

Public Water System Harmful Algal Blooms: 2015 Update and Draft Rules

October 26, 2015

Heather Raymond
PWS HAB Coordinator



2015 Ohio HAB Activities

- **January - March:**

- Microcystins Analytical Method Comparison Study
- First State-Wide HAB Emergency Response Tabletop Exercise

- **April:** Began Surveying Labs for ELISA Microcystins-ADDA Method

- **May:**

- Second State-Level HAB Emergency Response Table Top Exercise
- Susceptible PWSs Required to Add HABs to Contingency Plans

- **June:**

- Early Stakeholder Outreach HAB Rules
- U.S. EPA Released Health Advisory levels for Microcystin & Cylindrospermopsin
- HAB Treatment Optimization Outreach to PWSs Initiated
- Developed Mobile HAB Lab

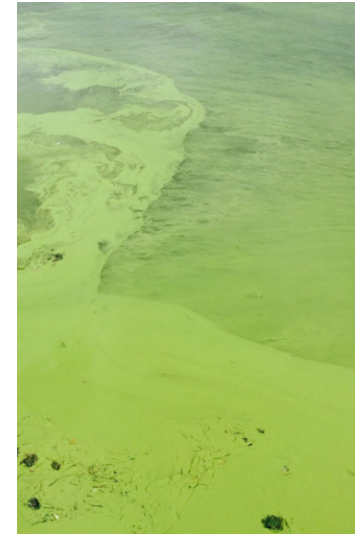
- **July:**

- Released Revised 2015 PWS HAB Response Strategy & Revised White Paper
- Ohio Law (SB 1) Passed Directing Ohio EPA to Implement Actions to Protect Against Cyanobacteria in the Western Basin of Lake Erie and in Public Water Supplies

- Released Map-based Online Cyanotoxin Monitoring Webpage

- **September:** Draft HAB Rules and Business Impact Analysis (BIA) Distributed for Interested Party Comment (comments due October 23)

- **FUNDING:** \$1 million grants, \$33 million 0% loans (\$17 million available)



Draft Rules - Overview

- PWS requirements - new rules in OAC Chapter 3745-90
 - Microcystins action levels in drinking water
 - Monitoring requirements
 - Treatment technique requirements
 - Public notification and Consumer Confidence Report (CCR) requirements
 - Recordkeeping requirements
- Laboratory Certification requirements –
New OAC rule 3745-90-04 and amended rules in Chapter 3745-89
 - Laboratory certification
 - Analytical techniques
 - Reporting deadlines



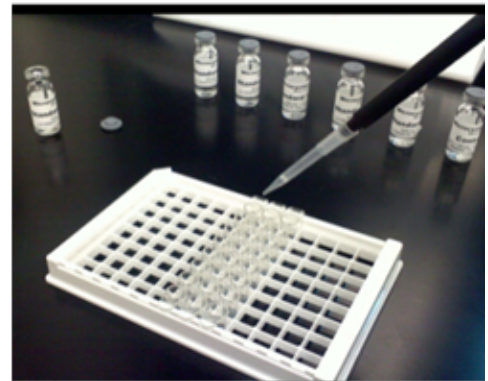
Microcystins Action Levels

- Based on U.S. EPA's health advisory levels
 - Based on oral ingestion of drinking water at these levels for up to ten days
 - Applied to total concentrations of all congeners/variants
 - Includes nursing and pregnant women, individuals with liver disease and those on dialysis
- Exceedance in a finished water sample will require:
 - Additional monitoring
 - Treatment optimization
 - Potentially other actions (e.g. public notification)

Action Level	Total Microcystins (µg/L)
Children under 6 and sensitive populations	0.3
Children 6 and older and adults	1.6

Monitoring Requirements

- Applies to surface water systems
- Routine weekly monitoring for cyanobacteria screening (raw)
 - Information will be used to determine if monitoring for cyanotoxins other than microcystins needs to be conducted by Ohio EPA (or voluntarily by the PWS)
- Routine weekly monitoring for microcystins (raw and finished)
 - Year-round
 - Option for a decreased monitoring schedule, after a year of data collection

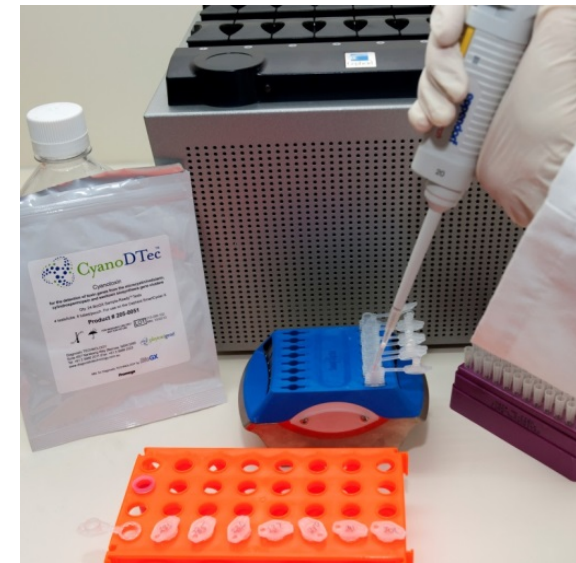


Methods

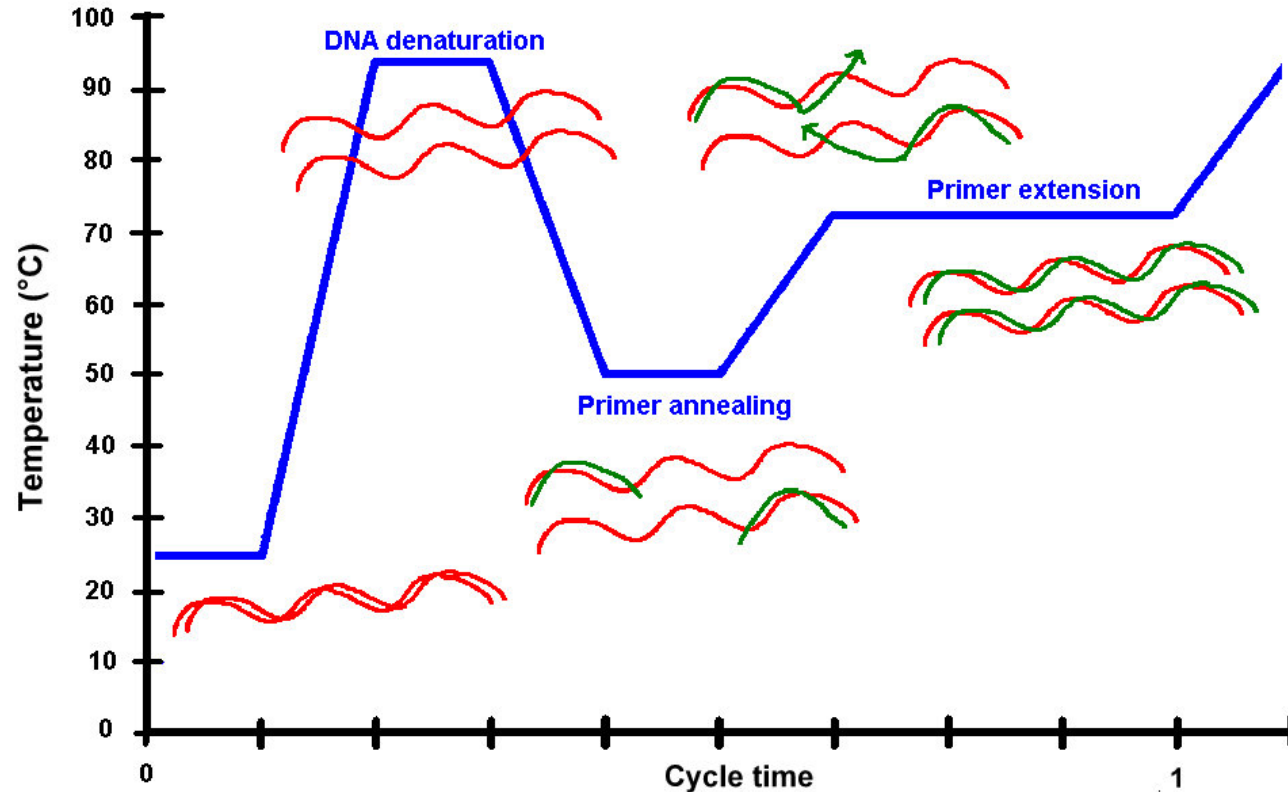
- Screening: qPCR
- Microcystins: ELISA- Microcystins-ADDA
- Other Methods if Deemed Acceptable by Director

