Observed Microcystin Concentrations

We found that lower PC1 scores in the PCA were indicative of less disturbed/productive habitat, whereas higher scores were indicative of more disturbed/productive habitat. Overall, there was no relationship between the environmental variables in all lakes combined (using PC1 as a surrogate for disturbance/productivity) and the amount of microcystin present. This is not too surprising, considering the amount of variation that has been observed in Michigan lakes for both cyanobacteria populations and microcystin production. In 2017, Sugden Lake had the highest microcystin concentrations detected, yet it is an oligotrophic lake. In contrast, 2 small water bodies, Quail Run Pond in Wayne County and West Bloomfield Lake in Oakland County, which had extremely high total phosphorus concentrations of 0.25 and 0.2 mg/l (>0.05 is considered hypereutrophic), respectively, had no microcystin detected in their cyanobacteria blooms.

Xie et al. (2012) found that microcystin concentrations in Spring Lake and Mona Lake were correlated to different environmental variables, even though they are located within 10 kilometers of each other. Even more striking, Xie et al. (2011) found distinct cyanobacteria populations and different correlates to microcystin concentrations in Bear and Muskegon Lakes, which are hydrologically connected.

Michigan inland lakes have genetically diverse populations of *Microcystis aeruginosa* both within and among populations (Wilson et al., 2005). *Microcystis* and *Planktothrix* populations have also been shown to undergo seasonal succession of toxic and non-toxic genotypes. Thus, cyanobacterial biomass itself may not fully correspond with observed microcystin concentrations (Kardinaal et al., 2007). In their review, Kardinaal and Visser (2005) listed numerous environmental factors that have been associated with cyanobacteria and their toxins around the world. They concluded that dominance of cyanobacteria in lakes “cannot be attributed to a single master factor.” Rather, they concluded that given the amount of diversity, in the form of physiology and growth requirements amongst cyanobacteria populations, they are capable of exploiting and adapting to a wide variety of environmental conditions. In a recent extensive review, Omidi et al. (2017) cited many studies that have provided evidence for numerous possible functions that microcystin may serve to increase the survival of cyanobacteria. However, given the wide variety of conditions in which microcystin production has occurred, a general function of microcystins, which could aid in the prediction of its production has not been found (Omidi et al., 2017).

MDEQ staff have observed extreme variation in the cyanobacterial growth and subsequent microcystin production in Michigan lakes. For example, water samples with only small amounts of visible cyanobacteria have contained elevated microcystin concentrations, whereas samples from water bodies with obvious cyanobacteria blooms have had no microcystin present (Figure 27). Furthermore, we have observed extreme variation within small geographic areas. For example, on August 16, 2017, a cyanobacteria bloom in West Bloomfield Lake in Oakland County contained no microcystin, whereas a cyanobacteria bloom in Sugden Lake, which is only 7 miles away from that lake, contained 61 µg/l of microcystin on the same day.

Figure 27. Left: Mona Lake on July 10, 2017. A sample from this site contained 17 µg/l of microcystin. Right: West Bloomfield Lake on July 19, 2017. A sample from this site contained no microcystin.

In 2017 microcystin concentrations were typically greater in the lower latitudes of Michigan, than the higher ones. However, environmental conditions in the lakes could not explain the observed microcystin concentrations. The latitudinal pattern though, is also weak, given the amount of variability in the southern Michigan microcystin concentrations. Also, caution should be taken with interpretation of 1 year's-worth of data. For example, cyanobacteria blooms occur on a regular basis in several Leelanau County lakes (near 45º latitude) and have produced high concentrations of microcystin (Woller-Skar, 2009; Gaskill and Woller-Skar, 2018). Given the diverse genotypes of cyanobacteria throughout Michigan (Wilson et al., 2005), along with variable lake chemistry, surrounding land use patterns, and presence/absence of dreissenid mussels, microcystin production is probably uniquely dependent on conditions within and around the water body in question.

Conclusion

Because microcystin is not routinely found in the randomly-sampled lakes throughout the state, it does not appear to be a widespread, frequent problem. However, harmful cyanobacteria blooms do occur in some lakes, albeit at various intensities and with varying degrees of microcystin production. The highest microcystin concentrations were in the southern Lower Peninsula. In 2017 we had an increase in the number of citizen and staff complaints about algal blooms and in some lakes, we observed the highest microcystin concentrations since we began routine monitoring. In 2016, we received fewer complaints and microcystin concentrations throughout the state were much lower. The extreme temporal variation of microcystin production and bloom intensities highlights the need for ongoing, rapid-response monitoring when cyanobacteria blooms are noted.

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Appendix 1: Raw data from sampled lakes.

Waterbody	County	TYPE	MONTH	DAY	TIME	LAT	LONG	SITE	SCUM	SITE_DEPTH (ft)	SAMP_DEPTH (ft)	TEMP (F)	DO (mg/l)	COND (µs/cm)	PH	PC RFU
Allens	LENAWEE	S/T	8	23	.	42.05917	-84.18334	Deep	NO	.	.	.	.	.	.	.
Au Train Lake	Alger	S/T	8	14	.	46.40183	-86.84958	Deep	NO	.	.	.	.	.	.	.
BEAR	MUSKEGON	TARGET	7	31	1616	43.25893	-86.27187	BEACH	NO	0.5	0	83.43	11.26	372.8	8.79	0.301
BIG BLUE	MUSKEGON	RESPONSE	8	28	1440	43.45006	-86.19515	PARK	NO	.	0.44	70.314	9.26	222	8.15	0.219
BIG BLUE	MUSKEGON	RESPONSE	8	28	1500	43.45982	-86.20289	LAKE AVE	NO	.	0.76	72.122	9.49	211.6	8.35	0.361
BIG BLUE	MUSKEGON	RESPONSE	9	25	1430	43.45977	-86.20285	LAKE AVE	NO	1	0	82.755	9.71	247.7	8.36	0.099
BIG BLUE	MUSKEGON	RESPONSE	9	25	1400	43.45011	-86.19507	COUNTY PARK	NO	1	0	80.291	9.42	260.1	8.18	0.246
BIG BLUE	MUSKEGON	RESPONSE	9	25	1445	43.45967	-86.20638	BOAT LAUNCH	YES	1	0	84.685	8.9	254.8	8.32	2.599
BIG BLUE	MUSKEGON	RESPONSE	10	2	.	43.45966	-86.20634	BOAT LAUNCH	NO	.	0	70.73	9.07	203.8	8.44	0.178
BIG BLUE	MUSKEGON	RESPONSE	10	2	.	43.4598	-86.2028	LAKE AVE	NO	.	0	71.16	9.25	204.2	8.49	0.158
Big Fish Lake/Joe's Big Fish Lake	Lapeer	S/T	8	16	.	42.88489	-83.39228	Deep	NO	.	.	.	.	.	.	.
BRIGHTON	LIVINGSTON	RESPONSE	8	11	915	42.52242	-83.80145	NORTH PARK	NO	.	0	76.177	8.34	839	8.27	11.78
BRIGHTON	LIVINGSTON	RESPONSE	8	11	950	42.52021	-83.78997	BOAT LAUNCH	NO	.	0	75.04	8.44	862	8.29	10.984
BRIGHTON	LIVINGSTON	RESPONSE	8	11	915	42.52242	-83.80145	NORTH PARK	YES	.	0	73.57	3.41	805	7.47	137.95
BRIGHTON	LIVINGSTON	RESPONSE	8	11	900	42.51678	-83.80258	WEST MINISTER PARK	YES	.	0	75.252	9.43	813	8.45	30.158
BRIGHTON	LIVINGSTON	RESPONSE	9	28	1320	42.52023	-83.78987	BOAT LAUNCH	NO	.	0	71.95	9.21	871	7.99	4.969
BRIGHTON	LIVINGSTON	RESPONSE	9	28	1330	42.5168	-83.80261	WESTMINISTER PARK	NO	.	0	71.15	6.29	921	7.19	5.313
BRIGHTON	LIVINGSTON	RESPONSE	9	28	1345	42.52241	-83.80147	NORTH PARK	NO	.	0	70.95	7.5	867	7.65	5.44
BRIGHTON	LIVINGSTON	RESPONSE	10	19	.	42.52241	-83.80144	NORTH PARK	NO	.	0	63.0374	11.63	669.7	9.26	7.52
BRIGHTON	LIVINGSTON	RESPONSE	10	19	.	42.51699	-83.80214	WESTMINISTER PARK	NO	.	0	62.1248	11.76	652.5	9.9	7.45
BRIGHTON	LIVINGSTON	RESPONSE	10	19	.	42.52301	-83.78996	LAKESIDE DR	NO	.	0	61.0088	9.57	608.9	10.9	0.09
BRIGHTON	LIVINGSTON	RESPONSE	10	19	.	42.52107	-83.80181	DEEP	YES	20	0	59.25	10.2	784.6	10.4	10.28
BRIGHTON	LIVINGSTON	RESPONSE	10	19	.	42.52107	-83.80181	DEEP	YES	20	3.5	59.15	9.87	783.8	9.87	10.28
BRIGHTON	LIVINGSTON	RESPONSE	10	19	.	42.52107	-83.80181	DEEP	YES	20	6.27	58.96	9.34	784.2	9.62	10.02
BRIGHTON	LIVINGSTON	RESPONSE	10	19	.	42.52107	-83.80181	DEEP	YES	20	8.55	58.9532	9.11	784.3	9.44	10
BRIGHTON	LIVINGSTON	RESPONSE	10	19	.	42.52107	-83.80181	DEEP	YES	20	15.498	58.8956	9.37	783.6	9.41	9.84
BRIGHTON	LIVINGSTON	RESPONSE	10	19	.	42.52107	-83.80181	DEEP	YES	20	16.811	59.1134	0.23	746.3	8.71	0.77
BRIGHTON	LIVINGSTON	RESPONSE	10	19	.	42.52138	-83.80253	West	YES	.	0	62.366	10.99	656.1	9.75	8.43
BRIGHTON	LIVINGSTON	RESPONSE	10	19	.	42.52019	-83.7945	ANCHOR BAY	YES	.	0	.	.	.	.	.
CRANBERRY	Oakland	RESPONSE	7	27	1400	42.65658	-83.48564	MAPLE HEIGHTS RD	NO	0.5	0	80.83	9.71	627	8.61	0.29
CRANBERRY	Oakland	RESPONSE	7	27	1415	42.65791	-83.47952	BEACH	NO	0.5	0	80.43	9.76	625	8.57	0.227
CROTON POND	NEWAYGO	RESPONSE	9	25	1500	43.44084	-85.65719	Ridge ST	NO	1	0	75.885	11.59	471.5	8.21	0.07
CROTON POND	NEWAYGO	RESPONSE	9	25	1510	43.44071	-85.65738	Ridge st west	NO	3	0	75.655	11.43	473.3	8.33	0.1
Dead River - Tourist Park	Marquette	S/T	8	21	.	46.5693	-87.4181	Deep	NO	.	.	.	.	.	.	.
Flat Rock Impoundment	Wayne	S/T	9	6	.	42.1046	-83.30654	Deep	NO	.	.	.	.	.	.	.
Four Lake	Gladwin	S/T	8	14	.	44.15503	-84.44746	Deep	NO	.	.	.	.	.	.	.
HAAS	OAKLAND	RESPONSE	8	11	1100	42.97748	-83.57909	EAST OF ROAD	NO	.	0	75.177	8.52	799	8.95	0.163
HAAS	OAKLAND	RESPONSE	8	11	1115	42.4758	-83.58644	BEACH 3	NO	.	0	77.43	6.35	857	8.3	0.081
HAAS	OAKLAND	RESPONSE	8	11	.	42.47165	-83.58758	BEACH 4	NO	.	0	77.344	6.63	901	8.27	0.099
HAAS	OAKLAND	RESPONSE	8	11	1140	42.48006	-83.57692	BEACH 2	NO	.	0	79.266	7.77	984	8.35	0.42
HAAS	OAKLAND	RESPONSE	8	11	.	.	.	BEACH 1	NO	.	0	78.47	7.08	1088	8.16	0.132
HAAS	OAKLAND	RESPONSE	8	11	1100	42.97748	-83.57909	EAST OF ROAD	YES	.	0	76.916	9.21	943	8.45	6.015
HOLLOWAY RES.	GENESEE/LAPEER	RESPONSE	10	16	.	43.13287	-83.42438	BITTERSWEET	NO	.	0	59.92	5.7	345.1	7.54	1.7
HOLLOWAY RES.	GENESEE/LAPEER	RESPONSE	10	16	.	43.11604	-83.47397	BOAT LAUNCH	NO	.	0	63.27	7.41	516	8.16	1.35
HOLLOWAY RES.	GENESEE/LAPEER	RESPONSE	10	16	.	43.11932	-83.49301	DAM	NO	.	0	64.56	8.43	520	8.27	1.05
HOLLOWAY RES.	GENESEE/LAPEER	RESPONSE	10	16	.	43.12704	-83.43453	MT MORRIS	NO	.	0	63.08	7.63	599	8.04	0.688
Indian Lake	Iosco	S/T	8	17	.	44.3475	-83.64945	Deep	NO	.	.	.	.	.	.	.
Lake George	Clare	S/T	8	30	.	43.95549	-84.93718	Deep	NO	.	.	.	.	.	.	.
Lake Medora	Keweenaw	S/T	8	22	.	47.43806	-87.96806	Deep	NO	.	.	.	.	.	.	.

