Work Plan and Quality Assurance Project Plan (QAPP)

2017 Michigan Inland Lake Harmful Algal Bloom Toxin Study
Michigan Department of Environmental Quality (MDEQ), Water Resources Division

Prepared by Aaron Parker, Project Lead
MDEQ
June, 2017

QAPP Approval

This QAPP has been reviewed and approved by the following persons (signatures):

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Aaron Parker, Project Lead   Date
Aquatic Biologist – Lake Michigan Unit
Surface Water Assessment Section, MDEQ

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Gary Kohlhepp, Project Supervisor   Date
Supervisor – Lake Michigan Unit
Surface Water Assessment Section, MDEQ

Table 1: Distribution list for the Michigan Inland Lake Harmful Algal Bloom Toxin Study Work Plan and Quality Assurance Project Plan.

Name	Affiliation	Project Role
Diana Klemans	MDEQ	Surface Water Assessment Section Chief
Michael Alexander	MDEQ	Lakes Erie, Huron, Superior Unit Supervisor
Kevin Goodwin	MDEQ	Field sampling, response efforts
Sarah Holden	MDEQ	Field sampling, response efforts
Matthew Geiger	DHHS	Laboratory cyanotoxin analysis
Kelly Ploehn	MDEQ	Executive division communications
Ashley Miller	DHHS	Communication with local health departments
Alexandra Rafalski	DHHS	Communication with local health departments

1. Introduction

The Michigan Department of Environmental Quality (MDEQ) – Water Resources Division (WRD) receives reports each year about nuisance algal conditions from district staff, lake associations, and the broader public. The number of such reports, particularly the occurrence of cyanobacteria blooms and concern over the possible presence of algal toxins such as microcystin, appear to have increased in recent years. 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, and to improve our understanding of the nature, extent, and frequency of algal blooms in inland waters and nearshore Great Lakes. The need to understand and address harmful algal blooms (HABs) became more urgent in August 2014. At that time, severe blooms were observed in the western basin of Lake Erie, and access to drinking water for hundreds of thousands of people was temporarily interrupted due to elevated levels of an algal toxin associated with the bloom. This event caused the MDEQ-WRD to re-examine and expedite our efforts related to HABs. This work plan focuses on inland lakes; however, we have other work focusing on blue-green algae sampling along Great Lakes shorelines. That project was initiated in 2012 at Lake Erie and expanded in 2016 to collect and analyze samples for microcystin from Saginaw Bay beaches.

The term "harmful algal bloom" generally describes accumulations of cyanobacteria that are aesthetically unappealing and produce algal toxins. The MDEQ–WRD developed the following definition for a HAB: "An algal bloom in recreational waters is harmful if microcystin levels are at or above the 20 ug/L WHO non-drinking water guideline, or other algal toxins are at or above appropriate guidelines that have been reviewed by MDEQ-WRD." A bloom should be considered *potentially* harmful when "the chlorophyll-*a* level is greater than 30 µg/L and visible surface accumulations/scum are present, or cells are visible throughout the water column." A key concept of this HAB definition is that while high chlorophyll-*a* concentration and visible surface/water column algal accumulation can indicate potential problems, water samples must be analyzed for the presence of toxins to confirm that a bloom may, in fact, be harmful to humans. Visual appearances of blooms cannot be used as a reliable predictor of toxin content. Even in toxin-producing blooms, there may be great variability in where the toxin is located. In the future, this definition may be updated if MDEQ, or another organization, develop algal toxin water quality standards.

1.1. Proposal

Approximately 53 lakes will be monitored for cyanotoxins in 2017. There are four components to the 2016 HABs monitoring. The first includes visiting randomly-selected inland lakes (Table 2) under the Department of Natural Resources (DNR) Fisheries Division's (FD) status and trends program twice during the summer growing season. The lakes will be sampled by DEQ-WRD staff in July 2017 and by DNR-FD staff in August 2017.

On both dates, field crews will visually assess whether an algal bloom is occurring in any portion of the lake, and use test strips to generate an estimate of microcystin concentrations. Sampling at these lakes is contingent upon boat access and the continued inclusion of these lakes in the status and trend program.