Cyanobacteria Screening: qPCR

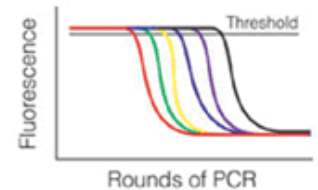
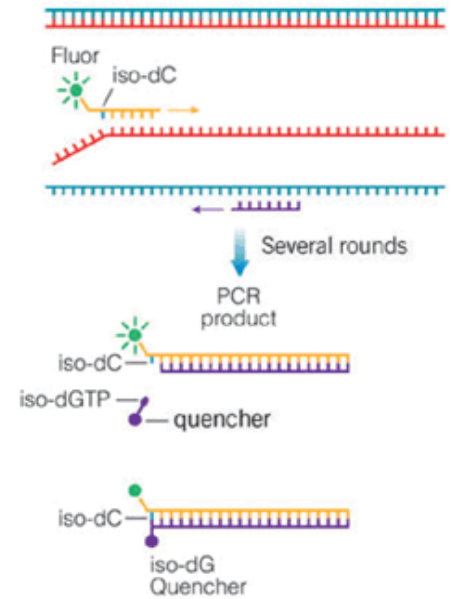
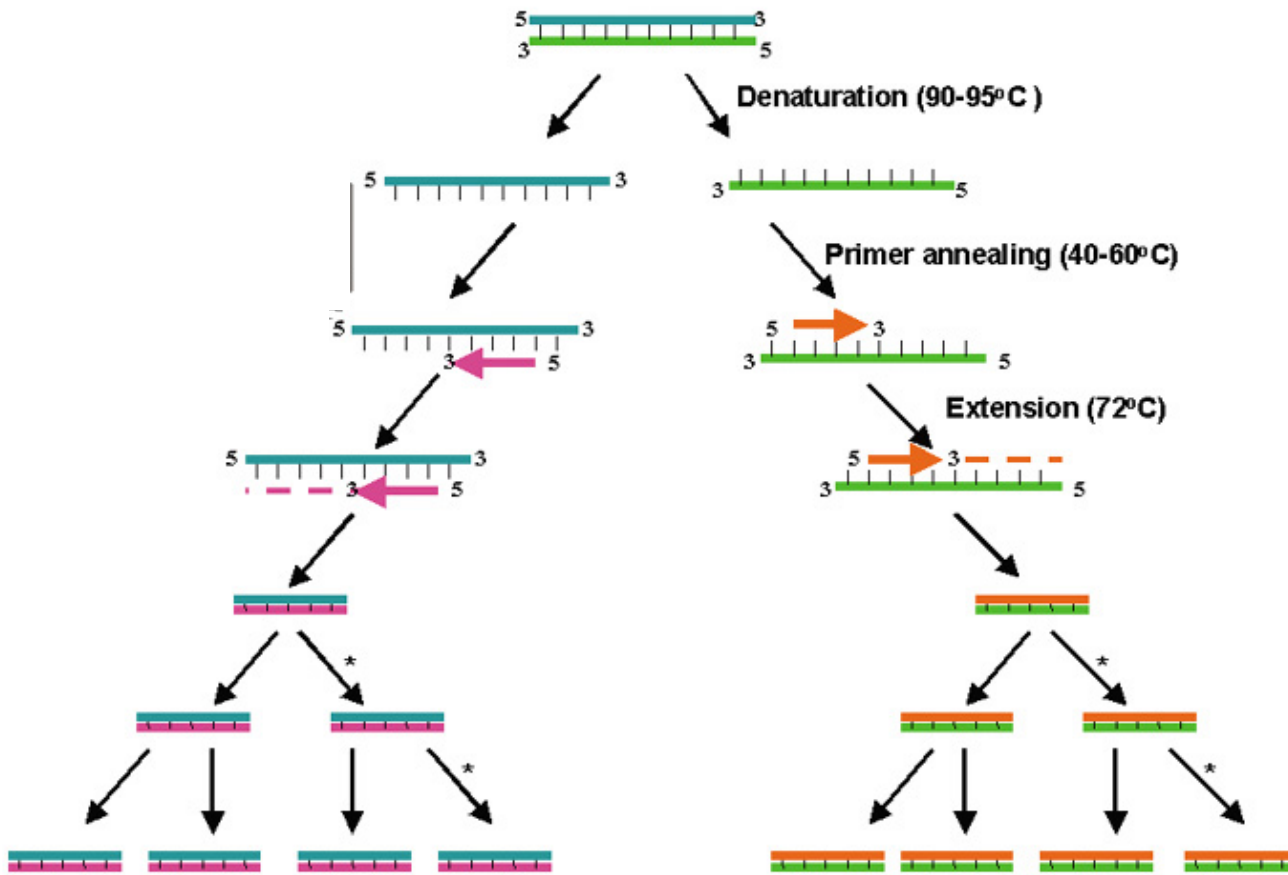
- Quantitative polymerase chain reaction (qPCR)
 - Identifies and quantifies the presence of:
 - Total cyanobacteria (16s rDNA genes)
 - Microcystins production genes (mcyE)
 - Cylindrospermopsin production genes (cyrA)
 - Saxitoxin production genes (sxtA)
 - Test completed within 2-3 hours (includes DNA extraction)
 - Scalable
 - Cost effective
 - Utilizes certified reference material
 - Produced following ISO standards
 - Specific: no gene, no toxin
- SOP development this winter
- Certification beginning in 2017
- Until there is sufficient capacity at certified laboratories to perform this method, DES will conduct these analyses



How Does PCR Work?



How Does qPCR Work?



Exponential Increase in DNA, 40 "Cycles" Provides High Sensitivity
1 gene ~1,000,000 genes after 20 cycles

Why qPCR Instead of Other Screening Tools?

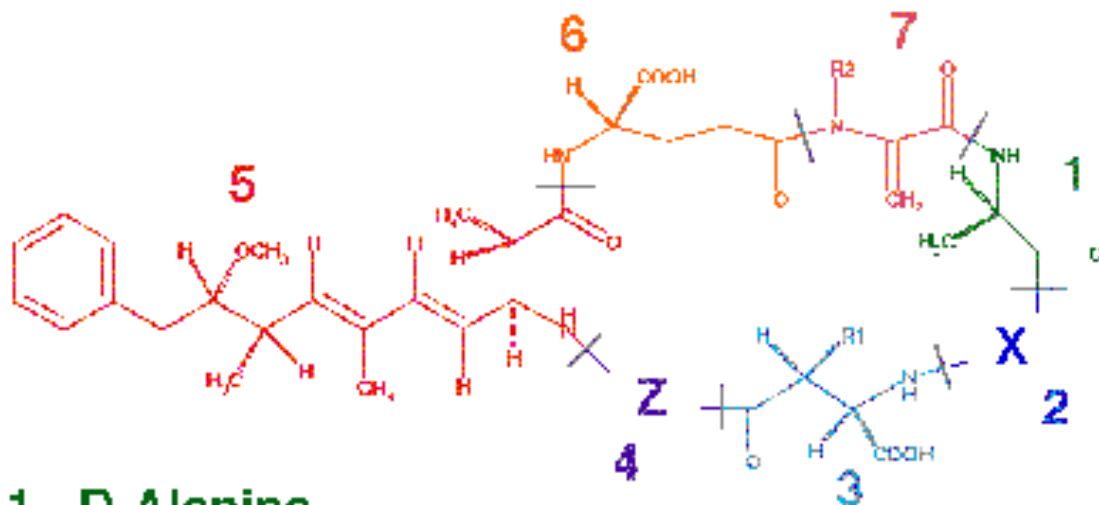
- Cannot Certify Phytoplankton ID/Enumeration (no standard methods, no internal standards, no quality controls)
- Phycocyanin concentrations vary based on environmental parameters (especially turbidity) and vary by type of cyanobacteria
- Phycocyanin does not provide information on toxin-production

How Will Ohio EPA Use qPCR Data?