Appendix 1 continued.

PC CONC (µg/l)	CHLA RFU	CHLA CONC (µg/l)	SECCHI (FT)	LAB_CHL (µg/l)	NH3 (mg/l)	N (mg/l)	NO2/NO3 (mg/l)	ORTHO P (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB_TOT_MC (µg/l)	LAB_ANATOX (µg/l)	LAB_CYLINDRO (µg/l)
.	.	.	.	0.0034	0.04	0.752	0.0007	.	0.0102	ND	0.125	0.1	0.1
.	.	.	.	0.00294	0.06	0.61	0.0019	.	0.0196	ND	0.125	0.1	0.1
0.3	1.546	5.8	.	.	.	.	.	.	.	.	1.7	0.1	0.1
0.19	0.641	2.39	.	.	.	.	.	.	.	.	0.25	0.1	0.1
0.34	3.11	0.75	.	.	.	.	.	.	.	.	0.25	0.1	0.1
0.07	0.37	1.23	1	.	.	.	.	.	.	.	0.92	0.1	0.1
0.22	0.715	2.54	1	.	.	.	.	.	.	.	.	.	.
2.44	6.104	30.22	1	.	.	.	.	.	.	.	11	0.1	0.1
0.21	0.334	1.04	.	.	.	.	.	.	.	.	0.125	0.1	0.1
0.19	0.351	1.29	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	0.0034	0.07	1.448	0.0007	.	0.0199	ND	0.125	0.1	0.1
10.78	2.839	10.69	.	.	.	.	.	.	.	.	7.8	1.8	0.1
11.25	2.677	10.35	.	.	.	.	.	.	.	.	.	.	.
154.11	15.21	53.13	.	.	.	.	.	.	.	.	375	0.1	0.1
25.72	3.914	15.9	.	.	.	.	.	.	.	.	5	2.5	0.1
5.55	2.38	9.05	.	.	.	.	.	.	.	.	2.4	0.1	0.1
6.01	2.533	9.26	.	.	.	.	.	.	.	.	.	.	.
6.08	2.85	11.11	.	.	.	.	.	.	.	.	.	.	.
6.21	1.36	5	.	.	.	.	.	.	.	.	0.125	.	.
6.15	1.37	5.04	.	.	.	.	.	.	.	.	.	.	.
0.08	0.89	3.34	.	.	.	.	.	.	.	.	.	.	.
8.48	2.15	7.74	1	55	0.008	1.8	0.014	0.021	0.063	.	.	.	.
8.48	2.08	7.51	.	.	.	.	.	.	.	.	.	.	.
8.27	2.09	7.54	.	.	.	.	.	.	.	.	.	.	.
8.25	2.23	8.02	.	.	.	.	.	.	.	.	.	.	.
8.12	2.08	7.5	.	.	.	.	.	.	.	.	.	.	.
0.64	1.57	0.38	.	.	.	.	.	.	.	.	.	.	.
6.96	1.52	5.53	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	22	.	.
0.41	1.233	4.66	.	.	0.01	0.86	0.005	0.006	0.015	.	0.41	0.1	0.1
0.34	1.063	4.34	.	.	.	.	.	.	.	.	.	.	.
0.12	0.676	2.05	1	.	.	.	.	.	.	.	.	.	.
0.12	1.437	5.14	3	.	.	.	.	.	.	.	.	.	.
.	.	.	.	0.00182	0.05	0.394	0.0651	.	0.0093	ND	0.125	0.1	0.1
.	.	.	.	0.00238	0.03	1.368	0.0735	.	0.0373	ND	0.125	0.1	0.1
.	.	.	.	0.00432	0.06	0.953	0.0007	.	0.0139	ND	0.125	0.1	0.1
0.2	0.481	1.91	.	.	.	.	.	.	.	.	0.0025	.	.
0.08	0.456	1.73	.	.	.	.	.	.	.	.	.	.	.
0.1	0.864	3.32	.	.	.	.	.	.	.	.	.	.	.
0.49	0.879	3.56	.	.	.	.	.	.	.	.	.	.	.
0.15	0.366	1.54	.	.	.	.	.	.	.	.	.	.	.
6.92	16.406	62.39	.	.	.	.	.	.	.	.	0.01	.	.
0.19	1.34	5.18	.	.	.	.	.	.	.	.	0.125	0.1	0.1
1.54	5.52	20.6	.	.	.	.	.	.	.	.	0.125	0.1	0.1
1.18	3.82	13.8	.	.	.	.	.	.	.	.	.	.	.
0.79	3.62	13.9	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	0.00314	0.08	1.379	0.0007	.	0.0163	ND	0.125	0.1	0.1
.	.	.	.	0.00647	0.03	0.777	0.0007	.	0.0275	ND	0.125	0.1	0.1
.	.	.	.	0.0034	0.04	0.486	0.0007	.	0.0097	ND	0.125	0.1	0.1

Appendix 1 continued.

Waterbody	County	TYPE	MONTH	DAY	TIME	LAT	LONG	SITE	SCUM	SITE_DEPTH (ft)	SAMP_DEPTH (ft)	TEMP (F)	DO (mg/l)	COND (µs/cm)	PH	PC RFU
Lake Michigamme	Marquette	S/T	8	21	.	46.52542	-88.03174	Deep	NO	.	.	.	.	.	.	.
LAMBERTON	KENT	TARGET	7	6	.	43.02252	-85.62835	HOUSE	.	.	.	.	.	.	.	.
LAMBERTON	KENT	TARGET	7	10	1105	43.02252	-85.62835	HOUSE	NO	1	0	78.979	10.17	.	8.39	0.238
LAMBERTON	KENT	TARGET	7	10	1055	43.01949	-85.62991	APT	NO	1	0	77.14	10.11	.	8.34	0.27
LAMBERTON	KENT	TARGET	7	17	1415	43.02251	-85.62846	HOUSE	NO	.	0	80.21	10.17	726	8.27	0.231
LAMBERTON	KENT	TARGET	7	17	1355	43.0195	-85.62984	APT	NO	.	0	80.43	10.02	722	8.27	0.227
LAMBERTON	KENT	TARGET	7	31	1238	43.02248	-85.62831	HOUSE	NO	2	0	.	11.84	673	8.21	0
LAMBERTON	KENT	TARGET	7	31	1217	43.01948	-85.62989	APT	NO	.	0	79.79	11.38	657	8.19	0
LAMBERTON	KENT	TARGET	7	31	1238	43.02248	-85.62831	HOUSE	YES	1	0	83.97	12.97	671	8.37	1.93
LAMBERTON	KENT	TARGET	8	14	1159	43.02249	-85.62836	HOUSE	NO	0.6	0	77.13	9.72	761	8.19	0.785
LAMBERTON	KENT	TARGET	8	14	1155	43.01941	-85.62987	APT	NO	.	2.1	76.39	9.91	749	8.17	0.227
LAMBERTON	KENT	TARGET	8	14	1159	43.02249	-85.62836	HOUSE	YES	.	0	78.59	9.74	771	8.03	15.77
LAMBERTON	KENT	TARGET	8	28	1117	43.01953	-85.62989	APT	NO	1	0.19	71.636	9.86	686	7.92	0.794
LAMBERTON	KENT	TARGET	8	28	1130	43.02245	-85.62837	HOUSE	NO	1	0.21	71.536	8.83	689	8.02	0.737
LAMBERTON	KENT	TARGET	9	11	1128	43.02254	-85.62849	HOUSE	NO	.	0	68.32	7.71	732	7.71	0.59
LAMBERTON	KENT	TARGET	9	11	1115	43.01949	-85.62998	APT	NO	.	0	67.75	7.39	720	7.69	0.34
LAMBERTON	KENT	TARGET	9	25	1100	43.02253	-85.62834	HOUSE	NO	1	0	76.354	8.92	769	8	0.104
LAMBERTON	KENT	TARGET	9	25	1040	43.01952	-85.6299	APT	NO	2	0	77.105	8.99	770	7.99	0.153
Little Fish Lake	St. Joseph	S/T	8	14	.	41.85362	-85.39628	Deep	NO	.	.	.	.	.	.	.
LOBDELL	GENESEE/LIVINGST(	RESPONSE	10	16	.	42.7963	-83.83504	SILVER LAKE RD	NO	.	0	61.844	6.65	496.1	7.6	0.042
LOBDELL	GENESEE/LIVINGST(	RESPONSE	10	16	.	42.79119	-83.84508	DAM	NO	.	0	61.88	5.79	543	7.76	0.02
LOBDELL	GENESEE/LIVINGST(	RESPONSE	10	16	.	42.78617	-83.84058	BOAT LAUNCH	NO	.	0	62.29	6.22	548	7.8	0.02
LOBDELL	GENESEE/LIVINGST(	RESPONSE	10	16	.	42.77568	-83.83329	SNAPPERS	NO	.	0	62.816	5.81	559	7.75	0.23
LOBDELL	GENESEE/LIVINGST(	RESPONSE	10	16	.	42.79007	-83.82034	HAVILAND BEACH RD	YES	.	0	64.6	7.36	483.8	8.02	0.42
LONG	IONIA	TARGET	7	6	.	43.11245	-85.10919	EAST	NO	1	.	.	.	.	.	.
LONG	IONIA	TARGET	7	6	817	.	.	DEEP	NO	44	.	.	.	.	.	.
LONG	IONIA	TARGET	7	6	800	43.10958	-85.12806	BEACH	NO	1	.	.	.	.	.	.
LONG	IONIA	TARGET	7	6	835	43.11573	-85.13425	WEST	NO	1	.	.	.	.	.	.
LONG	IONIA	TARGET	7	17	935	43.11302	-85.1096	EAST	NO	4.2	0	76.37	8.05	289	8.42	0.115
LONG	IONIA	TARGET	7	17	905	43.11411	-85.12869	DEEP	NO	39	0	76.8	8.84	282.5	8.59	0.241
LONG	IONIA	TARGET	7	17	905	43.11411	-85.12869	DEEP	NO	39	5	76.8	8.84	282.7	8.61	0.248
LONG	IONIA	TARGET	7	17	905	43.11411	-85.12869	DEEP	NO	39	10	76.8	8.82	282.7	8.61	0.241
LONG	IONIA	TARGET	7	17	905	43.11411	-85.12869	DEEP	NO	39	20	67.2	0.29	286.3	7.5	0.709
LONG	IONIA	TARGET	7	17	905	43.11411	-85.12869	DEEP	NO	39	30	54.99	0.15	267.1	7.44	0.03
LONG	IONIA	TARGET	7	17	905	43.11411	-85.12869	DEEP	NO	39	35	52.55	0.12	261.5	7.45	0.009
LONG	IONIA	TARGET	7	17	845	43.10955	-85.12805	BEACH	NO	0.5	0	74.52	8.8	275.1	8.55	0.181
LONG	IONIA	TARGET	7	17	925	43.11572	-85.12806	WEST	NO	2.8	0	74.38	10.42	279.4	8.54	0.036
LONG	IONIA	TARGET	7	31	1020	43.11319	-85.10956	EAST	NO	3.3	0	77.23	8.06	251.5	8.55	0
LONG	IONIA	TARGET	7	31	939	43.11154	-85.12663	DEEP	NO	46	0	77.23	9.48	240.5	8.7	0
LONG	IONIA	TARGET	7	31	939	43.11154	-85.12663	DEEP	NO	46	10	76.61	8.9	238.6	8.67	0
LONG	IONIA	TARGET	7	31	939	43.11154	-85.12663	DEEP	NO	46	20	66.91	0.25	260.9	7.4	0
LONG	IONIA	TARGET	7	31	939	43.11154	-85.12663	DEEP	NO	46	30	55.84	0.04	246.1	7.33	0
LONG	IONIA	TARGET	7	31	939	43.11154	-85.12663	DEEP	NO	46	40	52.08	0	240.8	7.41	0
LONG	IONIA	TARGET	7	31	922	43.10955	-85.12804	BEACH	NO	0.5	0	75.77	7.54	228.3	8.58	0
LONG	IONIA	TARGET	7	31	1006	43.1156	-85.1341	WEST	NO	3	0	75.02	12.29	224.7	9.04	0
LONG	IONIA	TARGET	7	31	1020	43.11319	-85.10956	EAST	YES	3.3	0	76.98	7.92	253.7	8.52	0
LONG	IONIA	TARGET	8	14	1024	43.11314	-85.10948	EAST	NO	2.7	0.46	75.23	7.97	290.1	8.42	0.194
LONG	IONIA	TARGET	8	14	1004	43.11287	-85.12682	DEEP	NO	54	0	74.82	8.65	278.4	8.57	0.114
LONG	IONIA	TARGET	8	14	1004	43.11287	-85.12682	DEEP	NO	54	8.91	74.54	8.13	278	8.49	0.086

Appendix 1 continued.