Table 2. Status and trend Program randomly-selected lakes to be 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

The second component of the project includes targeted sampling of lakes with a history of algal toxin production based on previous MDEQ-WRD monitoring (Table 3). Based on 2016 results, we identified four lakes with high potential for toxin-producing algal blooms (Mona Lake in Muskegon County, Lamberton Lake in Kent County, Long Lake in Ionia County, and Pontiac Lake in Oakland County). In addition to the use of test strips, crews will collect water samples from each lake for more precise analysis using Mass Spectrometry (MS). We will also use YSI sondes to measure phycocyanin (a pigment produced by cyanobacteria), and potentially collect samples for identification purposes. We will re-visit these four lakes approximately bi-weekly from July through September to track changes in toxins in these lakes throughout the season.

Oakland University will be sampling 31 inland lakes in the Lower Peninsula and 3 shoreline sites along the St. Mary’s River, Lake St. Claire, and Lake Erie (Table 3) for microcystins in 2017 and 2018. Their sampling will occur monthly from July to October. Oakland University will be able to report microcystin concentrations within about one week. If a sample from one of their study lakes has elevated microcystin concentrations, then we may respond by taking additional water samples to analyze for microcystins.

The fourth component of this project is conducting response monitoring for waterbodies with complaints about significant algal blooms. The intent of this component of the HABs monitoring plan is to provide a structure for monitoring when MDEQ-WRD staff believe collecting algal toxin data is warranted. We expect to monitor individual response lakes to analyze samples with both field test strips and quantitative MS analysis. The number of waterbodies assessed will depend on the frequency of complaints. The number of samples per response lake will depend on cyanotoxin results. If the initial sample results indicate elevated toxin levels, then regular follow-up monitoring will be conducted, as feasible, until concentrations decline.

Table 3. Proposed targeted lakes that will be sampled for microcystins by Oakland University and MDEQ from July through October.

Lake Name	County	Sampling organization	Sampling frequency	Latitude	Longitude
Bear Lake	Kalkaska	Oakland Univ.	Monthly	44.7282	-84.944
Belleville Lake	Wayne	Oakland Univ.	Monthly	42.2065	-83.501
Bogie Lake	Oakland	Oakland Univ.	Monthly	42.6206	-83.504
Brighton Lake	Livingston	Oakland Univ.	Monthly	42.517609	-83.797726
Brimley Bay, Lake Superior	Chippewa	Oakland Univ.	Monthly	46.44375	-84.59445
Coldwater Lake	Isabella	Oakland Univ.	Monthly	43.6613	-84.956
Deer Lake	Charlevoix	Oakland Univ.	Monthly	45.1659	-84.971
Ford Lake	Washtenaw	Oakland Univ.	Monthly	42.2165	-83.585
Geneva Lake	Oakland	Oakland Univ.	Monthly	42.6439	-83.366
Hamlin Lake	Mason	Oakland Univ.	Monthly	44.0547	-86.463
Houghton Lake	Roscommon	Oakland Univ.	Monthly	44.3444	-84.733
Hudson Lake	Lenawee	Oakland Univ.	Monthly	41.8339	-84.259
Intermediate Lake	Antrim	Oakland Univ.	Monthly	45.0291	45.029
Lake Cadillac	Wexford	Oakland Univ.	Monthly	44.2407	-85.425
Lake Erie	Macomb	Oakland Univ.	Monthly	42.07173	-83.19836
Lake Manitou	Shiawasee	Oakland Univ.	Monthly	42.9252	-84.203
Lake Margrethe	Crawford	Oakland Univ.	Monthly	44.648	-84.793
Lake Nepessing	Lapeer	Oakland Univ.	Monthly	43.0164	-83.373
Lake St Clair	Wayne	Oakland Univ.	Monthly	42.57114	-82.79667
Lime Lake	Hillsdale	Oakland Univ.	Monthly	41.7858	-84.381
Little Glen Lake	Leelanau	Oakland Univ.	Monthly	44.8653	-86.01
Little Round Lake	Lenawee	Oakland Univ.	Monthly	41.9094	-84.352
Ore Lake	Livingston	Oakland Univ.	Monthly	42.48	-83.796
Paradise Lake	Emmet	Oakland Univ.	Monthly	45.6868	-84.753
Platte Lake	Benzie	Oakland Univ.	Monthly	44.6906	-86.092
Pontiac Lake	Oakland	Oakland Univ.	Monthly	42.6678	-83.461
Posey Lake	Lenawee	Oakland Univ.	Monthly	41.89761	-84.30019
Round Lake	Lenawee	Oakland Univ.	Monthly	42.0708	-84.133
Sanford Lake	Midland	Oakland Univ.	Monthly	43.6901	-84.382
Seventh Spectacle	Montmorency	Oakland Univ.	Monthly	44.88696	-84.39492
Silver Lake	Grand Traverse	Oakland Univ.	Monthly	44.697662	-85.686095
Stony Creek Lake	Oakland	Oakland Univ.	Monthly	42.7264	-83.086
Twin Lake (East or West)	Montmorency	Oakland Univ.	Monthly	44.8753	-84.327
Wixom Lake	Gladwin	Oakland Univ.	Monthly	43.8195	-84.371
Lamberton Lake	Kent	MDEQ	Biweekly	43.020977	-85.629246
Long Lake	Ionia	MDEQ	Biweekly	43.11312	-85.122868
Mona Lake	Muskegon	MDEQ	Biweekly	43.180344	-86.122868
Pontiac Lake	Oakland	MDEQ	Monthly	42.6678	-83.461