- Detection of saxitoxin or cylindrospermopsin production genes will trigger cyanotoxin monitoring by Ohio EPA.
- May be able to reduce future microcystins monitoring if strong correlation between detection of microcystin gene (mcyE) and presence of microcystins.

Microcystins Testing

No “Perfect” Analytical Method for Detecting Total Microcystins



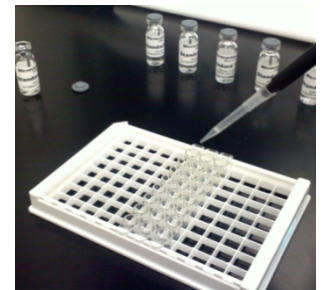
- 1 - D-Alanine
- 2 - Variable L-amino acid
- 3 - D-Methylaspartic acid
- 4 - Variable L-amino acid
- 5 - 3-amino-9-methoxy-2,6,8-trimethyl-10-phenyldeca-4,6-dienoic acid (Adda)
- 6 - D-Glutamic acid
- 7 - N-Methyldehydroalanine

Over 140 Microcystin Variants
Standards Not Available for Majority

Microcystins Testing - ELISA

- **Ohio EPA uses the Enzyme-Linked ImmunoSorbent Assay (ELISA) Microcystin-ADDA Method**
 - Measures Total Microcystins (all variants/congeners, based on ADDA)
 - Certified by USEPA (ETV Program)
 - Moderately sensitive (RL: 0.30ug/L)
 - Suitable for raw & finished water
 - Quick (four hours), useful for operational adjustments
 - Relatively inexpensive
 - Does not require high end equipment or expertise to run (can be used in water system lab)
 - Does not require pre-concentration solid phase extraction (SPE) step

- Does not provide concentrations of specific Microcystin variants
- Is an indirect measure of the toxin



Microcystins-ADDA Ohio EPA ELISA SOP

- Helps ensure consistent sample handling, preparation, and application of analytical method.
 - Finished water samples and treatment train samples that are subjected to an oxidant must be quenched upon collection.
- Labs must demonstrate they can achieve an acceptable level of precision and accuracy.
- Ohio EPA conducts site visits at labs performing analysis.

Increases Consistency & Confidence in Data

Site Visit & Acceptance Letter

Draft Rules Include Laboratory Certification



Microcystin Testing – Other Methods

- **Liquid Chromatography(LC) – UV Detection (LC-UV or HPLC-PDA)**
 - Can detect congeners without standards
 - Method prone to false positives and false negatives due to interferences
- **LC-UV & LC–Mass Spectrometry (LC-MS) scan**
 - Can detect variants without standards
 - Uses two methods in tandem to independently confirm presence of microcystins
 - No standard methods, expensive, requires complex data-interpretation, time-consuming
- **LC-MS/MS**
 - USEPA Method 544: Standard Method, includes QA/QC protocols and reduces variability in results between labs
 - USEPA Method 544 limited to 6 microcystin variants and finished water only
 - Other LC-MS/MS methods not as limited, but no standard methods
- LC-based methods typically require a solid phase extraction step, Expensive
- Lack of Certified Standards, lot-to-lot variability, lack of internal standards

LC-MS/MS MMPB Method

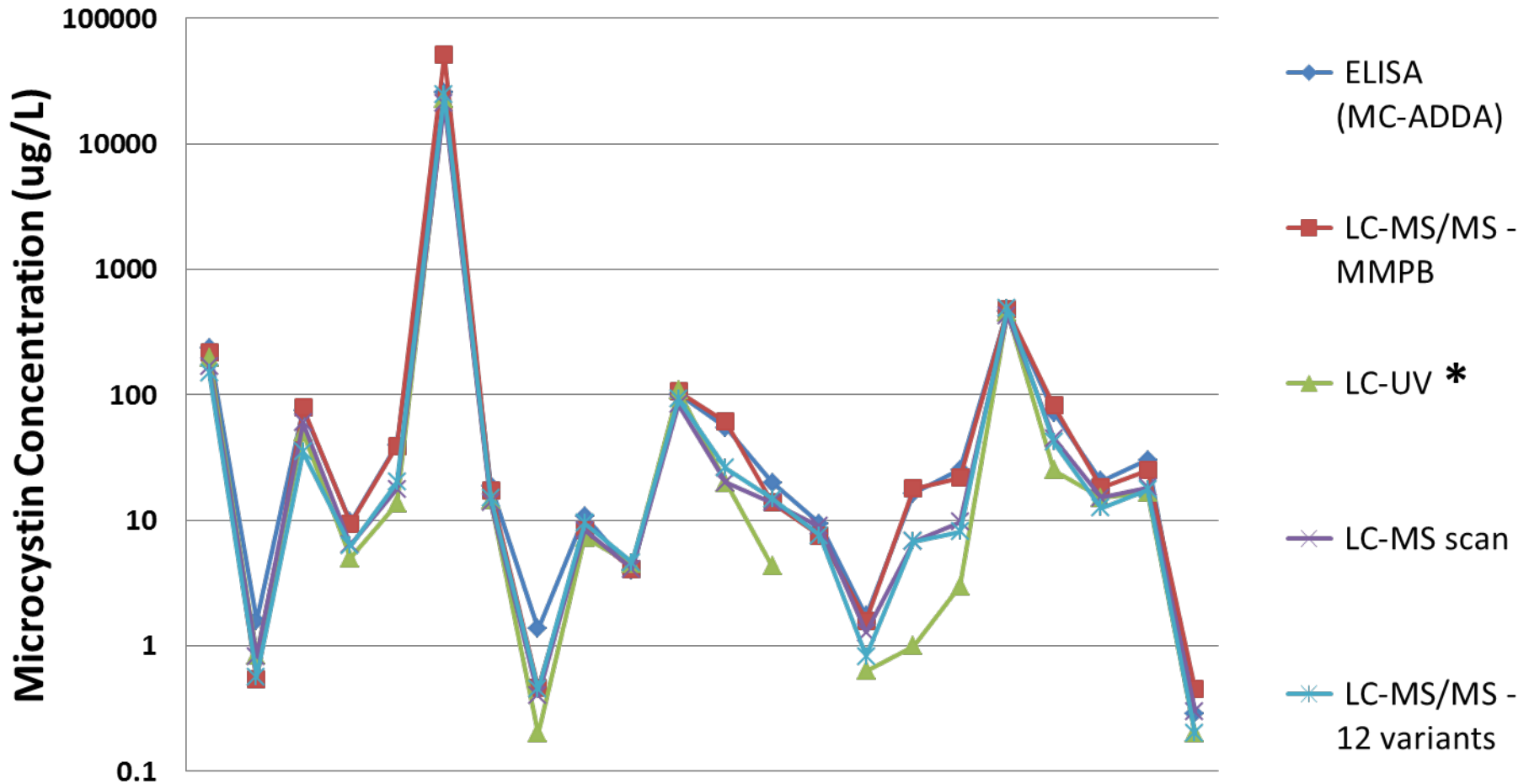
- MMPB (2-methyl-3(methoxy)-4-phenylbutyric acid) method analyzes the chemically cleaved Adda group common to all microcystin variants
 - Measures total microcystins (all variants)
 - Quick (~2 hours, does not require freeze/thaw or sonication)
 - Sensitive (0.05 ug/L)
 - Suitable for raw and finished water
 - Does not require standards for individual congeners
-
- Does not provide data on individual congeners

Toxicon 104 (2015) 91-101 (Foss & Aabel): Using the MMPB technique to confirm microcystin concentrations in water measured by ELISA and HPLC (UV, MS, MS/MS)