PC CONC (µg/l)	CHLA RFU	CHLA CONC (µg/l)	SECCHI (FT)	LAB_CHL (µg/l)	NH3 (mg/l)	N (mg/l)	NO2/NO3 (mg/l)	ORTHO P (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB_TOT_MC (µg/l)	LAB_ANATOX (µg/l)	LAB_CYLINDRO (µg/l)
.	.	.	.	0.00398	0.05	0.54	0.0588	.	0.0114	ND	0.125	0.1	0.1
.	.	.	.	.	.	.	.	.	.	.	10.55	0.5	0.5
0	1.431	4.92	.	.	.	.	.	.	.	.	0.18	0.5	0.5
0	1.555	4.22	.	8.1	0.02	0.59	0.079	0.006	0.013	.	.	.	.
0	0.83	2.6	.	.	.	.	.	.	.	.	0.64	0.1	0.1
0.13	1.159	3.61	.	4	0.04	0.57	0.11	0.005	0.017	.	.	.	.
0	0.875	3.2	.	6.5	0.005	0.64	0.021	0.007	0.013	.	0.3	0.1	0.1
0	0.903	2.9	.	.	.	.	.	.	.	.	.	.	.
1.96	1.685	5.77	.	.	.	.	.	.	.	.	1.3	0.1	0.1
0.26	0.737	2.71	0.6	3.5	0.01	0.525	0.29	0.0035	0.0165	.	0.66	0.1	0.1
0.23	0.763	2.97	2.1	.	.	.	.	.	.	.	.	.	.
10.15	10.078	21.67	.	.	.	.	.	.	.	.	8.1	0.1	0.1
0.75	1.815	6.36	1	.	.	.	.	.	.	.	.	.	.
0.7	1.317	4.85	1	9.6	0.04	0.6	0.03	0.006	0.016	.	.	.	.
0.64	1.56	5.98	.	8.7	0.11	0.79	0.058	0.004	0.019	.	1	0.1	0.1
0.37	0.97	3.8	.	.	.	.	.	.	.	.	.	.	.
0.13	0.976	3.57	1	2.4	0.04	0.55	0.039	0.004	0.011	.	0.64	0.1	0.1
0.15	0.878	3.31	2	.	.	.	.	.	.	.	.	.	.
.	.	.	.	0.00222	0.08	0.624	0.1443	.	0.0069	ND	0.125	0.1	0.1
0.04	0.61	2.3	.	.	.	.	.	.	.	.	1.3	0.1	0.1
0.02	0.34	1.3	.	.	.	.	.	.	.	.	.	.	.
0.03	0.45	1.7	.	.	.	.	.	.	.	.	.	.	.
0.27	1.33	5.2	.	.	.	.	.	.	.	.	.	.	.
0.5	1.65	6.3	.	.	.	.	.	.	.	.	5.1	0.1	0.1
.	.	.	.	.	.	.	.	.	.	.	1	0.5	0.5
.	.	.	7.5	2.6	0.005	0.58	0.005	0.005	0.016	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.
0	0.589	1.58	4.2	.	.	.	.	.	.	.	0.02	0.1	0.1
0	0.82	2.36	7.2	4.4	0.005	0.67	0.005	0.004	0.02	.	.	.	.
0	1.001	2.89	.	.	.	.	.	.	.	.	.	.	.
0	0.905	2.77	.	.	.	.	.	.	.	.	.	.	.
0.15	0.679	2.16	.	.	.	.	.	.	.	.	.	.	.
0	0.428	1	.	.	.	.	.	.	.	.	.	.	.
0	0.398	0.88	.	.	.	.	.	.	.	.	.	.	.
0	0.52	1.4	0.5	.	.	.	.	.	.	.	.	.	.
0	0.528	1.2	2.8	.	.	.	.	.	.	.	.	.	.
0	0.276	0.95	3.3	.	.	.	.	.	.	.	0.331	0.1	0.1
0	0.568	2.34	9.1	5	0.007	0.64	0.005	0.003	0.013	.	.	.	.
0	1.243	4.14	.	.	.	.	.	.	.	.	.	.	.
0	0.59	2.12	.	.	.	.	.	.	.	.	.	.	.
0	0.3	1.63	.	.	.	.	.	.	.	.	.	.	.
0	0.3	1.1	.	.	.	.	.	.	.	.	.	.	.
0	0.225	0.82	.	.	.	.	.	.	.	.	.	.	.
0.508	0.44	1.69	.	.	.	.	.	.	.	.	.	.	.
0	0.317	1.2	.	.	.	.	.	.	.	.	0.388	0.1	0.1
0.2	0.8	2.95	2.7	.	.	.	.	.	.	.	0.206	1	0.1
0.09	0.769	2.81	9.3	3.4	0.007	0.595	0.005	0.002	0.019	.	.	.	.
0.08	0.788	2.9	.	.	.	.	.	.	.	.	.	.	.

Appendix 1 continued.

Waterbody	County	TYPE	MONTH	DAY	TIME	LAT	LONG	SITE	SCUM	SITE_DEPTH (ft)	SAMP_DEPTH (ft)	TEMP (F)	DO (mg/l)	COND (µs/cm)	PH	PC RFU
LONG	IONIA	TARGET	8	14	1004	43.11287	-85.12682	DEEP	NO	54	20.29	69.96	7.54	293.3	7.53	0.611
LONG	IONIA	TARGET	8	14	1004	43.11287	-85.12682	DEEP	NO	54	28.41	57.45	7.42	295	7.42	0.291
LONG	IONIA	TARGET	8	14	1004	43.11287	-85.12682	DEEP	NO	54	39.2	52.55	1.4	285.5	7.5	0.144
LONG	IONIA	TARGET	8	14	1004	43.11287	-85.12682	DEEP	NO	54	50.93	51.78	1.1	284.3	7.53	0.175
LONG	IONIA	TARGET	8	14	930	43.10954	-85.12805	BEACH	NO	0.5	0	75.27	7.79	287.6	8.42	0.104
LONG	IONIA	TARGET	8	14	1019	43.1156	-85.1341	WEST	NO	2.3	0.1	74.5	7.04	301.3	8.16	0.189
LONG	IONIA	TARGET	8	14	1019	43.1156	-85.1341	WEST	NO	2.3	0.83	74.41	7.14	302	8.14	0.212
LONG	IONIA	TARGET	8	14	1024	43.11314	-85.10948	EAST	NO	2.7	0.97	75.2	8.11	290.7	8.44	0.195
LONG	IONIA	TARGET	8	28	905	43.10955	-85.12802	BOAT LAUNCH	NO	.	0	69.75	7.7	257.8	8	0.47
LONG	IONIA	TARGET	8	28	908	43.112	-85.12664	DEEP	NO	55	0.51	72.305	7.99	263.8	8.31	0.183
LONG	IONIA	TARGET	8	28	908	43.112	-85.12664	DEEP	NO	55	9.52	72.231	8	264.3	8.23	0.162
LONG	IONIA	TARGET	8	28	908	43.112	-85.12664	DEEP	NO	55	24.84	65.048	0.96	297.1	7.38	1.395
LONG	IONIA	TARGET	8	28	915	43.1158	-85.13427	WEST	NO	.	0.13	70.594	7.66	264.9	8.09	0.491
LONG	IONIA	TARGET	8	28	920	43.11315	-85.1094	EAST	NO	.	0.05	70.928	9.84	260	8.42	0.409
LONG	IONIA	TARGET	8	28	905	43.10955	-85.12802	BOAT LAUNCH	YES	.	0	68.804	7.89	258.7	8.16	0.787
LONG	IONIA	TARGET	9	11	855	43.10954	-85.12805	BEACH	NO	.	0	62.9	8.32	305	7.94	0.29
LONG	IONIA	TARGET	9	11	936	43.11576	-85.13422	WEST	NO	.	0	65	8.24	263.7	8.12	0.23
LONG	IONIA	TARGET	9	11	915	43.11173	-85.1259	DEEP	NO	50	0	66.81	7.74	266.2	8.3	0.24
LONG	IONIA	TARGET	9	11	915	43.11173	-85.1259	DEEP	NO	50	5	66.77	7.69	266	8.3	0.24
LONG	IONIA	TARGET	9	11	915	43.11173	-85.1259	DEEP	NO	50	10	66.47	6.7	266.9	8.11	0.27
LONG	IONIA	TARGET	9	11	915	43.11173	-85.1259	DEEP	NO	50	20	65.63	6.47	263	8.11	0.27
LONG	IONIA	TARGET	9	11	915	43.11173	-85.1259	DEEP	NO	50	30	55.9	0.15	302.5	7.22	0.58
LONG	IONIA	TARGET	9	11	915	43.11173	-85.1259	DEEP	NO	50	40	52.47	0.42	298	7.24	0.24
LONG	IONIA	TARGET	9	11	948	43.11321	-85.10937	EAST	NO	.	0	63.72	9.46	256.4	8.37	0.128
LONG	IONIA	TARGET	9	11	.	43.10955	-85.12802	BOAT LAUNCH	YES	.	0	64.93	7.67	292.2	7.92	2.15
LONG	IONIA	TARGET	9	15	845	43.10963	-85.12749	BOAT LAUNCH	NO	3	0	68.14	8.78	270.1	8.51	0.089
LONG	IONIA	TARGET	9	15	827	43.11206	-85.12604	DEEP	NO	52	0	69.32	10.54	264.8	8.62	0.137
LONG	IONIA	TARGET	9	15	827	43.11206	-85.12604	DEEP	NO	52	10	67.18	9.98	258.8	8.54	0.242
LONG	IONIA	TARGET	9	15	827	43.11206	-85.12604	DEEP	NO	52	20	65.76	6.54	258.6	6.45	0.213
LONG	IONIA	TARGET	9	15	827	43.11206	-85.12604	DEEP	NO	52	30	57.42	0.46	297	7.4	0.522
LONG	IONIA	TARGET	9	15	827	43.11206	-85.12604	DEEP	NO	52	40	52.46	0.23	288.1	7.47	0.171
LONG	IONIA	TARGET	9	15	827	43.11206	-85.12604	DEEP	NO	52	50	51.75	0.17	334.8	7.3	0.441
LONG	IONIA	TARGET	9	15	846	43.10958	-85.12805	BEACH	NO	.	0	68.09	8.73	263.4	8.32	0.101
LONG	IONIA	TARGET	9	15	940	43.11581	-85.1342	WEST	NO	.	0	67.37	7.81	268	8.2	0.111
LONG	IONIA	TARGET	9	15	955	43.11309	-85.10931	EAST	NO	.	0	69.43	10.86	265.4	8.62	0.256
LONG	IONIA	TARGET	9	15	945	43.1139	-85.11993	MID LAKE	YES	.	.	69.67	11.3	262.2	8.68	0.109
LONG	IONIA	TARGET	9	25	740	43.10956	-85.12804	BOAT LAUNCH	NO	.	0	73.149	8.65	270.5	8.49	0.119
LONG	IONIA	TARGET	10	2	845	43.10956	-85.12805	BEACH	NO	.	0	64.413	8.26	230	8.43	0.241
LONG	IONIA	TARGET	10	2	910	43.11218	-85.12675	DEEP	NO	56	0	66.49	7.84	236.8	8.42	0.228
LONG	IONIA	TARGET	10	2	910	43.11218	-85.12675	DEEP	NO	56	10	66.5	7.73	237.1	8.39	0.202
LONG	IONIA	TARGET	10	2	910	43.11218	-85.12675	DEEP	NO	56	20	65.8	4.3	288.5	7.9	0.115
LONG	IONIA	TARGET	10	2	910	43.11218	-85.12675	DEEP	NO	56	30	57.6	4.2	275.8	7.48	0.244
LONG	IONIA	TARGET	10	2	910	43.11218	-85.12675	DEEP	NO	56	40	52.6	0.2	269.9	7.44	0.101
LONG	IONIA	TARGET	10	2	910	43.11218	-85.12675	DEEP	NO	56	50	52.1	0.15	269.8	7.45	0.128
LONG	IONIA	TARGET	10	2	.	43.11575	-85.13418	WEST	NO	.	0	64.01	8.22	230.4	8.43	0.285
LONG	IONIA	TARGET	10	2	.	43.1134	-85.1095	EAST	NO	.	0	62.84	8.93	228.2	8.51	0.134
Martiny Lake/Big Evans	Mecosta	S/T	8	22	.	43.72871	-85.23021	Deep	NO	.	.	.	.	.	.	.
Michigamme Falls	Iron	S/T	8	21	.	45.9726	-88.2017	Deep	NO	.	.	.	.	.	.	.
MONA	MUSKEGON	TARGET	7	6	.	43.18637	-86.23614	BOAT LAUNCH	NO	.	.	.	.	.	.	.

Appendix 1 continued.