1.2. Study Objectives

This work plan is designed to address the following objectives:

- Measure the geographical extent of HABs in Michigan inland lakes (i.e. how widespread is the problem);
- Compare microcystin results obtained using different analytical methods;
- Assess annual and seasonal toxin variability; and
- Quantify algal toxin concentrations in lakes with public reports of concerning algal blooms.

1.3. Project Organization and Responsibility

Table 4 contains a list of all personnel involved in the execution of this Work Assignment. Contact information for these personnel is also provided.

Table 4. Personnel and monitoring/sample analysis responsibilities.

Personnel Name	Affiliation & Contact Information	Monitoring Responsibilities
Aaron Parker	MDEQ-Water Resources Division 517-284-5543 holdens1@michigan.gov	Project Lead, status and trend monitoring, targeted lake sampling, TMDL lake HABs monitoring coordination, response monitoring, QA oversight
Kevin Goodwin	MDEQ-Water Resources Division 517-284-5552 goodwink@michigan.gov	HABs committee, targeted lake sampling
Sarah Holden	MDEQ- Water Resources Division 517-284-5484 parkera7@michigan.gov	HABs committee, targeted lake sampling
Matt Geiger	Michigan Department of Health and Human Services 517-335-9071 geigerm@michigan.gov	cyanotoxins analysis

1.3.1. Project Lead

The MDEQ Project Lead (Aaron Parker) is responsible for the implementation of the study and its associated QAPP. In addition, the MDEQ Project Lead is responsible for:

- Ensuring an adequate QAPP is developed and distributed to all appropriate project personnel;
- Ensuring the overall goal and requirements outlined in the QAPP are met through effective organizing and planning;
- Ensuring effective lines of communication;
- Ensuring Standard Operating Procedures (SOPs) that describe current practices are written, approved, and distributed to appropriate project personnel;
- Ensuring all data products are reviewed and approved according to accepted policies and guidelines before being released.

1.3.2. Project Supervisor

Gary Kohlhepp is the Lake Michigan Unit Supervisor and the Project Supervisor. His responsibilities include:

- Ensuring the project is appropriately organized and has effective lines of communication;
- Ensuring program roles are clearly understood;

- Ensuring Standard Operating Procedures (SOPs) that describe current practices are written, approved, and distributed to appropriate project personnel;
- Implementing program-level corrective actions on an as-needed basis; and
- Reviewing reports to ensure quality assurance (QA) goals are met.

1.3.3. Monitoring Staff

The SWAS biologists (Sarah Holden, Kevin Goodwin, and Aaron Parker) are all on the HABs work group and will be used as available to conduct the project sampling and be responsible for following field/sampling SOPs and project QAPPs. Other SWAS staff may assist with sampling as needed. All collection and delivery of samples will be performed by these staff as well. Their responsibilities include:

- Keeping well-informed of the sampling schedule;
- Ensuring the monitoring staff commitments for all surveys are met;
- Ensuring effective lines of communication;
- Ensuring all quality assurance/quality control (QA/QC) requirements are followed;
- Managing the day-to-day field sampling activities to ensure field procedures and activities conform to the requirements of the applicable SOPs;
- Resolving day-to-day problems in the implementation of this monitoring study;
- Reviewing records and field data for accuracy, validity, and completeness; and
- Communicating problems to the Project Lead.