Analytical Method Comparison & Microcystin Congener Evaluation

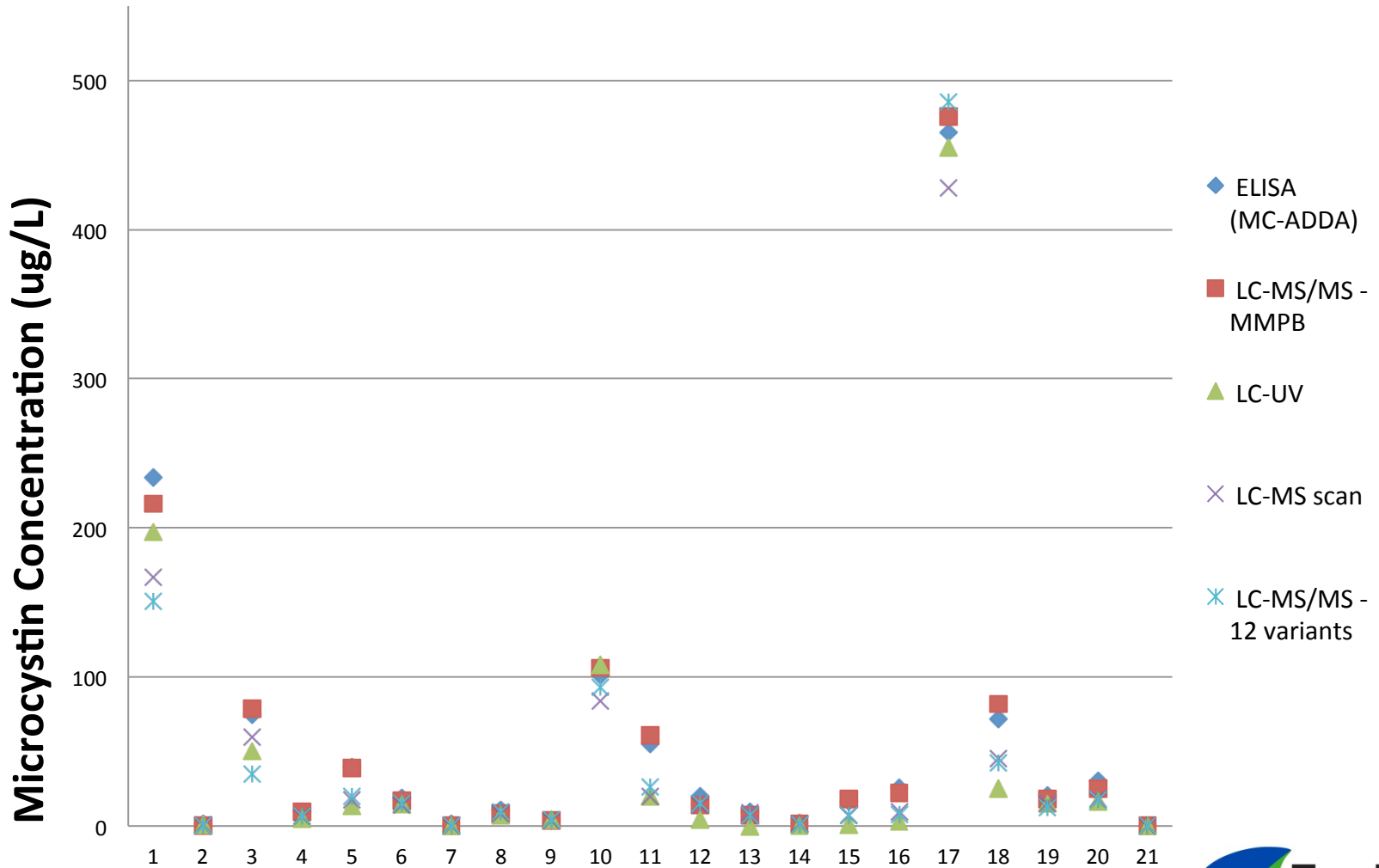
- 11 Sites: 4 Up-ground Reservoirs, 2 In-stream Reservoirs, 2 Lake Erie locations, 2 Canal-feeder Lakes, and 1 River Source.
- 22 Samples from 2014 Selected to Help Evaluate Spatial and Temporal Variability Within Source Waters
- Variety of Cyanobacteria Genera Represented
- Each Sample Analyzed Using 5 Separate Analytical Methods

Results of Method Comparison



* LC-UV data presented does not include false-positives that were eliminated from total (Based on lack of confirmation with LC-MS methods).
Sample # 14 was non-detect using LC-UV.

Analytical Method Comparison



Inland Lake Microcystin Congeners (Planktothrix)			
MC-Congener	Site 1	Site 2	Site 2
	6/16/14	6/16/14	9/2/14
[DAsp3] MC-RR	5.3	6.1	17.5
[Dha7] MC-LR	1.1	1.4	1.5
MC-YR	0.2-0.6	0.2-0.6	1.2
MC-RR		0.1-0.3	

Inland Lake Microcystin Congeners (Mixed Bloom)				
MC-Congener	Site 1	Site 2	Site 2	Site 3
	6/18/14	6/18/14	7/9/14	6/30/14
[Dha7] MC-RR	2.9	3-9	1.0	0.08
MC-RR	1.4	39	1.0	0.01-0.03
MC-YR	1.1	15	1.0	
MC-LR	4.0	67	2.4	0.55
[DAsp3] MC-LR	0.6	18	0.4	0.03
[Dha7] MC-LR	3.6		1.0	0.05
MC-WR	0.2-0.6		0.2-0.6	
MC-LA	0.2-0.6			
MC-LY	0.2-0.6	6	0.2-0.6	0.10

Ohio Microcystin Variant Data

MC-Variant	USEPA 544
MC-YR	Yes
[Dha7] MC-LR	No
[DAsp3] MC-RR	No
MC-LR	Yes
MC-RR	Yes
MC-LY	Yes
MC-WR	No
[DAsp3] MC-LR	No
MC-HiLR	No
MC-LA	Yes
[Dha7] MC-RR	No
MC-FR	No
[DAsp3] MC-FR	No
6.9 min 1049.5 m/z	No
7.5 min 1029.5 m/z	No
8.7 min 1043.5 m/z	No
MC-LF	Yes

Key Findings

- LC-based Methods Confirmed ELISA Results
- 16 Different MC-congeners were detected
- MC-LR was only detected at 5 of 11 sites (45%)
- Most common congeners were: MC-YR, [Dha7] MC-LR and [DAsp3] MC-RR
- HPLC-PDA Methods Prone to Interference, Especially at Lower Concentrations
- Generally, the Dominant/Co-Dominant Congener Did Not Vary Spatially nor Temporally
- Secondary and Minor Congeners Present Did Vary Spatially and Temporally
- 91% of sites had MC-congeners not detectable by USEPA Method 544

2015 PWS HAB Response Strategy

Analytical Methods

	Microcystins (µg/L)	Cylindro- spermopsin (µg/L)	Saxitoxins (µg/L)	Anatoxin-a (µg/L)
Surveillance sampling	ELISA (MC-ADDA)	ELISA	ELISA	LC-MS/MS
Repeat sampling in response to a finished water detection	ELISA (MC-ADDA)	LC-MS/MS	LC-MS/MS	LC-MS/MS