PC CONC (µg/l)	CHLA RFU	CHLA CONC (µg/l)	SECCHI (FT)	LAB_CHL (µg/l)	NH3 (mg/l)	N (mg/l)	NO2/NO3 (mg/l)	ORTHO P (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB_TOT_MC (µg/l)	LAB_ANATOX (µg/l)	LAB_CYLINDRO (µg/l)
0.67	0.931	3.97	.	.	.	.	.	.	.	.	.	.	.
0.32	0.696	2.6	.	.	.	.	.	.	.	.	.	.	.
0.16	0.486	1.87	.	.	.	.	.	.	.	.	.	.	.
0.17	0.507	1.92	.	.	.	.	.	.	.	.	.	.	.
0.1	0.608	2.28	.	.	.	.	.	.	.	.	.	.	.
0.19	0.741	2.73	2.3	.	.	.	.	.	.	.	.	.	.
0.22	0.86	3.02	.	.	.	.	.	.	.	.	.	.	.
0.18	0.848	3.11	.	.	.	.	.	.	.	.	.	.	.
0.36	0.709	2.75	.	.	.	.	.	.	.	.	0.25	0.1	0.1
0.14	0.82	3.07	10.3	4.8	0.01	0.58	0.005	0.005	0.014	.	.	.	.
0.15	1.845	3.46	.	.	.	.	.	.	.	.	.	.	.
1.55	1.422	5.64	.	.	.	.	.	.	.	.	.	.	.
0.74	3.994	18.9	.	.	.	.	.	.	.	.	.	.	.
0.29	0.762	4.07	.	.	.	.	.	.	.	.	.	.	.
0.72	0.911	3.48	.	.	.	.	.	.	.	.	0.25	0.1	0.1
0.27	0.53	2	.	.	.	.	.	.	.	.	0.125	0.1	0.1
0.25	0.59	2.31	.	.	.	.	.	.	.	.	1.5	0.1	0.1
0.25	0.88	3.36	10.2	5.8	3	0.58	0.005	0.0025	0.016	.	.	.	.
0.25	0.88	3.49	.	.	.	.	.	.	.	.	.	.	.
0.28	1.08	4.09	.	.	.	.	.	.	.	.	.	.	.
0.28	1.05	4	.	.	.	.	.	.	.	.	.	.	.
0.63	1.18	4.57	.	.	.	.	.	.	.	.	.	.	.
0.23	0.49	1.95	.	.	.	.	.	.	.	.	.	.	.
0.12	0.44	1.75	.	.	.	.	.	.	.	.	.	.	.
2.35	0.81	3.25	.	.	.	.	.	.	.	.	8	0.1	0.1
0.08	0.629	2.16	3	.	.	.	.	.	.	.	0.125	0.1	0.1
0.14	0.728	2.73	12.7	.	0.005	0.58	0.005	.	0.013	.	.	.	.
0.21	1.865	5.35	.	.	.	.	.	.	.	.	.	.	.
0.2	1.143	3.67	.	.	.	.	.	.	.	.	.	.	.
0.46	1.391	5.29	.	.	.	.	.	.	.	.	.	.	.
0.16	0.665	2.44	.	.	.	.	.	.	.	.	.	.	.
0.4	0.813	3.02	.	.	.	.	.	.	.	.	.	.	.
0.1	0.495	1.86	.	.	.	.	.	.	.	.	.	.	.
0.1	0.751	2.82	.	.	.	.	.	.	.	.	.	.	.
0.18	0.717	3.6	.	.	.	.	.	.	.	.	.	.	.
0.09	0.891	3.32	.	.	.	.	.	.	.	.	6.2	0.1	0.1
0.1	0.6	2.18	.	.	.	.	.	.	.	.	0.125	0.1	0.1
0.3	0.747	3.16	.	.	.	.	.	.	.	.	0.125	0.1	0.1
0.27	0.885	3.23	11.4	2.6	0.01	0.58	0.005	0.004	0.017	.	.	.	.
0.23	0.977	3.53	.	.	.	.	.	.	.	.	.	.	.
0.14	0.556	2.16	.	.	.	.	.	.	.	.	.	.	.
0.28	0.755	2.78	.	.	.	.	.	.	.	.	.	.	.
0.13	0.472	1.75	.	.	.	.	.	.	.	.	.	.	.
0.16	0.538	1.92	.	.	.	.	.	.	.	.	.	.	.
0.29	0.711	2.69	.	.	.	.	.	.	.	.	.	.	.
0.17	0.561	2.05	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	0.0034	0.07	0.854	0.0007	.	0.0204	ND	0.125	0.1	0.1
.	.	.	.	0.0009	0.07	0.743	0.0332	.	0.0125	ND	0.125	0.1	0.1
.	.	.	.	.	.	.	.	.	.	.	25	0.5	0.5

Appendix 1 continued.

Waterbody	County	TYPE	MONTH	DAY	TIME	LAT	LONG	SITE	SCUM	SITE_DEPTH (ft)	SAMP_DEPTH (ft)	TEMP (F)	DO (mg/l)	COND (µs/cm)	PH	PC RFU
MONA	MUSKEGON	TARGET	7	6	1145	43.17829	-86.25986	DEEP	NO	24.8	0	.	.	.	.	.
MONA	MUSKEGON	TARGET	7	6	1154	43.17606	-86.24649	BEACH	NO	3.4	.	.	.	.	.	.
MONA	MUSKEGON	TARGET	7	6	1200	43.18468	-86.24605	LBC	NO	1.8	.	.	.	.	.	.
MONA	MUSKEGON	TARGET	7	6	1205	43.18252	-86.23156	EAST	NO	1.3	.	.	.	.	.	.
MONA	MUSKEGON	TARGET	7	10	845	43.18637	-86.23614	BOAT LAUNCH	NO	1	0	75.16	8.34	.	8.6	0.585
MONA	MUSKEGON	TARGET	7	10	915	43.18386	-86.22546	HIDDEN COVE	NO	1	0	76.01	8.62	.	8.63	0.582
MONA	MUSKEGON	TARGET	7	10	945	43.17713	-86.25462	BOAT CLUB	NO	1	0	75.01	8.29	.	8.5	0.392
MONA	MUSKEGON	TARGET	7	10	955	43.17559	-86.24731	BEACH	NO	1	0	75.119	9	.	8.64	0.591
MONA	MUSKEGON	TARGET	7	17	1136	43.18638	-86.23623	BOAT LAUNCH	NO	.	0	78.47	12.74	467.8	8.9	1.111
MONA	MUSKEGON	TARGET	7	17	1155	43.17852	-86.25877	DEEP	NO	24.5	0	77.3	11.69	464.5	8.84	0.81
MONA	MUSKEGON	TARGET	7	17	1155	43.17852	-86.25877	DEEP	NO	24.5	5	76.7	11.08	462.9	8.75	1.084
MONA	MUSKEGON	TARGET	7	17	1155	43.17852	-86.25877	DEEP	NO	24.5	10	76.6	11.01	462.9	8.73	1.091
MONA	MUSKEGON	TARGET	7	17	1155	43.17852	-86.25877	DEEP	NO	24.5	15	73.2	3.4	429.1	7.68	0.234
MONA	MUSKEGON	TARGET	7	17	1155	43.17852	-86.25877	DEEP	NO	24.5	20	70.3	3.5	428.9	7.43	0.059
MONA	MUSKEGON	TARGET	7	17	1215	43.17559	-86.24731	BEACH	NO	2.4	0	78.19	12.02	464.9	8.89	0.745
MONA	MUSKEGON	TARGET	7	17	1225	43.18266	-86.23201	EAST	NO	8.1	0	79.05	12.82	468.1	8.96	1.062
MONA	MUSKEGON	TARGET	7	31	1519	43.18256	-86.23192	EAST	NO	8.6	0	79.29	11.23	429	8.67	0
MONA	MUSKEGON	TARGET	7	31	1450	43.17873	-86.25871	DEEP	NO	25	0	77.89	8.98	423	8.47	0
MONA	MUSKEGON	TARGET	7	31	1450	43.17873	-86.25871	DEEP	NO	25	5	77.6	8.98	421.6	8.47	0
MONA	MUSKEGON	TARGET	7	31	1450	43.17873	-86.25871	DEEP	NO	25	10	77.98	7.2	417.2	8.22	0
MONA	MUSKEGON	TARGET	7	31	1450	43.17873	-86.25871	DEEP	NO	25	15	75.41	0.28	415.1	7.54	0
MONA	MUSKEGON	TARGET	7	31	1450	43.17873	-86.25871	DEEP	NO	25	20	70.22	0.11	405.9	7.21	0
MONA	MUSKEGON	TARGET	7	31	1450	43.17873	-86.25871	DEEP	NO	25	24	69.65	0.07	405.3	7.2	0
MONA	MUSKEGON	TARGET	7	31	1440	43.18636	-86.23619	BOAT LAUNCH	NO	3.6	0	79.6	10.37	433.3	8.61	0
MONA	MUSKEGON	TARGET	7	31	1508	43.1762	-86.24547	BEACH	NO	1.7	0	80.19	10.05	435.7	8.59	0
MONA	MUSKEGON	TARGET	8	14	1432	43.1826	-86.232	EAST	NO	.	0.27	78.97	12.8	500	8.86	1.972
MONA	MUSKEGON	TARGET	8	14	1356	43.17916	-86.25816	DEEP	NO	25	0.44	75.96	9.14	491.1	8.49	0.911
MONA	MUSKEGON	TARGET	8	14	1356	43.17916	-86.25816	DEEP	NO	25	8.32	74.46	7.31	485.1	8.18	0.856
MONA	MUSKEGON	TARGET	8	14	1356	43.17916	-86.25816	DEEP	NO	25	13.95	74.24	7.13	484.5	8.15	0.72
MONA	MUSKEGON	TARGET	8	14	1356	43.17916	-86.25816	DEEP	NO	25	21.51	71.42	7.24	464.9	7.24	0.118
MONA	MUSKEGON	TARGET	8	14	1356	43.17916	-86.25816	DEEP	NO	25	24.99	70.86	0.23	463.1	6.87	0.933
MONA	MUSKEGON	TARGET	8	14	1419	43.17617	-86.24579	BEACH	NO	3.6	0.36	78.43	9.9	503	8.54	0.861
MONA	MUSKEGON	TARGET	8	14	1340	43.18644	-86.23612	BOAT LAUNCH	YES	3.8	0.26	77.27	11.5	493.2	8.75	2.058
MONA	MUSKEGON	TARGET	8	14	1432	43.1826	-86.232	EAST	YES	.	0.43	80.52	12.85	505	8.85	13.319
MONA	MUSKEGON	TARGET	8	28	1330	43.18264	-86.23202	EAST	NO	5.8	1.3	72.413	9.82	448	8.43	1.923
MONA	MUSKEGON	TARGET	8	28	1259	43.17888	-86.2589	DEEP	NO	27	0.66	71.884	7.79	449.7	8.15	1.519
MONA	MUSKEGON	TARGET	8	28	1259	43.17888	-86.2589	DEEP	NO	27	7.24	71.424	7.09	448.9	8.03	1.583
MONA	MUSKEGON	TARGET	8	28	1259	43.17888	-86.2589	DEEP	NO	27	14.26	71.541	6.83	448.4	7.98	1.478
MONA	MUSKEGON	TARGET	8	28	1259	43.17888	-86.2589	DEEP	NO	27	20.11	71.384	6.69	448	7.91	1.069
MONA	MUSKEGON	TARGET	8	28	1259	43.17888	-86.2589	DEEP	NO	27	22.98	71.219	4.17	445.7	7.57	0.669
MONA	MUSKEGON	TARGET	8	28	1259	43.17888	-86.2589	DEEP	NO	27	25.34	71.181	1.86	443.4	7.36	0.565
MONA	MUSKEGON	TARGET	8	28	1315	43.17596	-86.2466	BEACH	NO	3.8	0.29	72.449	10.11	450.4	8.42	1.683
MONA	MUSKEGON	TARGET	8	28	1256	43.18645	-86.23619	BOAT LAUNCH	YES	2.6	1.53	72.138	10.83	445	8.66	2.478
MONA	MUSKEGON	TARGET	8	28	1256	43.1866	-86.23713	FISHING PIER	YES	.	0.55	74.159	15.67	442.2	9.12	57.303
MONA	MUSKEGON	TARGET	9	11	1336	43.17564	-86.24712	BEACH	NO	.	0	70.93	10.58	465.2	8.42	1.59
MONA	MUSKEGON	TARGET	9	11	1316	43.17883	-86.25873	DEEP	YES	26	0	69.29	9.53	460.4	8.37	2.68
MONA	MUSKEGON	TARGET	9	11	1302	43.18656	-86.23615	BOAT LAUNCH	YES	.	0	69.58	9.16	473.4	8.16	20.07
MONA	MUSKEGON	TARGET	9	11	1336	43.17564	-86.24712	BEACH	YES	.	0	72.09	10.54	475.7	8.4	6.7
MONA	MUSKEGON	TARGET	9	11	1347	43.18272	-86.23184	EAST	YES	.	0	68.17	9.25	456.2	8.33	2.74

Appendix 1 continued.