2. SAMPLING AND ANALYTICAL PROCEDURES

2.1. Sampling Locations and Schedule

Status and Trend Lakes
The status and trend lakes (Table 2) are included in this study because they were randomly selected by DNR-FD and can provide information on the general condition of microcystin concentrations in Michigan inland lakes. The lakes will be monitored on one date in July and one date in August in conjunction with other planned monitoring at these lakes.

Targeted Lakes
Four lakes were chosen based on 2016 sampling results for ongoing algal toxin monitoring because of our interest in gathering additional data on the changes in algal toxins in Michigan inland lakes over the course of the summer (Table 3). Mona, Lamberton, Long, and Pontiac Lakes were chosen because we anticipate they may have cyanobacteria blooms that could produce harmful algal toxins. Sampling is expected to occur approximately every other week from July through September to evaluate the changes in cyanotoxin concentrations over the course of the summer. Pontiac Lake will be sampled monthly by MDEQ and monthly by Oakland University. Sample scheduling by MDEQ and Oakland University has been staggered to make sure that it is sampled every other week. The exact timing and frequency of sampling will be determined by the Project Lead and Project Supervisor.

Response Lakes
Response lakes will be sampled based on reports and documentation of significant algal blooms. We currently expect to monitor lakes in the southern region of the state, from which most of the bloom reports tend to originate. We are planning to limit response monitoring to a maximum of 20 lake trips, although this number is flexible based on the status of other monitoring responsibilities. If we sample one lake more than once, it will mean we sample fewer lakes total. Also, if we do not receive complaints on additional lakes, we may not reach the target number of lakes.

District staff will also be provided with Abraxis test strips and trained on how to use them. To respond to lakes in a timely manner, district staff will be encouraged to collect samples and run the initial test strip analysis on the samples. Depending on the initial results, district staff and the project lead will arrange further sample analysis at the laboratory, additional sample collections, or closure of the response.

2.2. Sampling Methods

2.2.1. Field Protocols

Photographs

During each visit, photos will be taken if they are likely to provide helpful documentation of the visual extent of the algal bloom in at least one near-shore sampling location. Photos should be taken to generally cover the range of conditions present (i.e. looking down into the water, looking out across the lake, near shore conditions, and use of props to provide visual evidence of the amount of algae present). Other photos will be taken as needed to capture any other noteworthy conditions. Pictures will be taken from the same location to facilitate comparison over time if a lake is sampled more than once. Upon return to the office, pictures will be downloaded to the designated network drive and folder for storage.

Survey Forms

The Harmful Algae Bloom Survey form (Appendix A) will be filled out completely and any necessary assessments or measurements of shoreline or in-water algae build-up will be recorded per the form. Upon return to the office forms will be submitted to the Project Lead for data entry and storage. A GPS device will be used to record the location of each sampling station.

Water Samples

Three shoreline sites and one center lake location will generally be sampled at all lakes for cyanotoxins. Lamberton Lake does not have a public boat launch, therefore, we may be restricted to shoreline samples. Response lakes that do not have public boat access will also be limited to shoreline sampling. All lakes will be sampled for total microcystin (qualitative Abraxis test strips) and a suite of cyanotoxins (LC/MS/MS quantitative see 2.2.2.). Cyanotoxin samples will be collected in 250 ml PETG sample bottles that have been triple-rinsed with site water. Shoreline sampling locations will be distributed approximately evenly around the shoreline of each lake. However, downwind locations, bays which may be used for recreation (i.e. have shoreline homes, access sites), areas impacted by river outlets, or beaches will be preferentially targeted. Shoreline samples will be collected in water approximately 3 to 6 feet deep, at a depth of approximately 0.5 to 1 foot. Ambient water that is representative of the site will be sampled. However, if a visible algal scum is present at a site, additional scum samples may be collected.

At the center location of all lakes temperature, conductivity, pH, dissolved oxygen, phycocyanin, and chlorophyll-a will be measured using a YSI sonde along a depth gradient. Phycocyanin and chlorophyll-a will also be measured at the surface and 2-4 feet of water at each shoreline location. Sonde calibration will follow established protocols at the start of each sampling day and a calibration sheet will be completed and stored at the DEQ Filley Street facility.