ELISA: Enzyme-Linked Immunosorbent Assay

LC-MS/MS: Liquid Chromatography followed by tandem Mass Spectrometry

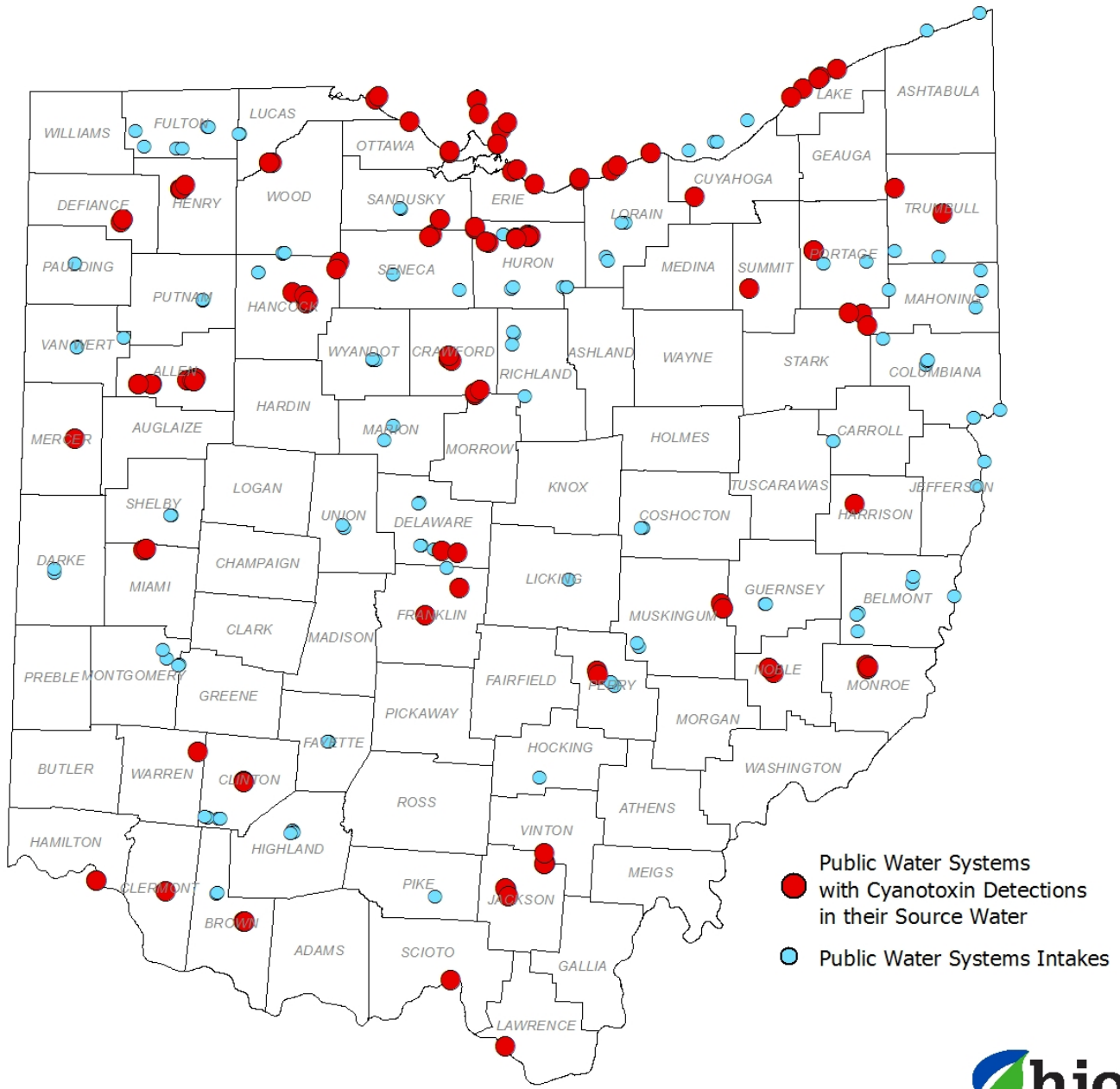


Microcystins Occurrence

- Over 3000 raw water samples have been collected at Ohio public drinking water sources
 - Sampled ~1/2 of all surface water systems
 - 46% of samples had microcystins concentrations $> 0.30 \text{ ug/L}$
 - 23% of samples were $> 1.6 \text{ ug/L}$
 - Maximum concentration $> 20,000 \text{ ug/L}$
- Finished water microcystins detections at 8 public water systems
 - **5 finished water detections in 2015: No advisories**



Public Water Systems with Cyanotoxin Detections in their Source Water (54 Total)



- Public Water Systems with Cyanotoxin Detections in their Source Water
- Public Water Systems Intakes

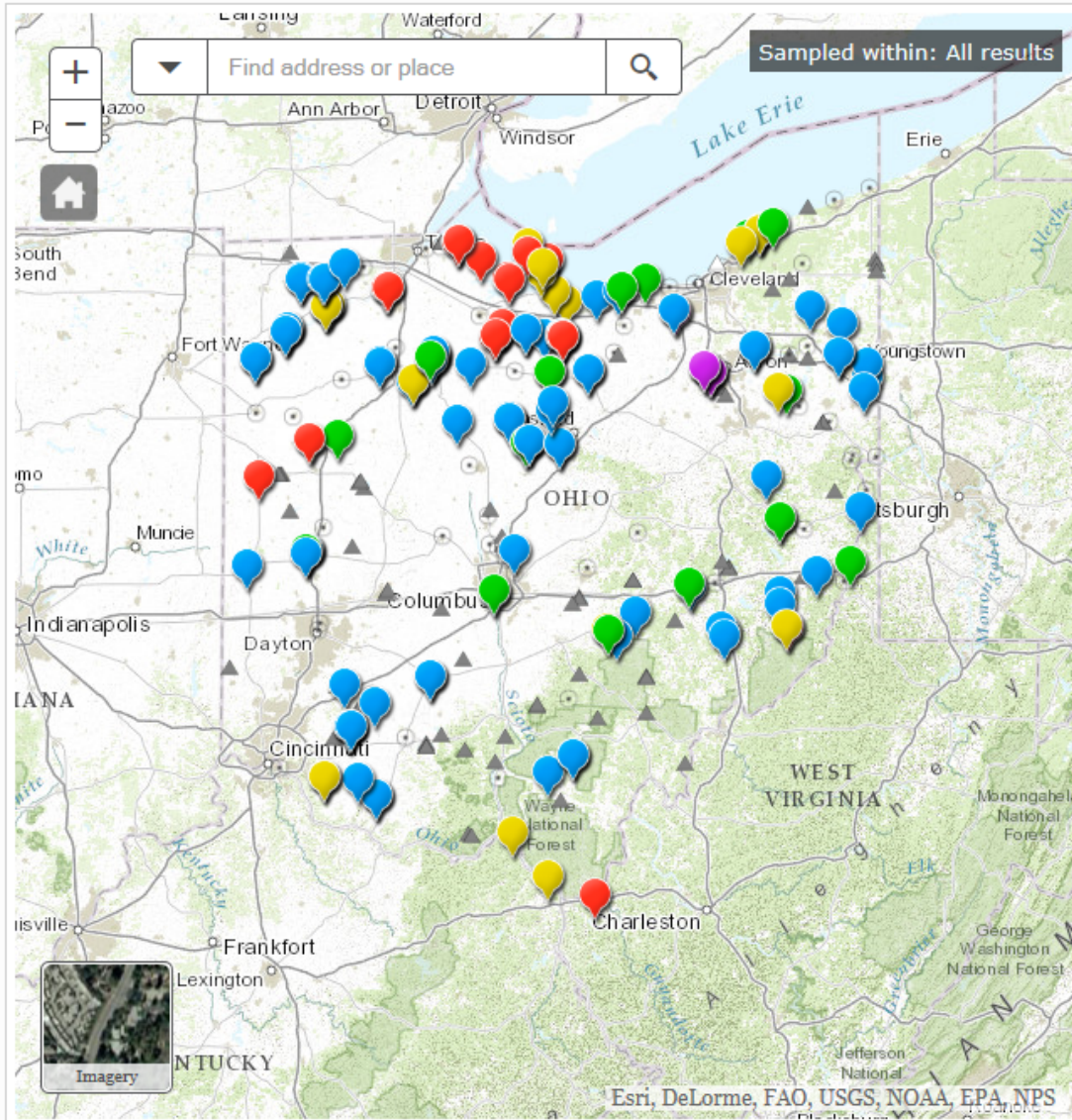
0 25 50 Miles



September 25, 2015

Sampled 1/2 of all SW PWSs

Harmful Algal Blooms: Cyanotoxin Monitoring in Ohio



Legend Toxin Results About this site

Filter the sampling sites by time period or type.

Sites sampled within:






- 7 days
 14 days
 30 days
 90 days
 1 year
 All

Type of Sampling Sites:








- Lakes
 Rivers
 Groundwater
 PWS Reservoirs/Intakes
 Finished Drinking Water
 ODNR Beaches
 All sites

[Download](#) all results (excel file).