PC CONC (µg/l)	CHLA RFU	CHLA CONC (µg/l)	SECCHI (FT)	LAB_CHL (µg/l)	NH3 (mg/l)	N (mg/l)	NO2/NO3 (mg/l)	ORTHO P (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB_TOT_MC (µg/l)	LAB_ANATOX (µg/l)	LAB_CYLINDRO (µg/l)
.	.	.	7.2	13	0.02	0.63	0.14	0.005	0.027	.	.	.	.
.	.	.	3.4	.	.	.	.	.	.	.	.	.	.
.	.	.	1.8	.	.	.	.	.	.	.	.	.	.
.	.	.	1.3	.	.	.	.	.	.	.	.	.	.
0.28	2.772	11.07	1	.	.	.	.	.	.	.	17	0.5	0.5
0.28	3.021	9.98	.	.	.	.	.	.	.	.	.	.	.
0.06	2.56	8.77	3	.	.	.	.	.	.	.	.	.	.
0.29	3.01	9.99	1	.	.	.	.	.	.	.	.	.	.
0.9	6.303	23.92	.	.	.	.	.	.	.	.	0.5	0.1	0.1
0.46	3.902	14.3	3.3	24	0.007	0.82	0.005	0.007	0.037	.	.	.	.
0.85	6.505	23.9	.	.	.	.	.	.	.	.	.	.	.
0.88	6.906	24.23	.	.	.	.	.	.	.	.	.	.	.
0	1.662	5.85	.	.	.	.	.	.	.	.	.	.	.
0	1.006	3.29	.	.	.	.	.	.	.	.	.	.	.
0.44	3.559	13.05	2.4	.	.	.	.	.	.	.	.	.	.
0.84	5.949	22.17	3.3	.	.	.	.	.	.	.	.	.	.
0	3.394	12.83	3.8	.	.	.	.	.	.	.	0.19	0.1	0.1
0	2.351	9.01	4.3	16	0.008	0.69	0.004	0.005	0.034	.	.	.	.
0	3.007	11.34	.	.	.	.	.	.	.	.	.	.	.
0	2.54	9.44	.	.	.	.	.	.	.	.	.	.	.
0	1.484	5.5	.	.	.	.	.	.	.	.	.	.	.
0	0.715	2.65	.	.	.	.	.	.	.	.	.	.	.
0	0.711	2.63	.	.	.	.	.	.	.	.	.	.	.
0	3.759	13.89	3.6	.	.	.	.	.	.	.	.	.	.
0	2.413	9	1.7	.	.	.	.	.	.	.	.	.	.
2.27	4.447	19.28	.	.	.	.	.	.	.	.	3.78	0.1	0.1
1.02	3.167	11.63	3.6	18	0.0055	0.825	0.005	0.006	0.0545	.	.	.	.
0.92	1.503	5.8	.	.	.	.	.	.	.	.	.	.	.
0.8	1.582	5.85	.	.	.	.	.	.	.	.	.	.	.
0.11	0.832	3.03	.	.	.	.	.	.	.	.	.	.	.
0.42	0.213	0.67	.	.	.	.	.	.	.	.	.	.	.
0.91	1.956	7.56	3.6	.	.	.	.	.	.	.	.	.	.
2.28	3.344	12.59	1.9	.	.	.	.	.	.	.	1.341	0.1	0.1
20.13	3.075	9.25	.	.	.	.	.	.	.	.	326.5	0.1	0.1
1.89	10.014	36.79	2.5	.	.	.	.	.	.	.	1.3	0.1	0.1
1.45	4.242	13.19	3.4	19	0.02	1	0.005	0.015	0.075	.	.	.	.
1.55	3.279	12.45	.	.	.	.	.	.	.	.	.	.	.
1.37	3.703	9.29	.	.	.	.	.	.	.	.	.	.	.
1.05	1.897	6.03	.	.	.	.	.	.	.	.	.	.	.
0.62	1.342	5.15	.	.	.	.	.	.	.	.	.	.	.
0.53	1.255	4.54	.	.	.	.	.	.	.	.	.	.	.
1.62	4.226	13.91	2.8	.	.	.	.	.	.	.	.	.	.
2.33	10.546	36.92	2.6	.	.	.	.	.	.	.	2.7	0.1	0.1
51.53	12.223	45.87	.	.	.	.	.	.	.	.	150	0.1	0.1
1.81	3.83	14.84	.	.	.	.	.	.	.	.	1.15	0.39	0.1
2.97	10.27	40.23	2	66	0.003	0.96	0.005	0.006	0.063	.	4.25	0.26	0.1
23.7	4.22	16.5	.	.	.	.	.	.	.	.	395	0.27	0.1
7.5	2.87	11.07	.	.	.	.	.	.	.	.	54.5	0.27	0.1
3.04	3.51	13.42	.	.	.	.	.	.	.	.	92	0.52	0.1

Appendix 1 continued.

Waterbody	County	TYPE	MONTH	DAY	TIME	LAT	LONG	SITE	SCUM	SITE_DEPTH (ft)	SAMP_DEPTH (ft)	TEMP (F)	DO (mg/l)	COND (µs/cm)	PH	PC RFU
MONA	MUSKEGON	TARGET	9	11	1316	43.17883	-86.25873	DEEP	YES	26	5	67.82	7.77	457.4	8.16	2.18
MONA	MUSKEGON	TARGET	9	11	1316	43.17883	-86.25873	DEEP	YES	26	10	67.43	5.81	459.1	7.83	0.44
MONA	MUSKEGON	TARGET	9	11	1316	43.17883	-86.25873	DEEP	YES	26	15	67.26	4.71	459.5	7.26	0.57
MONA	MUSKEGON	TARGET	9	11	1316	43.17883	-86.25873	DEEP	YES	26	20	66.81	4.25	480.1	7.56	0.55
MONA	MUSKEGON	TARGET	9	11	1316	43.17883	-86.25873	DEEP	YES	26	25	66.78	3.04	471.1	7.05	1.025
MONA	MUSKEGON	TARGET	9	15	1225	43.17596	-86.24624	BEACH	NO	.	.	71	13.34	450.7	8.74	1.592
MONA	MUSKEGON	TARGET	9	15	1210	43.17914	-86.25828	DEEP	NO	25.4	0	70.81	12.84	451	8.69	1.653
MONA	MUSKEGON	TARGET	9	15	1230	43.18263	-86.23201	EAST	NO	.	.	71.46	13.83	453.1	8.79	2.517
MONA	MUSKEGON	TARGET	9	15	1210	43.17914	-86.25828	DEEP	NO	25.4	5	69.21	11.54	444.4	8.62	2.139
MONA	MUSKEGON	TARGET	9	15	1210	43.17914	-86.25828	DEEP	NO	25.4	10	68.82	11.34	440.9	8.61	1.717
MONA	MUSKEGON	TARGET	9	15	1210	43.17914	-86.25828	DEEP	NO	25.4	15	67.13	4.39	444.1	7.6	0.272
MONA	MUSKEGON	TARGET	9	15	1210	43.17914	-86.25828	DEEP	NO	25.4	20	66.31	1.45	450.1	7.39	0.195
MONA	MUSKEGON	TARGET	9	15	1210	43.17914	-86.25828	DEEP	NO	25.4	24	66.24	0.79	451.8	7.34	0.254
MONA	MUSKEGON	TARGET	9	15	1200	43.18657	-86.23608	BOAT LAUNCH	YES	.	.	75.06	17.08	456.1	9.21	89.994
MONA	MUSKEGON	TARGET	9	25	1230	43.17898	-86.25836	DEEP	YES	30	0	76.997	12.13	473.9	8.66	1.629
MONA	MUSKEGON	TARGET	9	25	1240	43.17604	-86.24648	BEACH	YES	3.9	0	77.505	13.02	476.9	8.72	1.967
MONA	MUSKEGON	TARGET	9	25	1300	43.18267	-86.23194	EAST	YES	8	0	80.759	16.31	464.4	8.9	3.895
MONA	MUSKEGON	TARGET	9	25	1200	43.18645	-86.23622	BOAT LAUNCH	YES	4.1	0	78.105	18.15	464.4	8.8	5.901
MONA	MUSKEGON	TARGET	9	25	1230	43.17898	-86.25836	DEEP	YES	30	5	75.109	10.68	468	8.55	1.992
MONA	MUSKEGON	TARGET	9	25	1230	43.17898	-86.25836	DEEP	YES	30	10	69.906	1.96	462.5	7.73	0.965
MONA	MUSKEGON	TARGET	9	25	1230	43.17898	-86.25836	DEEP	YES	30	15	67.865	0.18	446.9	7.28	0.181
MONA	MUSKEGON	TARGET	9	25	1230	43.17898	-86.25836	DEEP	YES	30	20	66.99	0.18	449.2	7.22	0.081
MONA	MUSKEGON	TARGET	9	25	1230	43.17898	-86.25836	DEEP	YES	30	24	66.701	0.2	452.5	7.22	0.08
MONA	MUSKEGON	TARGET	10	2	.	43.17605	-86.24648	BEACH	NO	.	0	67.28	7.12	294.99	8.19	2.389
MONA	MUSKEGON	TARGET	10	2	.	43.17916	-86.25889	DEEP	NO	25	0	67.39	6.24	409.2	7.99	1.889
MONA	MUSKEGON	TARGET	10	2	.	43.17916	-86.25889	DEEP	NO	25	5	66.94	5.37	407.8	7.86	2.058
MONA	MUSKEGON	TARGET	10	2	.	43.17916	-86.25889	DEEP	NO	25	10	66.92	5.29	407.7	7.85	2.002
MONA	MUSKEGON	TARGET	10	2	.	43.17916	-86.25889	DEEP	NO	25	15	66.91	5.31	407.7	7.85	2.021
MONA	MUSKEGON	TARGET	10	2	.	43.17916	-86.25889	DEEP	NO	25	24	66.25	0.88	397.7	7.48	0.785
MONA	MUSKEGON	TARGET	10	2	1135	43.18639	-86.23621	BOAT LAUNCH	NO	.	0	67.32	6.42	407.1	8.05	2.288
MONA	MUSKEGON	TARGET	10	2	.	43.18265	-86.23194	EAST	NO	.	0	66.9	8.61	397.4	8.42	3.2
Mullett Lake	Cheboygan	S/T	8	22	.	45.48445	-84.56028	Deep	NO	.	.	.	.	.	.	.
NEVA	Oakland	RESPONSE	8	16	1051	42.6368	-83.51743	.	NO	.	0	76.95	5.47	600	7.37	0.088
PONTIAC	Oakland	TARGET	7	19	1307	42.66991	-83.46951	LIGHTHOUSE BAY	NO	3.8	0	81.4	9.3	432.1	8.34	0.27
PONTIAC	Oakland	TARGET	7	19	1339	42.66325	-83.44229	BOAT LAUNCH	NO	2.5	0	83.19	10.94	431.8	8.25	0.231
PONTIAC	Oakland	TARGET	7	19	.	42.66801	-83.44725	BEACH	NO	0.5	0	84.18	9.65	466.9	8.5	0.24
PONTIAC	Oakland	TARGET	7	19	1150	42.666	-83.45137	DEEP	NO	29	0	80.015	9.36	446.3	8.38	0.166
PONTIAC	Oakland	TARGET	7	19	1150	42.666	-83.45137	DEEP	NO	29	5	79.14	9.37	442	8.36	0.233
PONTIAC	Oakland	TARGET	7	19	1150	42.666	-83.45137	DEEP	NO	29	10	76.3	4.96	438.7	7.95	0.681
PONTIAC	Oakland	TARGET	7	19	1150	42.666	-83.45137	DEEP	NO	29	15	75.19	3.36	435.7	7.82	0.459
PONTIAC	Oakland	TARGET	7	19	1150	42.666	-83.45137	DEEP	NO	29	20	63.03	0.19	391.1	7.59	0.251
PONTIAC	Oakland	TARGET	7	19	1150	42.666	-83.45137	DEEP	NO	29	25	56.46	0.1	366.3	7.42	0.32
PONTIAC	Oakland	TARGET	7	19	1218	42.66911	-83.45554	SKULL ISLAND	NO	8.3	0	80.18	9.49	447.8	8.43	0.21
PONTIAC	Oakland	TARGET	7	19	1250	42.66794	-83.46425	CANAL 1	NO	4.6	0	81.95	8.82	457	8.38	0.315
PONTIAC	Oakland	TARGET	7	19	1250	42.66882	-83.46626	CASTLE BAY	NO	5.2	0	79.47	6.75	449.9	8.04	0.733
PONTIAC	Oakland	TARGET	7	19	1322	42.66906	-83.47065	WEST BAY	NO	4.6	0	80.28	8.23	448.4	8.17	0.634
PONTIAC	Oakland	TARGET	7	27	1455	42.66819	-83.44733	BEACH	NO	0.5	0	80.21	9.75	449.3	8.52	0.58
PONTIAC	Oakland	TARGET	7	27	1440	42.66326	-83.44224	BOAT LAUNCH	NO	.	0	79.73	12.41	396.1	8.41	0.259
PONTIAC	Oakland	TARGET	7	27	1520	42.66991	-83.46951	LIGHTHOUSE BAY	YES	.	0	81.48	8.95	477	8.42	0.369

Appendix 1 continued.