Surface water samples will be collected from the center of the lake at approximately 1 foot depth using new 250 milliliter (ml) PETG (quantitative cyanotoxins) sample bottles that have been triple-rinsed with site water. The following four sample bottles will be collected: (1) General

Chemistry Acidic (GA) and (1) Neutral (GN), (1) Chlorophyll-a, and (1) cyanotoxins. Following sampling, preservatives will be added to the chlorophyll-a and GA bottles and then all sample bottles will be placed in a cooler on ice for transport and storage prior to delivery to the laboratory.

Nutrient samples (GA: one bottle for total phosphorus, total Kjeldahl nitrogen, and nitrate+nitrite; GN: one bottle for orthophosphate; and one chlorophyll-a bottle) will be submitted to the DEQ Environmental Laboratory for analysis. Quantitative cyanotoxin samples will be submitted to the Michigan Department of Health and Human Services (MDHHS) lab for analysis using LC/MS/MS. Qualitative microcystin samples will be analyzed by DEQ using Abraxis test strips.

Qualitative microcystin samples may be held on ice or refrigerated for 5 days prior to analysis. If microcystin samples are held longer than 5 days, they should be frozen with care taken to reduce volume to allow for expansion, typically leaving head space above the 'shoulder' in the sample bottle.

The inland lake status and trend sampling is detailed in a separate work plan. Water sample collection at the status and trend lakes and the targeted lakes are generally similar, but have a few key differences. There is no GN sample collected from the status and trend lakes and quantitative cyanotoxin analysis will only be performed on samples that produce a positive microcystin result with the test strips. Also, August status and trend lake sampling may not include phycocyanin and chlorophyll-a on the sonde measurements because the sampling is being conducted by Michigan DNR and they may not have access to the same equipment.

Algae Sample Collection

At any lake noted to have a suspected cyanobacteria bloom, an additional surface water sample may be collected using a small plankton tow net, at a location with opaque water for dominant taxa identification. The tow net will be used to collect a concentrated algal sample for ID purposes. We are not collecting information on algal densities, so information on net diameter and tow length will not be retained. The algal sample will be refrigerated until analysis by SWAS staff to identify dominant algae taxa.

2.2.2. Sample Analysis

See Table 5 for analytical methods and reporting limits for all sample analyses. Nutrient and chlorophyll-a samples will be submitted to the DEQ lab for analysis. Quantitative cyanotoxin samples will be submitted to Michigan Department of Health and Human Services (DHHS) laboratory for LC-MS-MS analysis of these toxins: Anatoxin-A, Cylindrospermopsin, Microcystin-LR, Microcystin-LA, Microcystin-YR, Microcystin-RR, Microcystin -LY, Microcystin -LF, Microcystin -LW, and Microcystin -WR. Qualitative microcystin samples will be tested using Abraxis test strips (PN52022) at the DEQ Filley Street facility, or by the Great Lakes Environmental Center following procedures provided with the test strips.

Table 5. 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

2.2.3. Corrective Action

Monitoring staff will maintain close communication with the Project Lead. Adjustments to the sampling schedule, or adjustments to any other aspects of the study, will only be made in consultation with the Project Lead. All field and laboratory personnel are responsible for notifying the Project Lead of circumstances that may necessitate any adjustments. Changes to the project work plan will be reflected through submission of work plan amendments, as necessary.

2.2.4. Chain of Custody

Proper sample handling and custody procedures ensure the custody and integrity of samples from the time of sampling, continuing through transport, sample receipt, preparation and analysis. All chain of custody procedures will be followed for both the State of Michigan Labs.

2.3. Reporting

2.3.1. Data Management

All field notes and data sheets will be maintained in the SWAS raw data file. Electronic copies of scanned field sheets and water chemistry results will be saved to a designated network drive and folder for storage. Results will be shared with Alexandra Rafalski and Ashley Miller at DHHS as soon as they are available. After each sampling event, the initial microcystin test strip results will be sent to DHHS, who will then report the results to the appropriate county health departments (see Appendix B for example of data that will be sent to DHHS after each sampling event).

2.3.2. Final Report

A final report will be prepared by the Project Lead to communicate the results of this study to interested parties. Because previous response sampling has occurred as late as November, the report will be completed in 2018.