Microcystins Concentration

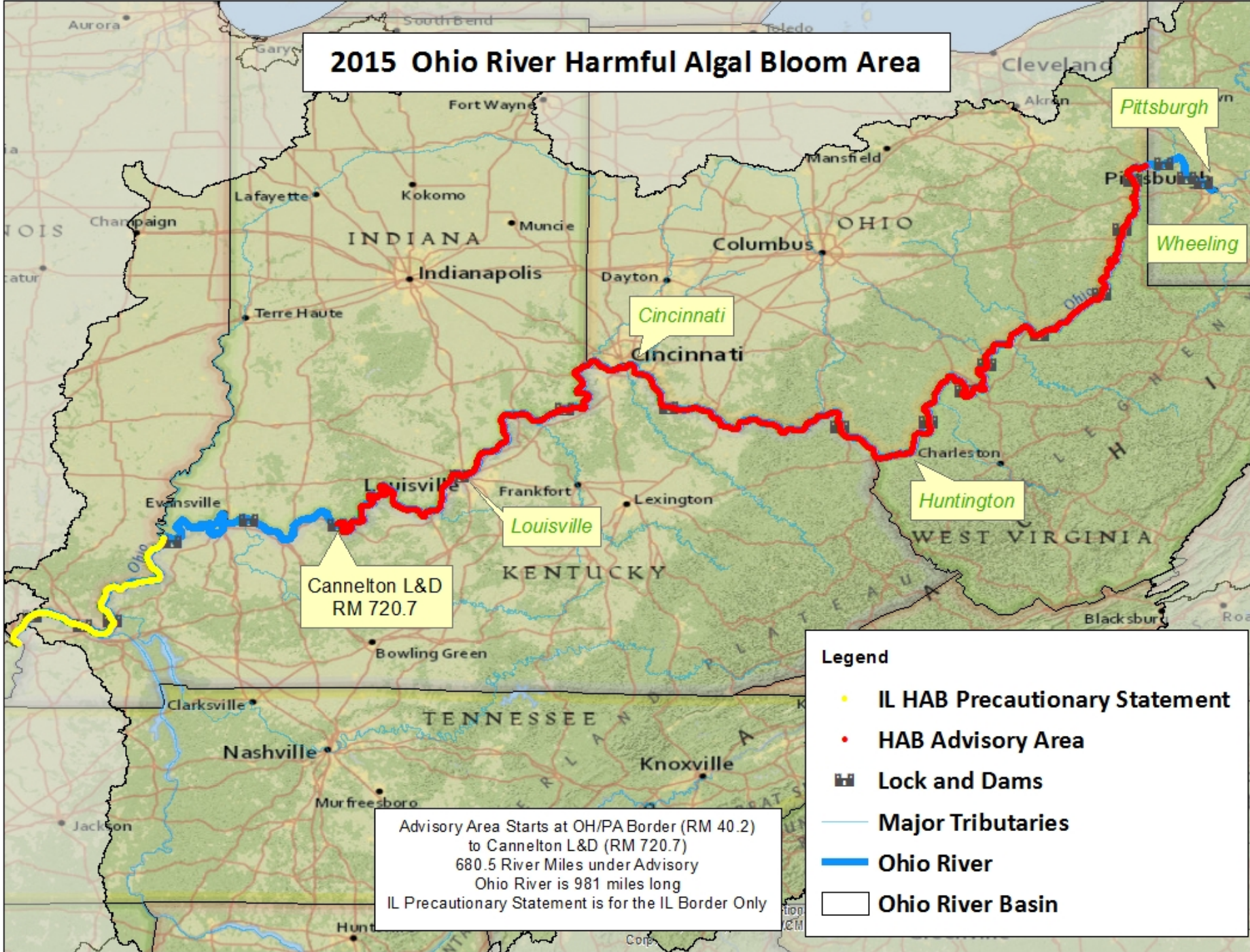
-  Below detection (<0.30 µg/l)
-  Between 0.30 - 1.6 µg/l
-  Between 1.6 - 6 µg/l
-  Between 6 - 20 µg/l
-  Greater than 20 µg/l

Site Type

-  Public Water System (PWS) Finished Water
-  Reservoirs/Intakes (PWS)
-  Lakes & Rivers
-  Groundwater
-  PWS (no data)
-  ODNR State Park Beach (no data)
-  Non-ODNR Beach (no data)

Markers on the map show sites sampled for microcystins during the selected time period. Marker color indicates that one or more results for that time period were within the range indicated by the marker color. Marker shape indicates the type of sampling site. Concentration Units µg/l - micrograms per liter