PC CONC (µg/l)	CHLA RFU	CHLA CONC (µg/l)	SECCHI (FT)	LAB_CHL (µg/l)	NH3 (mg/l)	N (mg/l)	NO2/NO3 (mg/l)	ORTHO P (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB_TOT_MC (µg/l)	LAB_ANATOX (µg/l)	LAB_CYLINDRO (µg/l)
2.44	2.11	8.1	.	.	.	.	.	.	.	.	.	.	.
1.05	1.51	5.73	.	.	.	.	.	.	.	.	.	.	.
0.61	1.21	4.97	.	.	.	.	.	.	.	.	.	.	.
0.59	1.21	4.52	.	.	.	.	.	.	.	.	.	.	.
2.31	4.7	22.2	.	.	.	.	.	.	.	.	.	.	.
1.42	2.669	9.63	.	.	.	.	.	.	.	.	6.3	0.45	0.1
1.53	2.489	9.54	2.71	.	0.003	1.3	0.005	.	0.075	.	2.2	0.51	0.1
2.2	7.369	27.44	.	.	.	.	.	.	.	.	14	0.69	0.1
1.98	2.119	8.8	.	.	.	.	.	.	.	.	.	.	.
1.59	2.717	9.29	.	.	.	.	.	.	.	.	.	.	.
0.25	1.393	5.1	.	.	.	.	.	.	.	.	.	.	.
0.17	1.185	4.45	.	.	.	.	.	.	.	.	.	.	.
0.22	1.431	5.1	.	.	.	.	.	.	.	.	.	.	.
92.08	16.448	56.04	.	.	.	.	.	.	.	.	430	0.81	0.1
1.52	2.95	10.81	1.9	30	0.005	0.96	0.005	0.008	0.055	.	1.7	1.7	0.1
1.84	4.522	15.15	2.2	.	.	.	.	.	.	.	1.5	2.8	0.1
3.82	16.896	50.287	1.4	.	.	.	.	.	.	.	9.2	4	0.1
5.53	9.481	39.15	1.6	.	.	.	.	.	.	.	430	4.4	0.1
1.85	2.281	8.21	.	.	.	.	.	.	.	.	.	.	.
0.99	1.258	4.36	.	.	.	.	.	.	.	.	.	.	.
0.17	1.111	4.07	.	.	.	.	.	.	.	.	.	.	.
0.1	0.937	3.38	.	.	.	.	.	.	.	.	.	.	.
0.89	0.902	3.32	.	.	.	.	.	.	.	.	.	.	.
2.6	3.06	11.47	.	.	.	.	.	.	.	.	3.3	0.78	0.1
2.13	2.779	2.91	2.4	22	0.01	1	0.005	0.018	0.1	.	.	.	.
2.27	2.148	8.01	.	.	.	.	.	.	.	.	.	.	.
2.25	2.46	9.37	.	.	.	.	.	.	.	.	.	.	.
2.26	2.684	9.15	.	.	.	.	.	.	.	.	.	.	.
0.89	1.099	4.18	.	.	.	.	.	.	.	.	.	.	.
2.57	2.66	2.73	.	.	.	.	.	.	.	.	.	.	.
3.3	4.5	18.38	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	0.00131	0.06	0.605	0.0007	.	0.0064	ND	0.125	0.1	0.1
0.08	1.104	3.86	.	.	.	.	.	.	.	.	.	.	.
0	1.353	4.5	3.2	.	.	.	.	.	.	.	7.4	0.1	0.1
0	0.481	1.23	2.5	.	.	.	.	.	.	.	1.8	0.1	0.1
0	0.6	1.63	.	.	.	.	.	.	.	.	1.7	0.1	0.1
0	0.742	2.07	5.9	3.8	.	.	.	.	.	.	.	.	.
0	1.044	3.42	.	.	.	.	.	.	.	.	.	.	.
0.45	1.179	3.07	.	.	.	.	.	.	.	.	.	.	.
0.1	0.926	2.79	.	.	.	.	.	.	.	.	.	.	.
0	0.764	2.12	.	.	.	.	.	.	.	.	.	.	.
0	0.765	2.23	.	.	.	.	.	.	.	.	.	.	.
0	0.818	2.51	4.5	.	.	.	.	.	.	.	.	.	.
0	1.892	6.9	2.5	.	.	.	.	.	.	.	.	.	.
0.49	3.229	12.35	2.3	.	.	.	.	.	.	.	.	.	.
0.36	4.372	20.96	2.7	.	.	.	.	.	.	.	.	.	.
0.69	1.395	5.44	.	.	.	.	.	.	.	.	0.924	0.1	0.1
0.35	1.104	4.38	.	.	0.005	0.79	0.005	0.005	0.026	.	.	.	.
0.49	1.834	9.7	.	.	.	.	.	.	.	.	7.73	0.1	0.1

Appendix 1 continued.

Waterbody	County	TYPE	MONTH	DAY	TIME	LAT	LONG	SITE	SCUM	SITE_DEPTH (ft)	SAMP_DEPTH (ft)	TEMP (F)	DO (mg/l)	COND (µs/cm)	PH	PC RFU
PONTIAC	Oakland	TARGET	8	4	1520	42.66991	-83.46951	LIGHTHOUSE BAY	NO	.	0	77.16	6.62	440.5	7.47	0.451
PONTIAC	Oakland	TARGET	8	16	1430	42.66604	-83.45237	DEEP	NO	32	0	77.89	7.84	410.9	7.96	0.245
PONTIAC	Oakland	TARGET	8	16	1415	42.66327	-83.44236	BOAT LAUNCH	NO	.	0	79.2	6.03	419.5	7.43	0.07
PONTIAC	Oakland	TARGET	8	16	1445	42.66913	-83.45566	SKULL ISLAND	NO	.	0	78.32	8.11	411.8	8.1	0.183
PONTIAC	Oakland	TARGET	8	16	1456	42.6701	-83.46915	LIGHTHOUSE BAY	NO	.	0	80.48	8.34	430.7	7.93	0.182
PONTIAC	Oakland	TARGET	8	16	.	42.66808	-83.44733	BEACH	NO	.	0	81.49	8.59	428.9	7.95	0.357
PONTIAC	Oakland	TARGET	8	16	1430	42.66604	-83.45237	DEEP	NO	32	4.96	77.52	7.97	407.9	8.07	0.386
PONTIAC	Oakland	TARGET	8	16	1430	42.66604	-83.45237	DEEP	NO	32	9.98	75.98	6.89	404.3	8.02	0.612
PONTIAC	Oakland	TARGET	8	16	1430	42.66604	-83.45237	DEEP	NO	32	15.14	74.19	3	398.6	7.52	0.545
PONTIAC	Oakland	TARGET	8	16	1430	42.66604	-83.45237	DEEP	NO	32	19.75	69.98	0.17	387.6	7.34	0.461
PONTIAC	Oakland	TARGET	8	16	1430	42.66604	-83.45237	DEEP	NO	32	29.63	55.27	0.04	369.1	7	0.371
PONTIAC	Oakland	TARGET	9	13	1315	42.66625	-83.45038	DEEP	NO	13	0	68.018	10.03	425	8.29	0.45
PONTIAC	Oakland	TARGET	9	13	1315	42.66625	-83.45038	DEEP	NO	13	3	66.596	9.89	425	8.29	0.66
PONTIAC	Oakland	TARGET	9	13	1315	42.66625	-83.45038	DEEP	NO	13	6	65.804	8.38	426	8.15	0.906
PONTIAC	Oakland	TARGET	9	13	1315	42.66625	-83.45038	DEEP	NO	13	9	65.246	7.51	427	7.92	1.012
PONTIAC	Oakland	TARGET	9	13	1315	42.66625	-83.45038	DEEP	NO	13	11.3	65.03	2.65	459	7.48	1.631
PONTIAC	Oakland	TARGET	9	13	1255	42.66329	-83.44231	BOAT LAUNCH	NO	3	0	66.902	10.66	422	8.18	0.94
PONTIAC	Oakland	TARGET	9	13	1340	42.66908	-83.44834	BEACH	NO	2.1	0	69.692	9.9	426	8.29	0.355
PONTIAC	Oakland	TARGET	9	13	1348	42.66913	-83.45566	SKULL ISLAND	NO	7	0	68.882	9.86	425	8.28	0.38
PONTIAC	Oakland	TARGET	9	13	1400	42.66494	-83.46124	KINGSTON BAY	YES	4.6	1.9	69.386	8.82	419	8.47	3.101
PONTIAC	Oakland	TARGET	9	13	1415	42.66875	-83.46624	CASTLE BAY	YES	4.5	0	70.376	9.82	438	8.32	0.435
PONTIAC	Oakland	TARGET	9	13	1430	42.66993	-83.46947	LIGHTHOUSE BAY	YES	3.1	0	68.558	9.64	435	8.23	0.558
PONTIAC	Oakland	TARGET	9	21	.	42.66329	-83.44231	BOAT LAUNCH	NO	.	0	71.64	7.92	737.5	8.23	0.928
PONTIAC	Oakland	TARGET	9	21	.	42.66494	-83.46124	KINGSTON BAY	NO	.	0	72.11	8.54	737.7	8.26	0.758
PONTIAC	Oakland	TARGET	9	21	.	42.66875	-83.46624	CASTLE BAY	NO	.	0	72.13	8.25	737.5	8.24	0.727
PONTIAC	Oakland	TARGET	9	21	.	42.66625	-83.45038	DEEP	NO	.	0	71.64	8.84	737.7	8.37	0.56
PONTIAC	Oakland	TARGET	9	21	.	42.66908	-83.44834	BEACH	NO	.	0	73.15	8.85	737.6	8.17	0.512
PONTIAC	Oakland	TARGET	9	21	.	42.66913	-83.45566	SKULL ISLAND	NO	.	0	72.39	9.18	737.7	8.19	0.815
PONTIAC	Oakland	TARGET	9	21	.	42.66993	-83.46947	LIGHTHOUSE BAY	NO	.	0	72.93	8.14	737.5	8.09	0.415
PONTIAC	Oakland	TARGET	9	21	.	42.66494	-83.46124	KINGSTON BAY	YES	.	0	.	.	.	.	.
PONTIAC	Oakland	TARGET	9	21	.	42.66807	-83.46218	ISLAND	YES	.	0	73.74	9.03	737.8	8.25	0.57
PONTIAC	OAKLAND	TARGET	9	28	1100	42.66329	-83.44231	BOAT LAUNCH	NO	.	0	70.96	6.29	456.5	7.27	1.389
PONTIAC	OAKLAND	TARGET	9	28	.	42.66875	-83.46624	CASTLE BAY	NO	.	0	72.05	6.33	502	7.52	0.999
PONTIAC	OAKLAND	TARGET	9	28	.	42.66993	-83.46947	LIGHTHOUSE BAY	NO	.	0	70.22	5.96	567	7.06	0.722
PONTIAC	OAKLAND	TARGET	9	28	1120	42.66908	-83.44834	BEACH	NO	.	0	69.22	6.84	443	7.72	0.468
PONTIAC	OAKLAND	TARGET	9	28	1145	42.66494	-83.46124	KINGSTON BAY	NO	.	0	70.66	6.95	526	7.32	0.622
QUAIL RUN POND	WAYNE	RESPONSE	7	27	1100	42.3523	-83.51968	CENTER COVE	YES	0.5	0	79	5.14	431.6	7.78	1.971
QUAIL RUN POND	WAYNE	RESPONSE	7	27	1045	42.35294	-83.51952	NE	YES	0.5	0	78.85	4.48	432.6	7.78	0.033
QUAIL RUN POND	WAYNE	RESPONSE	7	27	1105	42.35184	-83.5204	SOUTH	YES	0.5	0	81.49	5.36	450.9	7.84	1.365
Round Lake	Iosco	S/T	8	17	.	44.33889	-83.65746	Deep	NO	.	.	.	.	.	.	.
Sharps	Jackson	S/T	8	14	.	42.20365	-84.3949	Deep	NO	.	.	.	.	.	.	.
Stevenson Lake	Isabella	S/T	8	15	.	43.7614	-84.83047	Deep	NO	.	.	.	.	.	.	.
SUGDEN	Oakland	RESPONSE	7	20	1100	42.61513	-83.49424	WOODSTONE	NO	2	0	79.9	8.89	760	8.39	0.245
SUGDEN	Oakland	RESPONSE	7	20	1100	42.61513	-83.49424	WOODSTONE	YES	1	0	79.83	7.9	756	8.35	4.063
SUGDEN	Oakland	RESPONSE	7	27	1200	42.61512	-83.4942	WOODSTONE	NO	2	0	79.98	8.88	778	8.49	0.167
SUGDEN	Oakland	RESPONSE	7	27	1240	42.61404	-83.49632	BOGIE LAKE RD	NO	1	0	79.89	9.87	775	8.4	0.621
SUGDEN	Oakland	RESPONSE	7	27	1220	42.61637	-83.49603	BOAT LAUNCH	NO	.	0	79.33	9.49	808	8.09	0.424
SUGDEN	Oakland	RESPONSE	7	27	1240	42.61404	-83.49632	BOGIE LAKE RD	YES	0.5	0	79.23	8.65	748	8.37	12.906
SUGDEN	Oakland	RESPONSE	8	4	1130	42.61405	-83.49628	BOGIE LAKE RD	NO	.	0	77.208	7.03	721	7.81	0.131

Appendix 1 continued.