3. DATA QUALITY OBJECTIVES AND CRITERIA

The primary objective of this project is to investigate the concentration of cyanotoxins in Michigan inland lakes. To achieve this, SWAS biologists will collect algal bloom condition and water quality data at 19 status and trend lakes, 4 targeted lakes, and 10-20 response lakes. Quantitative algal toxin samples will also be collected in four targeted inland lakes and approximately 10-20 algal bloom response lakes. Status and trend lakes were selected to represent a wide geographic range and are expected to provide the ability to broadly understand conditions in Michigan's inland lakes during the summer growing season. The four targeted lakes were selected because they are known to have high concentrations of nutrients, historic problems with algae blooms, and had quantifiable concentrations of algal toxins in past sampling efforts. The response lakes will be sampled to determine if lakes with reports of algal blooms have algal toxin concentrations at levels of concern.

3.1. Data Quality Objectives

A mixture of variables may affect data quality, including staff training, sample collection/handling procedures and equipment, sample analysis techniques, and record keeping. To control these variables, the Data Quality Objective (DQO) process is used. DQOs developed for this project specify discrete parameters in four areas: Observational Precision and Accuracy, Representativeness, Completeness, and Comparability. A brief description of each of these parameters is presented below.

3.1.1. Observational Precision and Accuracy

Precision is the degree of agreement between two or more measurements, while accuracy is a measurement of correctness. For this study, lake and shoreline conditions are assessed through the use of qualitative and semi-quantitative observations (Appendix A). Observational data that are qualitative will be either gathered collaboratively by two staff or be gathered by one and independently confirmed by the second staff person in the field prior to departing from the site. Accuracy is ensured by measuring necessary data with standardized and calibrated field equipment including metric measuring rods, optic range finders, and water chemistry sondes.

Because of the qualitative and semi-quantitative types of data gathered, use of consistent, trained staff and a system of checks and balances in the field are critical to maintaining precision between staff and accuracy for all staff measurements. Categorical assessments or estimations of extent will be agreed upon by two staff after each arrive at their independent assessment, with discrepancies discussed and resolved to create a process by which staff are routinely calibrating their estimations.

Field data quality is addressed, in part, by consistent performance of sample procedures as laid out in this QAPP. Quality is enhanced by the training and experience of project staff and documentation of sampling activities. This QAPP and the Work plan will be distributed to all field sampling personnel who will be required to read and verify they understand the procedures and requirements.

3.1.2. Representativeness

Because the objective of this project is to investigate the concentration of cyanotoxins in Michigan inland lakes, key factors considered in the design of the sampling plan included: (1) encompassing a wide geographic range of lakes with the goal of capturing the range of broad variation in conditions related to cyanobacteria blooms, (2) targeting lakes with a known history of cyanobacteria blooms, (3) performing these sampling protocols during specified sample frame that is relevant to questions of nutrient expression (July through late October), and sampling in response to reports of algal blooms to understand not only conditions but the persistence thereof.

3.1.3. Completeness

Field sheets, photographs, and samples will be reviewed and confirmed prior to departing each sampling site during each sampling event. Additionally, field sheets will be re-reviewed following each sampling event to confirm that all information was filled out completely. If a sample bottle is lost or damaged during shipping, we will use the results generated by the other samples at a lake to draw conclusions about the missing data.

3.1.4. Comparability

Comparability is a measure of the confidence with which one data set can be compared with another. Field and laboratory data comparability will be ensured by conducting sample collection and preservation, and laboratory analysis in accordance with this QAPP. Well-established sample locations, clear definition of the assessed locations at each lake, limiting the participating trained field staff, use of the same labs for specified parameters, and following routine processes and order (e.g., first center lake sample collection and then shoreline sample collection) all serve to reduce variability associated with sampling error. The objective is to facilitate observations and conclusions that can be made from comparing the results both over time and over geographic extent.

3.2. Quality Assurance and Quality Control

Field staff will complete all required fields on the standardized Harmful Algal Bloom Monitoring field sheet. The data will be reviewed by the originator in the field prior to departing each survey site and then reviewed again in the office for completeness prior to being scanned and stored. The final report for this study will be reviewed for accuracy before being submitted the Project Sponsor.

Field duplicate samples for all water samples, including microcystin, will be collected at a rate of approximately 10%. Duplicate samples will be collected as two sample bottles taken simultaneously at the same location and handled, preserved (as needed), transported, and analyzed identically. Field blanks will be collected at a rate of approximately 5% for all water samples. Duplicates and blanks will be run for parameters submitted to the State of Michigan Labs and the microcystin test strips.