2015 Ohio River Harmful Algal Bloom Area



Aerial Helicopter Surveys Not in Job Description



Site 1: Cincinnati and Northern Kentucky Intake Region



Site 1: Cincinnati and Northern Kentucky Intake Region



Site 6: Higginsport



Site 7: Maysville Intake



Site 9: Portsmouth Intake



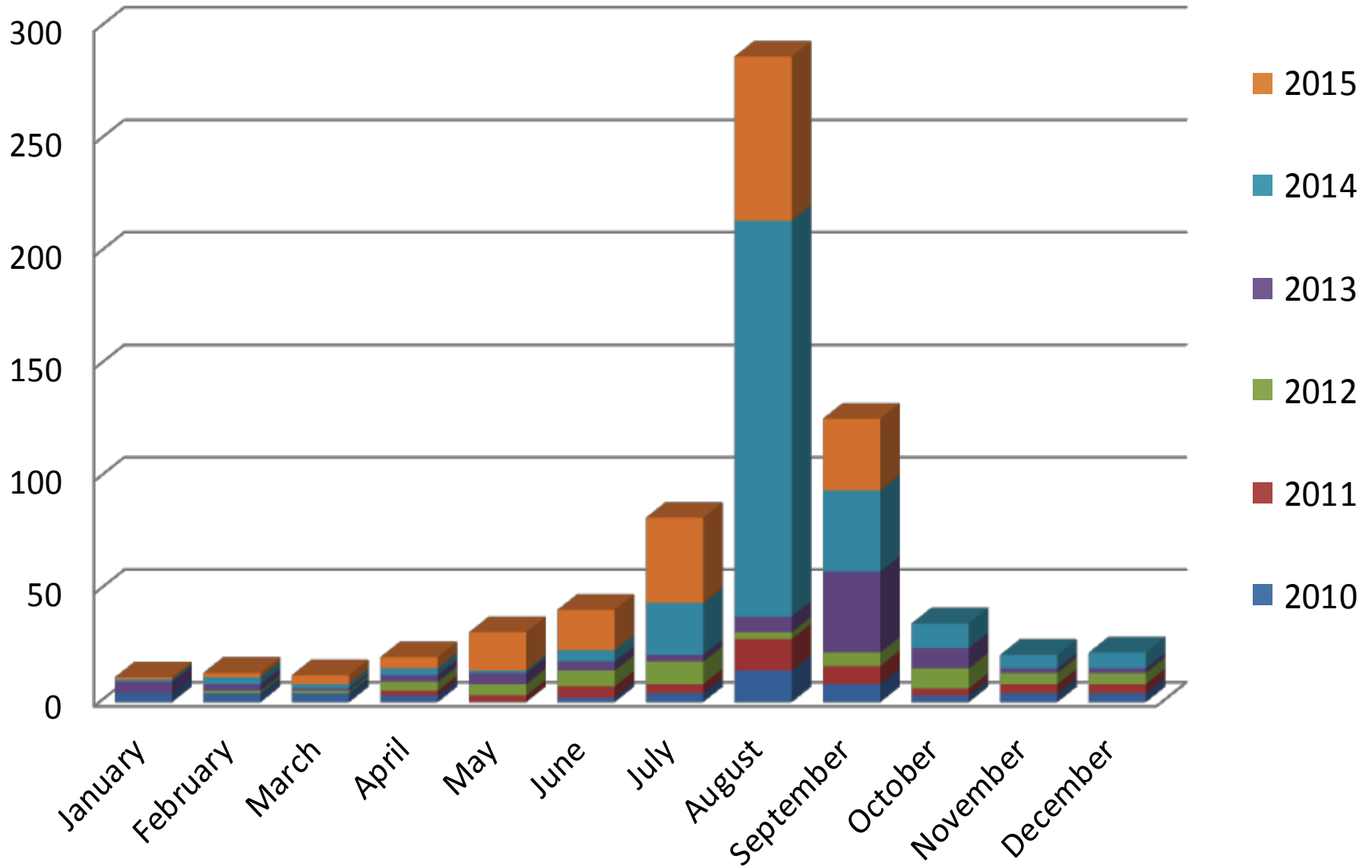
Site 10: Russel Intake



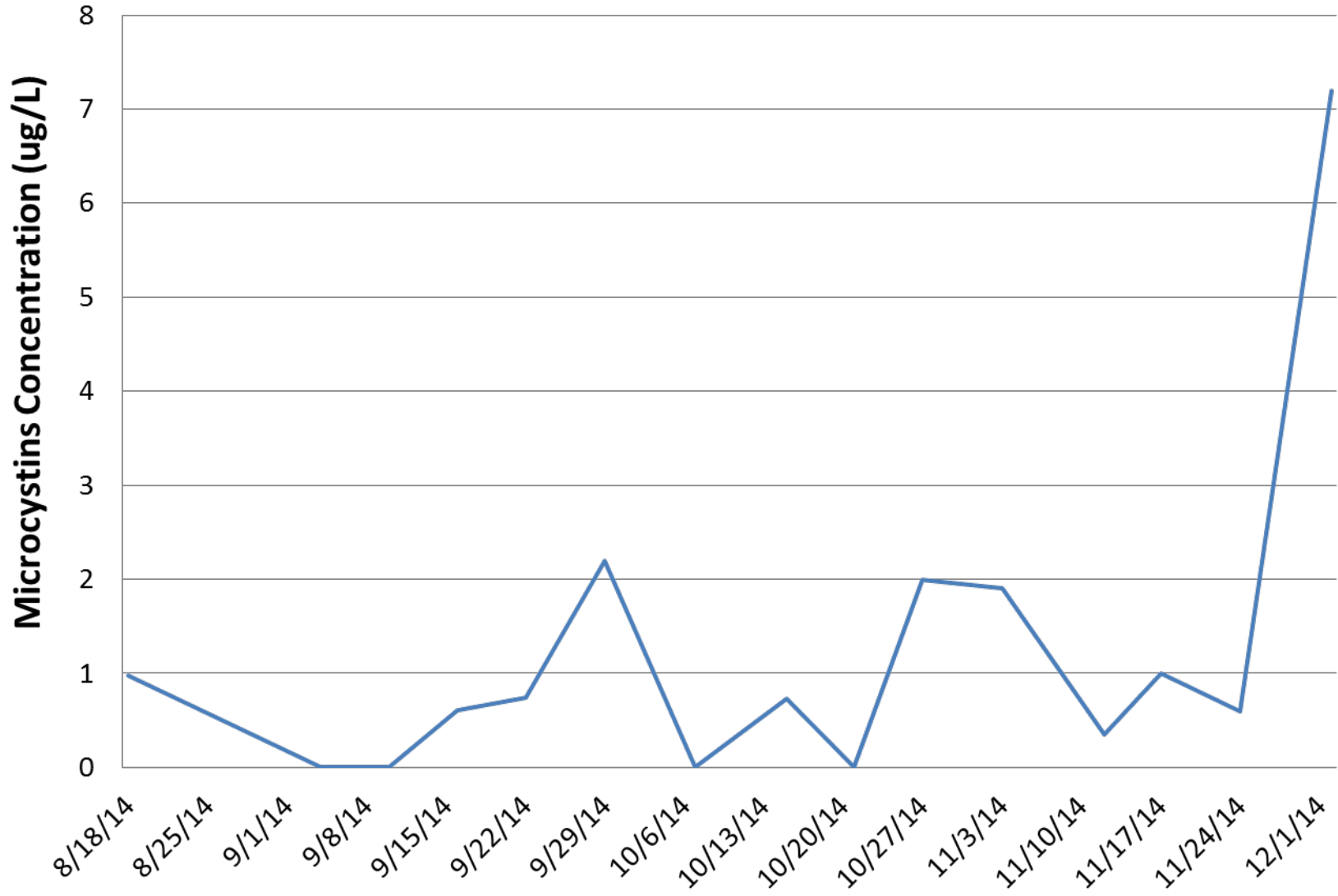
Site 11: Ironton Intake

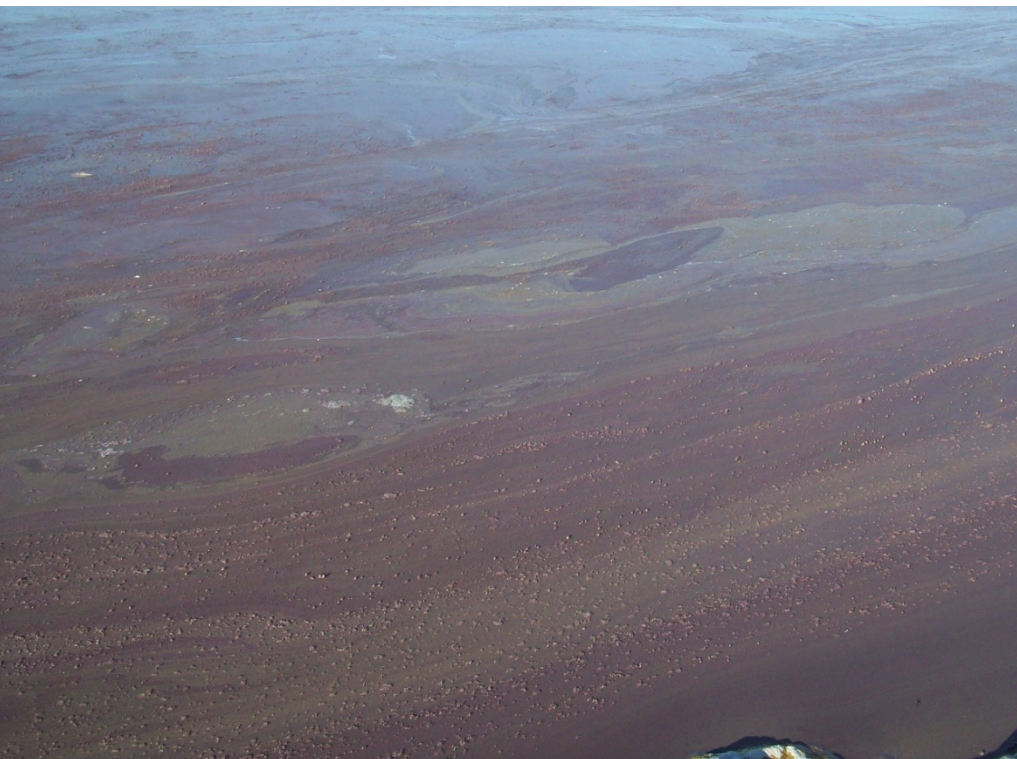
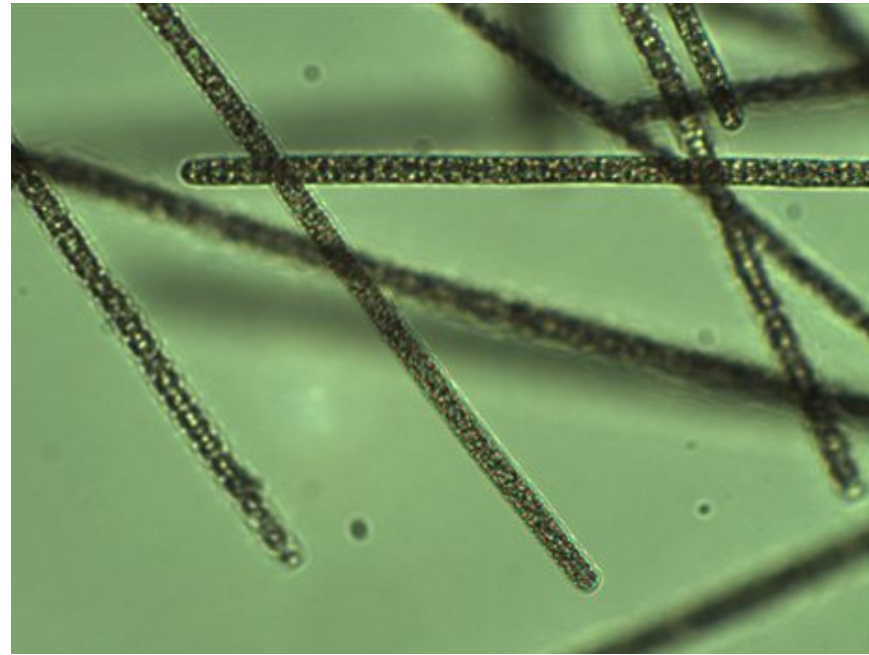


Seasonal Variations in Microcystins Concentrations in PWS Source Waters (Microcystins > 1.6 ug/L)



Microcystin Concentrations at Cadiz Lower Intake on Tappan Lake (Raw Water)