PC CONC (µg/l)	CHLA RFU	CHLA CONC (µg/l)	SECCHI (FT)	LAB_CHL (µg/l)	NH3 (mg/l)	N (mg/l)	NO2/NO3 (mg/l)	ORTHO P (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB_TOT_MC (µg/l)	LAB_ANATOX (µg/l)	LAB_CYLINDRO (µg/l)
0.56	1.945	7.96	.	.	.	.	.	.	.	.	.	.	.
0.27	1.031	3.67	4.3	4.7	0.005	0.74	0.005	0.006	0.026	.	0.41	0.1	0.1
0.05	0.904	3.44	.	.	.	.	.	.	.	.	0.21	0.1	0.1
0.19	0.933	3.49	.	.	.	.	.	.	.	.	0.25	0.1	0.1
0.18	1.381	5.32	.	.	.	.	.	.	.	.	0.26	0.1	0.1
0.33	1.109	4.09	.	.	.	.	.	.	.	.	0.68	0.1	0.1
0.39	1.443	5.4	.	.	.	.	.	.	.	.	.	.	.
0.61	1.478	5.47	.	.	.	.	.	.	.	.	.	.	.
0.55	1.027	3.84	.	.	.	.	.	.	.	.	.	.	.
0.46	0.832	3.21	.	.	.	.	.	.	.	.	.	.	.
0.39	0.663	2.44	.	.	.	.	.	.	.	.	.	.	.
0.43	1.56	5.78	3.3	7.6	0.005	0.83	0.005	0.005	0.031	.	.	.	.
0.55	2.47	8.88	.	.	.	.	.	.	.	.	.	.	.
0.83	3.71	13.17	.	.	.	.	.	.	.	.	.	.	.
0.9	3.19	11.65	.	.	.	.	.	.	.	.	.	.	.
1.7	1.21	4.31	.	.	.	.	.	.	.	.	.	.	.
0.87	3.501	12.34	1.9	.	.	.	.	.	.	.	.	.	.
0.33	1.41	5.09	2.1	.	.	.	.	.	.	.	.	.	.
0.34	1.515	5.74	3.6	.	.	.	.	.	.	.	.	.	.
2.76	1.658	6.61	1.9	.	.	.	.	.	.	.	265	0.1	0.1
0.41	2.024	7.44	2.2	.	.	.	.	.	.	.	16	0.1	0.1
0.55	3.051	11.22	1.9	.	.	.	.	.	.	.	21	0.1	0.1
0.95	4.04	14.97	.	.	.	.	.	.	.	.	16	0.1	0.1
0.77	1.912	7.06	.	.	.	.	.	.	.	.	3.5	0.1	0.1
0.74	2.45	9.09	.	.	.	.	.	.	.	.	12	0.1	0.1
0.58	1.69	6.26	3.2	12	0.005	0.82	0.005	0.004	0.029	.	.	.	.
0.52	1.357	5	.	.	.	.	.	.	.	.	.	.	.
0.83	2.18	8.05	.	.	.	.	.	.	.	.	.	.	.
0.42	3.29	12.2	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	78	0.1	0.1
6.58	1.243	4.58	.	.	.	.	.	.	.	.	.	.	.
1.6	3.945	15.17	.	.	.	.	.	.	.	.	2	0.1	0.1
1.14	2.317	7.48	.	.	.	.	.	.	.	.	.	.	.
0.82	2.174	11.21	.	.	.	.	.	.	.	.	.	.	.
0.54	0.722	2.72	.	.	.	.	.	.	.	.	.	.	.
0.68	1.185	3.62	.	.	.	.	.	.	.	.	.	.	.
2.16	14.23	52.25	.	.	.	.	.	.	.	.	0.135	0.1	0.1
0.15	1.229	4.81	.	.	0.39	1.6	0.062	0.17	0.25	.	.	.	.
1.49	3.64	13.21	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	0.00235	0.06	0.865	0.0007	.	0.0144	ND	0.125	0.1	0.1
.	.	.	.	0.01046	0.06	0.71633	0.0007	.	0.0091	ND	0.125	0.1	0.1
.	.	.	.	0.00968	0.13	1.43	0.0007	.	0.0243	ND	0.125	0.1	0.1
0	0.574	1.73	2	19	.	.	.	.	.	.	3.5	0.1	0.1
3.79	8.76	18.46	.	.	.	.	.	.	.	.	6.9	0.1	0.1
0.26	1.001	3.71	.	.	0.01	0.65	0.005	0.003	0.01	.	2.44	0.1	0.1
0.74	1.254	5.03	.	.	.	.	.	.	.	.	4.96	0.1	0.1
0.48	4.742	7.75	.	.	.	.	.	.	.	.	.	.	.
8.74	4.4	17.12	.	.	.	.	.	.	.	.	1420	0.1	0.1
0.15	0.762	2.6	.	.	.	.	.	.	.	.	2.5	0.1	0.1

Appendix 1 continued.

Waterbody	County	TYPE	MONTH	DAY	TIME	LAT	LONG	SITE	SCUM	SITE_DEPTH (ft)	SAMP_DEPTH (ft)	TEMP (F)	DO (mg/l)	COND (µs/cm)	PH	PC RFU
SUGDEN	Oakland	RESPONSE	8	4	1040	42.61772	-83.4942	BAYVIEW	NO	.	0	76.187	7.44	693	7.95	0.168
SUGDEN	Oakland	RESPONSE	8	4	950	42.61512	-83.4942	WOODSTONE	NO	.	0	76.06	7.11	702	7.84	0.122
SUGDEN	Oakland	RESPONSE	8	4	1110	42.61642	-83.49608	BOAT LAUNCH	NO	.	0	78.01	8.43	710	8.08	0.107
SUGDEN	Oakland	RESPONSE	8	4	1040	42.61772	-83.4942	BAYVIEW	YES	.	0	74.75	7.45	708	7.81	1.96
SUGDEN	Oakland	RESPONSE	8	11	1310	42.61511	-83.49417	WOODSTONE	NO	.	0	77.837	7	778	8.27	0.069
SUGDEN	Oakland	RESPONSE	8	11	.	42.61772	-83.4942	BAYVIEW	NO	.	0	78.246	8.2	771	8.41	0.61
SUGDEN	Oakland	RESPONSE	8	11	.	42.61405	-83.49628	BOGIE LAKE RD	NO	.	0	78.586	8.01	777	8.36	0.104
SUGDEN	Oakland	RESPONSE	8	11	.	42.61772	-83.4942	BAYVIEW	YES	.	0	78.65	8.66	771	8.38	0.401
SUGDEN	Oakland	RESPONSE	8	16	1138	42.61713	-83.49747	DEEP	NO	47	0	77.67	8.18	706	8.02	0
SUGDEN	Oakland	RESPONSE	8	16	1234	42.61406	-83.49629	BOGIE LAKE RD	NO	.	0	79.61	9.59	722	8.28	0
SUGDEN	Oakland	RESPONSE	8	16	1243	42.61515	-83.49424	WOODSTONE	NO	.	0	79.35	8.27	752	8.02	0
SUGDEN	Oakland	RESPONSE	8	16	1250	42.61773	-83.4942	BAYVIEW	NO	.	0	80.483	11.11	738	8.3	0
SUGDEN	Oakland	RESPONSE	8	16	1138	42.61713	-83.49747	DEEP	NO	47	9.94	76.59	8.05	697	8.3	0
SUGDEN	Oakland	RESPONSE	8	16	1138	42.61713	-83.49747	DEEP	NO	47	20.05	64.49	7.31	629	7.76	0.192
SUGDEN	Oakland	RESPONSE	8	16	1138	42.61713	-83.49747	DEEP	NO	47	29.71	52.47	1.46	541	7.43	0.912
SUGDEN	Oakland	RESPONSE	8	16	1138	42.61713	-83.49747	DEEP	NO	47	39.79	48.36	0.8	526	7.28	0.945
SUGDEN	Oakland	RESPONSE	8	16	1224	42.6183	-83.50072	SUGDEN LAKE RD	YES	0.5	0	81.4	9.33	734	8.36	4.536
SUGDEN	Oakland	RESPONSE	8	25	950	42.61406	-83.49629	BOGIE LAKE RD	NO	.	0	71.1	9.36	726	8.45	0.137
SUGDEN	Oakland	RESPONSE	8	25	930	42.61692	-83.4978	DEEP	NO	41	0	73.18	8.67	746	8.39	0.071
SUGDEN	Oakland	RESPONSE	8	25	930	42.61692	-83.4978	DEEP	NO	41	4.97	73.21	8.66	746	8.39	0.091
SUGDEN	Oakland	RESPONSE	8	25	930	42.61692	-83.4978	DEEP	NO	41	9.99	73.18	8.62	746	8.38	0.102
SUGDEN	Oakland	RESPONSE	8	25	930	42.61692	-83.4978	DEEP	NO	41	19.98	52.94	2.15	605	7.53	0.601
SUGDEN	Oakland	RESPONSE	8	25	930	42.61692	-83.4978	DEEP	NO	41	30.07	50.17	0.23	586	7.5	2.564
SUGDEN	Oakland	RESPONSE	8	25	930	42.61692	-83.4978	DEEP	NO	41	39.52	48.51	0.15	589	7.37	0.757
SUGDEN	Oakland	RESPONSE	8	25	1005	42.61516	-83.49426	WOODSTONE	NO	.	0	71.87	8.07	739	8.32	0.113
SUGDEN	Oakland	RESPONSE	8	25	1020	42.61774	-83.49421	BAYVIEW	NO	.	0	71.78	8.22	734	8.33	0.074
SUGDEN	Oakland	RESPONSE	8	25	1030	42.6183	-83.50063	SUGDEN LAKE RD	NO	.	0	73.84	9.13	752	8.4	0.066
SUGDEN	Oakland	RESPONSE	8	25	950	42.61406	-83.49629	BOGIE LAKE RD	YES	.	0	69.43	9.37	706	8.49	6.83
SUGDEN	OAKLAND	RESPONSE	9	13	1035	42.61407	-83.49624	BOGIE LAKE RD	NO	1.5	0	67.5	8.84	730	8.11	0.085
SUGDEN	OAKLAND	RESPONSE	9	13	1000	42.61743	-83.49854	DEEP	NO	41	0	68.16	9.26	724	8.17	0.055
SUGDEN	OAKLAND	RESPONSE	9	13	1000	42.61743	-83.49854	DEEP	NO	41	5	68.09	9.25	724	8.18	0.072
SUGDEN	OAKLAND	RESPONSE	9	13	1000	42.61743	-83.49854	DEEP	NO	41	10	67.57	8.84	725	8.14	0.058
SUGDEN	OAKLAND	RESPONSE	9	13	1000	42.61743	-83.49854	DEEP	NO	41	20	66.69	8.45	726	8.06	0.068
SUGDEN	OAKLAND	RESPONSE	9	13	1000	42.61743	-83.49854	DEEP	NO	41	30	53.76	2.25	751	7.38	1.754
SUGDEN	OAKLAND	RESPONSE	9	13	1000	42.61743	-83.49854	DEEP	NO	41	40	48.7	0.21	798	7.23	0.905
SUGDEN	OAKLAND	RESPONSE	9	13	1045	42.61515	-83.49426	WOODSTONE	NO	1.1	0	67.59	9.14	731	8.14	0.058
SUGDEN	OAKLAND	RESPONSE	9	13	.	42.61771	-83.49426	BAYVIEW	NO	1	0	66.74	8.22	733	7.96	0.542
SUGDEN	OAKLAND	RESPONSE	9	13	1025	42.61827	-83.50069	SUGDEN LAKE RD	YES	1.6	0	68.27	9.24	725	8.18	0.028
SUGDEN	Oakland	RESPONSE	9	21	.	42.61827	-83.50069	SUGDEN LAKE RD	NO	.	0	72.43	8.01	738.4	8.04	0.239
SUGDEN	Oakland	RESPONSE	9	21	935	42.61743	-83.49854	DEEP	NO	42	0	71.9	9.13	738.4	8.32	0.41
SUGDEN	Oakland	RESPONSE	9	21	.	42.61407	-83.49624	BOGIE LAKE RD	NO	.	0	71.44	8.76	738.4	8.12	0.15
SUGDEN	Oakland	RESPONSE	9	21	.	42.61515	-83.49426	WOODSTONE	NO	.	0	71.313	8.52	.	8.02	0.017
SUGDEN	Oakland	RESPONSE	9	21	.	42.61771	-83.49426	BAYVIEW	NO	.	0	71.89	7.5	738.4	7.95	0
SUGDEN	Oakland	RESPONSE	9	21	.	42.61827	-83.50069	SUGDEN LAKE RD	YES	.	0	75.45	8.02	738.4	8.1	0.165
SUGDEN	OAKLAND	RESPONSE	9	28	1020	42.61827	-83.50069	SUGDEN LAKE RD	NO	.	0	72.07	7.01	885	7.25	0.074
SUGDEN	OAKLAND	RESPONSE	9	28	930	42.61513	-83.49419	WOODSTONE	NO	.	0	70.85	6.75	752	7.38	0.72
SUGDEN	OAKLAND	RESPONSE	9	28	955	42.61771	-83.49426	BAYVIEW	NO	.	0	69.09	7.19	938	7.09	0.077
SUGDEN	OAKLAND	RESPONSE	9	28	1005	42.61407	-83.49624	BOGIE LAKE RD	NO	.	0	70.18	6.91	738	7.67	0.144
Tee Lake	Ogemaw	S/T	8	14	.	44.20712	-84.35085	Deep	NO	.	.	.	.	.	.	.