The MDEQ lab routinely conducts batch lab replicates to test for precision and accuracy using Metrix Spike/Matrix Spike Duplicate samples. This standardized process will be relied upon to understand analytical precision and can be used in concert with field duplicate samples to partition variance between analytical procedures and sampling procedures.

3.3. Special Training

All field personnel conducting inland lake harmful algae bloom monitoring will receive guidance in monitoring procedures relevant to this study and adherence to quality assurance and control involved in these protocols. Staff will conduct sampling with the project lead or with other staff who have conducted sampling with the project lead to ensure consistency in field protocols and be provided copies of the QAPP and field guide cheat sheet (Appendix B).

3.4. Progress and Analysis Quality Control

This QAPP and other supporting materials will be distributed to all personnel involved in the work assignment. All project members will conform to the following guidelines:

All technical assessment activities including data interpretation, calculations, or other related computational activities are subject to audit or peer review. Thus, project members are instructed to maintain careful written and electronic records for all aspects of the assessment process.

The Project Supervisor will perform surveillance activities throughout the duration of the project to ensure that management and technical aspects are being properly implemented according to the schedule and quality requirements specified in the data review and technical approach documentation. These surveillance activities will include ensuring:

- Project milestones are achieved and documented
- Corrective actions are implemented
- Budgets are followed
- Peer reviews are performed
- Data are properly stored and maintained

3.5. Reports to Management

The Project Lead will provide periodic progress reports to the Project Supervisor. As appropriate, these reports will inform the Project Sponsor of the following:

- Adherence to project schedule
- Deviations from approved QAPP, as determined from project assessment and oversight activities
- The impact of these deviations on analytical tool application quality and uncertainty
- The need for, and results, of response actions to correct the deviations
- Potential uncertainties in decisions based on analytical tool results and data

Appendix A

Harmful Algal Bloom Survey Form and Field Guide

2017 MDEQ Harmful Algae Bloom Monitoring Field Form

Name of Lake: Date: STORET:

Staff:

GENERAL CONDITIONS

Weather Condition: ☐ Sunny ☐ Mostly Sunny ☐ Partly Sunny ☐ Mostly Cloudy ☐ Cloudy

Air Temperature (approx): ºF Rainfall (time since/amount of last rainfall): ☐ Unknown

Relative Wind Speed: ☐ none ☐ light ☐ moderate/breezy ☐ heavy/gusty Wind Direction:

Comments/Observations:

WATER QUALITY SITES

Mid-lake Lat/Lon:____ ☐ Pictures_________ Time__________

Water Depth: ft /m Secchi: _ft / m

Depth	Temp	DO	Cond	pH	PC RFU	PC ug/L	Chl a RFU	Chl a ug/L

Turbidity:☐ Clear ☐ Slightly Turbid ☐ Turbid ☐ Opaque **Color** :☐White ☐Blue/green ☐Green☐ Brown ☐Other:

Algae: ☐ Flocculent ☐ Paint spill ☐ Surface Scum ☐ Other:

Shoreline: ☐ Similar☐ Less Algae☐ More Algae

Samples Collected: ☐ GA/GN ☐ CA ☐ All Cyanotoxins (HPLC) ☐ Microcystin (test strip) ☐ Algae Sample

Shoreline Station 1 Lat/Lon:______________________________________ ☐ Pictures_________ Time__________

Water Depth: ft /m Secchi: _ft / m

Depth	Temp	DO	Cond	pH	PC RFU	PC ug/L	Chl a RFU	Chl a ug/L

Turbidity:☐ Clear ☐ Slightly Turbid ☐ Turbid ☐ Opaque **Color** :☐White ☐Blue/green ☐Green☐ Brown ☐Other:

Algae: ☐ Flocculent ☐ Paint spill ☐ Surface Scum ☐ Other:

Shoreline: ☐ Similar☐ Less Algae☐ More Algae

Samples Collected: ☐ All Cyanotoxins (HPLC) ☐ Microcystin (test strip) ☐ Algae Sample

Shoreline Station 2 Lat/Lon:______________________________________ ☐ Pictures_________ Time__________

Water Depth: ft /m Secchi: _ft / m

Depth	Temp	DO	Cond	pH	PC RFU	PC ug/L	Chl a RFU	Chl a ug/L

Turbidity:☐ Clear ☐ Slightly Turbid ☐ Turbid ☐ Opaque **Color** :☐White ☐Blue/green ☐Green☐ Brown ☐Other:

Algae: ☐ Flocculent ☐ Paint spill ☐ Surface Scum ☐ Other:

Shoreline: ☐ Similar☐ Less Algae☐ More Algae

Samples Collected: ☐ All Cyanotoxins (HPLC) ☐ Microcystin (test strip) ☐ Algae Sample

Shoreline Station 3 Lat/Lon:______________________________________ ☐ Pictures_________ Time__________

Water Depth: ft /m Secchi: _ft / m

Depth	Temp	DO	Cond	pH	PC RFU	PC ug/L	Chl a RFU	Chl a ug/L

Turbidity:☐ Clear ☐ Slightly Turbid ☐ Turbid ☐ Opaque **Color** :☐White ☐Blue/green ☐Green☐ Brown ☐Other:

Algae: ☐ Flocculent ☐ Paint spill ☐ Surface Scum ☐ Other:

Shoreline: ☐ Similar☐ Less Algae☐ More Algae

Samples Collected: ☐ All Cyanotoxins (HPLC) ☐ Microcystin (test strip) ☐ Algae Sample

TARGETED LAKES HABS FIELD GUIDE

Sampling Description

One lake center location:	3 shoreline locations:
• Integrated CA (2X secchi) • Water Chem Nutrients (GA & GN) • Secchi • Sonde measurements (6 depths)	• Secchi • Surface grabs Cyanotoxin • Algal community sample collection (one site) • Sonde measurements (2 depths)

Sample Types

GA: 250ml standard sampling bottle; total phosphorus, total Kjeldahl nitrogen, and nitrate+nitrite; DEQ Lab
GN: 250ml standard sampling bottle, orthophosphate; DEQ Lab
CA: 250 amber CA bottle; Chlorophyll a; DEQ Lab
Algal Toxins: 250 ml PETG bottle (square); Test strip sampled pulled from this bottle. Then bottle to DHHS Lab for: Anatoxin-A , Cylindrospermopsin, Microcystins

Sample Locations

Surface grabs: ~1 foot from surface of water. Can use chlorophyll sampling bottle or submerge bottle past elbow.
Shoreline sampling locations should be distributed approximately evenly around the lake. However, downwind locations, bays which may be used for recreation, areas impacted by river outlets, or beaches will be preferentially targeted.

Equipment List

Field Equipment	Bottles per Lake	Boat Gear	Etc.
YSI	4 250ml PETG bottles	Boat, Motor, Anchor	Bottle Labels
Secchi	1 Chl A bottle	Gas Can	Sharpies, Pencils
Chl Sampling Bottle	3 Standard 250ml bottles	Extras for Dups/Blanks	Gloves
Chem Kit	Extras for Dups/Blanks	Throwables, Life Vests	Cooler, Ice
Small Plankton Net		Depth finder	Field Sheets/Lake Maps

Field Sheets/Labeling

Label all bottles with Lake Name, Sample Date, Storet, and Station #
Lake outline/bathymetric map to mark shoreline sample locations
HABs field sheet
DEQ Lab Sheet
DHHS Lab Sheet

Sample Storage

Samples should be refrigerated if not analyzed for test strip microcystin and taken to the lab on the day of sampling

Duplicates

10% of samples should be duplicates and 5% of samples should be blanks. [Based on 15 sample events: Duplicates = 2 for GA/GN; 2 for CA; 8 for cyanotoxins; 3 for microcystin]

Shipping/Sample Delivery

GA, GN, CA samples will be delivered to the DEQ Lab within 48 hours of collection.
Cyanotoxins will be delivered to the DHHS Lab within 48 hours of collection.

Project Contacts

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Appendix B

Lake	County	Site	Latitude	Longitude	Waterbody type	Month	Day	Year	Recreational use?	Reason for sample	Site visual assessment	Sample type (scum or ambient)	Algal Strip Result (Total MC ug/l)	Chlorphyll a conc (ug/l)	Phycocyanin conc (ug/l)	Total microcystins (lab; ug/l)	Anatoxin (lab; ug/l)	Cylindrospermopsin (lab; ug/l)	Comments
Mona	*Muskegon*	*S1 - Beach*	*43.176218*	*-86.24658*	*Lake*	*7*	*7*	*2017*	*Yes*	*Targeted lake*	*no scum present*	*ambient*	*>10*	*30*	*35*				