Appendix 1 continued.

PC CONC (µg/l)	CHLA RFU	CHLA CONC (µg/l)	SECCHI (FT)	LAB_CHL (µg/l)	NH3 (mg/l)	N (mg/l)	NO2/NO3 (mg/l)	ORTHO P (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB_TOT_MC (µg/l)	LAB_ANATOX (µg/l)	LAB_CYLINDRO (µg/l)
0.1	0.733	2.74	.	.	.	.	.	.	.	.	0.29	0.1	0.1
0.15	0.76	2.71	.	.	.	.	.	.	.	.	.	.	.
0.12	0.504	1.73	.	.	.	.	.	.	.	.	.	.	.
2.04	2.019	8.31	.	.	.	.	.	.	.	.	101	0.1	0.1
0.06	0.305	1.21	.	.	.	.	.	.	.	.	0.48	0.1	0.1
0.69	1.913	7.81	.	.	.	.	.	.	.	.	0.51	0.1	0.1
0.11	0.323	1.14	.	.	.	.	.	.	.	.	0.13	0.1	0.1
0.42	2.239	5.1	.	.	.	.	.	.	.	.	11	0.1	0.1
0	0.078	0.28	8.9	1.6	0.003	0.57	0.002	0.005	0.008	.	0.14	0.1	0.1
0	0.366	1.28	.	.	.	.	.	.	.	.	0.3	0.1	0.1
0	0.251	1.04	.	.	.	.	.	.	.	.	0.092	0.1	0.1
0	0.47	1.84	.	.	.	.	.	.	.	.	0.28	0.1	0.1
0	0.25	0.99	.	.	.	.	.	.	.	.	.	.	.
0.19	0.514	1.77	.	.	.	.	.	.	.	.	.	.	.
0.91	0.841	3.05	.	.	.	.	.	.	.	.	.	.	.
0.95	0.606	2.25	.	.	.	.	.	.	.	.	.	.	.
4.41	1.05	4.24	.	.	.	.	.	.	.	.	61	1.2	0.1
0.14	0.456	1.71	.	.	.	.	.	.	.	.	0.25	0.1	0.1
0.05	0.339	1.22	11.5	1.5	0.02	0.53	0.005	0.006	0.005	.	.	.	.
0.1	0.392	1.47	.	.	.	.	.	.	.	.	.	.	.
0.1	0.407	1.59	.	.	.	.	.	.	.	.	.	.	.
0.6	1.047	4.11	.	.	.	.	.	.	.	.	.	.	.
2.96	1.275	4.8	.	.	.	.	.	.	.	.	.	.	.
0.85	0.753	2.73	.	.	.	.	.	.	.	.	.	.	.
0.11	0.324	1.23	.	.	.	.	.	.	.	.	.	.	.
0.07	0.279	1.09	.	.	.	.	.	.	.	.	.	.	.
0.07	0.368	1.4	.	.	.	.	.	.	.	.	.	.	.
6.71	4.31	13.78	.	.	.	.	.	.	.	.	3.2	0.1	0.1
0.07	0.439	1.58	1.5	.	.	.	.	.	.	.	8.6	0.1	0.1
0.04	0.365	1.44	15	1.9	0.009	0.53	0.005	0.003	0.006	.	.	.	.
0.06	0.445	1.49	.	.	.	.	.	.	.	.	.	.	.
0.05	0.536	1.87	.	.	.	.	.	.	.	.	.	.	.
0.07	0.577	2.01	.	.	.	.	.	.	.	.	.	.	.
1.63	2.601	9.33	.	.	.	.	.	.	.	.	.	.	.
0.84	0.887	3.32	.	.	.	.	.	.	.	.	.	.	.
0.04	0.371	1.59	1.1	.	.	.	.	.	.	.	.	.	.
0.105	0.08	1.99	1	.	.	.	.	.	.	.	.	.	.
0.05	0.527	1.92	1.6	.	.	.	.	.	.	.	20	0.1	0.1
0.24	0.391	1.36	.	.	.	.	.	.	.	.	0.65	0.1	0.1
0.02	0.444	1.74	15.7	2.2	0.004	0.59	0.005	0.0025	0.004	.	.	.	.
0	0.41	1.26	.	.	.	.	.	.	.	.	.	.	.
0.01	0.2	0.77	.	.	.	.	.	.	.	.	.	.	.
0	0.28	0.95	.	.	.	.	.	.	.	.	.	.	.
0.14	0.345	1.15	.	.	.	.	.	.	.	.	391	0.1	0.1
0.09	0.287	1.21	.	.	.	.	.	.	.	.	1.5	0.1	0.1
0.07	0.463	1.71	.	.	.	.	.	.	.	.	.	.	.
0.08	0.321	1.55	.	.	.	.	.	.	.	.	.	.	.
0.16	0.466	1.86	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	0.0034	0.08	1.704	0.0007	.	0.0112	ND	0.125	0.1	0.1

Appendix 1 continued.

Waterbody	County	TYPE	MONTH	DAY	TIME	LAT	LONG	SITE	SCUM	SITE_DEPTH (ft)	SAMP_DEPTH (ft)	TEMP (F)	DO (mg/l)	COND (µs/cm)	PH	PC RFU
THORNAPPLE	BARRY	RESPONSE	7	20	1427	42.62077	-85.19382	BEACH	NO	0.5	0	81.74	14.9	865	8.29	2.116
THORNAPPLE	BARRY	RESPONSE	7	20	1250	42.62382	-85.18969	DEEP	NO	30	0	78.45	21.79	754	8.56	6.44
THORNAPPLE	BARRY	RESPONSE	7	20	1250	42.62382	-85.18969	DEEP	NO	30	5	73.23	6.85	847	7.71	0.806
THORNAPPLE	BARRY	RESPONSE	7	20	1250	42.62382	-85.18969	DEEP	NO	30	10	71.35	3.28	827	7.49	0.131
THORNAPPLE	BARRY	RESPONSE	7	20	1250	42.62382	-85.18969	DEEP	NO	30	15	68.04	0.2	923	7.47	0.34
THORNAPPLE	BARRY	RESPONSE	7	20	1250	42.62382	-85.18969	DEEP	NO	30	20	62.5	0.1	902	7.46	0.97
THORNAPPLE	BARRY	RESPONSE	7	20	1250	42.62382	-85.18969	DEEP	NO	30	25	55.75	0.07	805	7.43	0.091
THORNAPPLE	BARRY	RESPONSE	7	20	1334	42.62536	-85.1806	BARRY'S	NO	3	0	82.81	23.32	755	8.83	8.977
THORNAPPLE	BARRY	RESPONSE	7	20	1203	42.62095	-85.19405	BEACH	YES	0.5	0	80.81	16	871	7.72	3.225
THORNAPPLE	BARRY	RESPONSE	7	20	1238	42.61784	-85.19837	BOAT LAUNCH	YES	.	0	80.78	15.98	828	8.21	2.071
THORNAPPLE	BARRY	RESPONSE	7	20	1354	42.62967	-85.18436	CHANNEL	YES	.	0	78.03	9.16	823	7.66	2.046
THORNAPPLE	BARRY	RESPONSE	7	20	1401	42.62906	-85.18662	EAGLE CHANNEL	YES	1.9	0	77.28	7.26	911	7.43	4.996
Tull	Oakland	RESPONSE	6	1	1022	42.65099	-83.46452	BERRY PATCH LN	NO	.	0	69.245	9.67	584	8.07	0
Tull	Oakland	RESPONSE	6	1	930	42.64918	-83.46808	DEEP	NO	10	0	68.953	10.05	582	8	0
Tull	Oakland	RESPONSE	6	1	930	42.64918	-83.46808	DEEP	NO	10	2	68.664	10.02	582	7.98	0
Tull	Oakland	RESPONSE	6	1	930	42.64918	-83.46808	DEEP	NO	10	4	68.255	9.58	582	7.93	0
Tull	Oakland	RESPONSE	6	1	930	42.64918	-83.46808	DEEP	NO	10	6	68.193	9.66	579	7.96	0
Tull	Oakland	RESPONSE	6	1	930	42.64918	-83.46808	DEEP	NO	10	8	66.538	4.41	582	7.5	0
Tull	Oakland	RESPONSE	6	1	1000	42.64816	-83.46895	RIVER INPUT	NO	3	0	68.419	9.11	589	7.89	0
Tull	Oakland	RESPONSE	6	1	1000	42.64816	-83.46895	RIVER INPUT	NO	3	3	68.088	8.97	590	7.86	0
Tull	Oakland	RESPONSE	6	1	1007	42.64861	-83.47077	WACKO BAY	NO	8	0	67.94	9.22	589	8.01	0
Tull	Oakland	RESPONSE	6	1	1007	42.64861	-83.47077	WACKO BAY	NO	8	7	66.684	2.34	586	7.27	1.055
Tull	Oakland	RESPONSE	6	1	.	42.64773	-83.46901	HURON CANAL	NO	.	0	64.3	7.12	589	7.26	0
Wakeley Lake	Crawford	S/T	8	22	.	44.6343	-84.5138	Deep	NO	.	.	.	.	.	.	.
WEST BLOOMFIELD	OAKLAND	RESPONSE	7	19	920	42.56127	-83.38155	WEST BLOOMFIELD LAKE PARK	YES	1	0	78.28	15.14	242.4	9.75	7.255
WEST BLOOMFIELD	OAKLAND	RESPONSE	7	19	935	42.56286	-83.38229	LAKE BLUFF RD	YES	2	0	78.39	15.55	243.5	9.79	6.943
WEST BLOOMFIELD	OAKLAND	RESPONSE	8	16	935	42.56128	-83.38163	WEST BLOOMFIELD LAKE PARK	YES	.	0	75.97	9.33	228.2	9.11	15.504
WEST BLOOMFIELD	OAKLAND	RESPONSE	8	16	1000	42.56288	-83.38232	LAKE BLUFF RD	YES	.	0	75.65	7.77	231.9	8.98	9.15
Worchester Lake	Schoolcraft	S/T	8	14	.	46.4421	-86.2792	Deep	NO	.	.	.	.	.	.	.

Appendix 1 continued.

PC CONC (µg/l)	CHLA RFU	CHLA CONC (µg/l)	SECCHI (FT)	LAB_CHL (µg/l)	NH3 (mg/l)	N (mg/l)	NO2/NO3 (mg/l)	ORTHO P (mg/l)	Total P (mg/l)	MC_STRIP_RESULT	LAB_TOT_MC (µg/l)	LAB_ANATOX (µg/l)	LAB_CYLINDRO (µg/l)
3.105	3.337	13.09	.	.	.	.	.	.	.	.	0.21	0.1	0.1
8.07	11.222	41.35	1.4	98	.	.	.	.	.	.	.	.	.
0.88	3.039	9.01	.	.	.	.	.	.	.	.	.	.	.
0.16	1.615	6.31	.	.	.	.	.	.	.	.	.	.	.
0.36	1.078	4.21	.	.	.	.	.	.	.	.	.	.	.
0.12	1.252	4.97	.	.	.	.	.	.	.	.	.	.	.
0.11	1.31	5.16	.	.	.	.	.	.	.	.	.	.	.
10.07	1.682	46.54	0.9	.	.	.	.	.	.	.	.	.	.
3.51	5.265	21.56	.	.	.	.	.	.	.	.	3.3	0.1	0.1
2.73	4.716	17.91	.	.	.	.	.	.	.	.	.	.	.
2.37	6.63	23.38	.	.	.	.	.	.	.	.	.	.	.
6.12	3.691	12.36	0.6	.	.	.	.	.	.	.	.	.	.
0	2.669	9.9	.	.	.	.	.	.	.	.	0.01	0.5	0.5
0	2.749	10.16	2.9	15	0.007	0.66	0.005	0.006	0.024	.	.	.	.
0	4.72	12.48	.	.	.	.	.	.	.	.	.	.	.
0	4.443	12.67	.	.	.	.	.	.	.	.	.	.	.
0	3.844	14.76	.	.	.	.	.	.	.	.	.	.	.
0	3.006	14.05	.	.	.	.	.	.	.	.	.	.	.
0	1.331	7.34	3	.	.	.	.	.	.	.	.	.	.
0	3.195	10.93	.	.	.	.	.	.	.	.	.	.	.
0	1.603	10.17	.	.	.	.	.	.	.	.	.	.	.
1.04	5.121	20.69	.	.	.	.	.	.	.	.	.	.	.
0	2.43	9	.	.	0.03	0.65	0.02	0.01	0.039	.	.	.	.
.	.	.	.	0.00706	0.12	0.903	0.0067	.	0.0117	ND	0.125	0.1	0.1
8.07	1.724	5.9	.	76	.	.	.	.	.	.	2.7	0.1	0.1
7.8	1.823	5.74	.	.	.	.	.	.	.	.	0.2	0.1	0.1
13.44	2.479	9.27	.	.	.	.	.	.	.	.	.	.	.
9.76	2.077	7.72	.	94	0.003	2.6	0.006	0.048	0.2	.	0.2	.	.
.	.	.	.	0.00338	0.07	1.517	0.0082	.	0.0329	ND	0.125	0.1	0.1