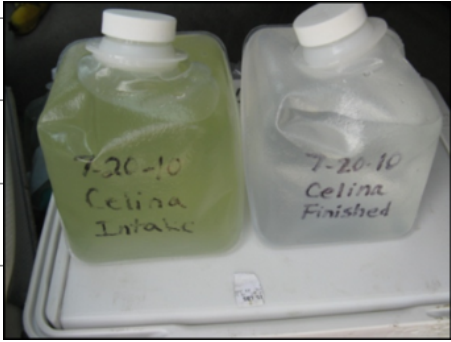
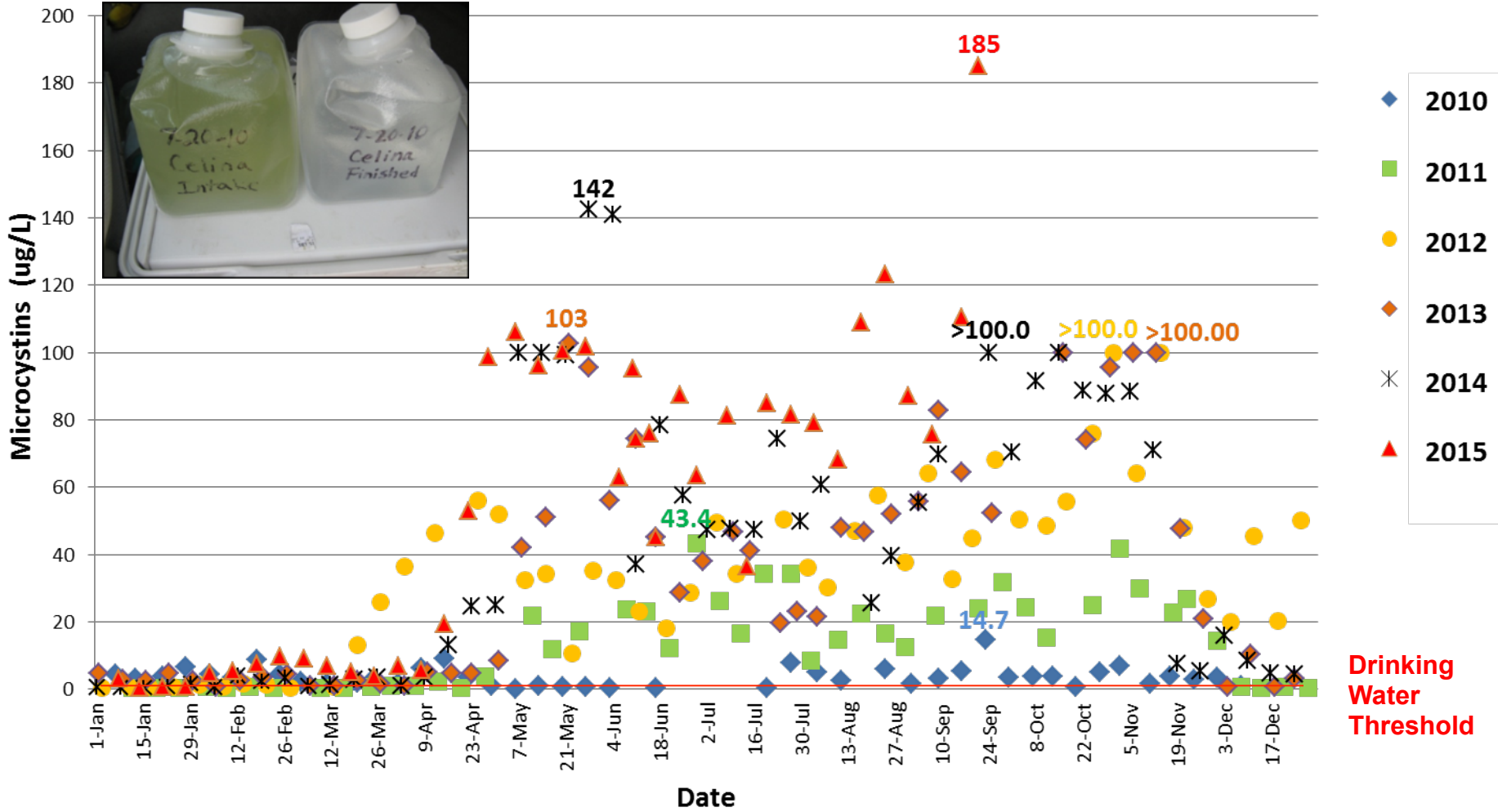


**William's Reservoir
November, 2012**

**Microcystin
Concentration: 1400 ug/L**



Grand Lake St. Marys Microcystin Concentrations at City of Celina Intake (Raw Water)





Celina Intake on Grand Lake Saint Mary,
September, 2015

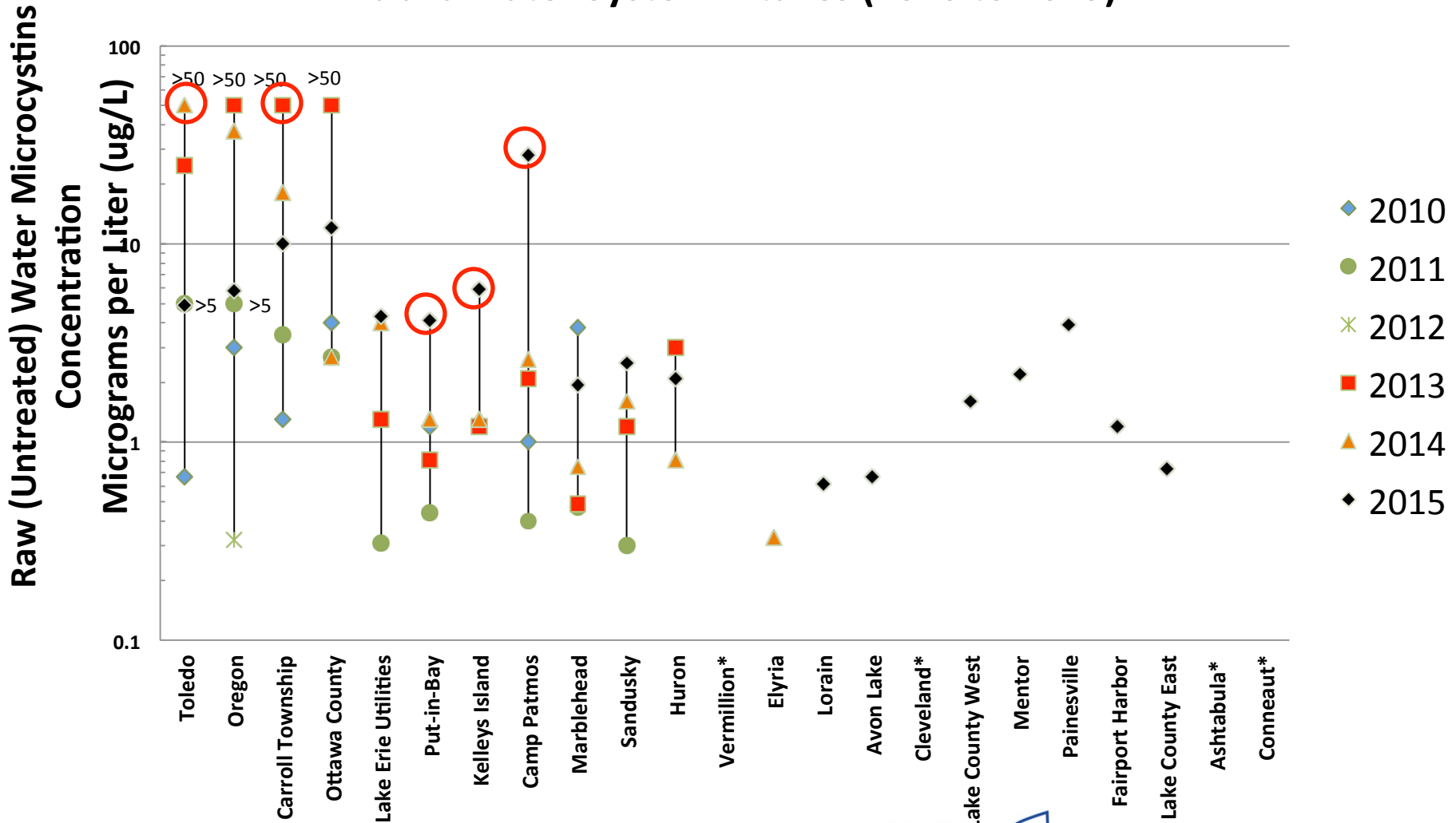
Planktothrix Bloom, Microcystins 185 ug/L



Very visually striking and overwhelming odor!
Low DO resulted in a fish kill.



Maximum Microcystin Concentrations at Lake Erie Public Water System Intakes (2010 to 2015)



*microcystins were not detected above reporting level of 0.30 ug/L at these locations

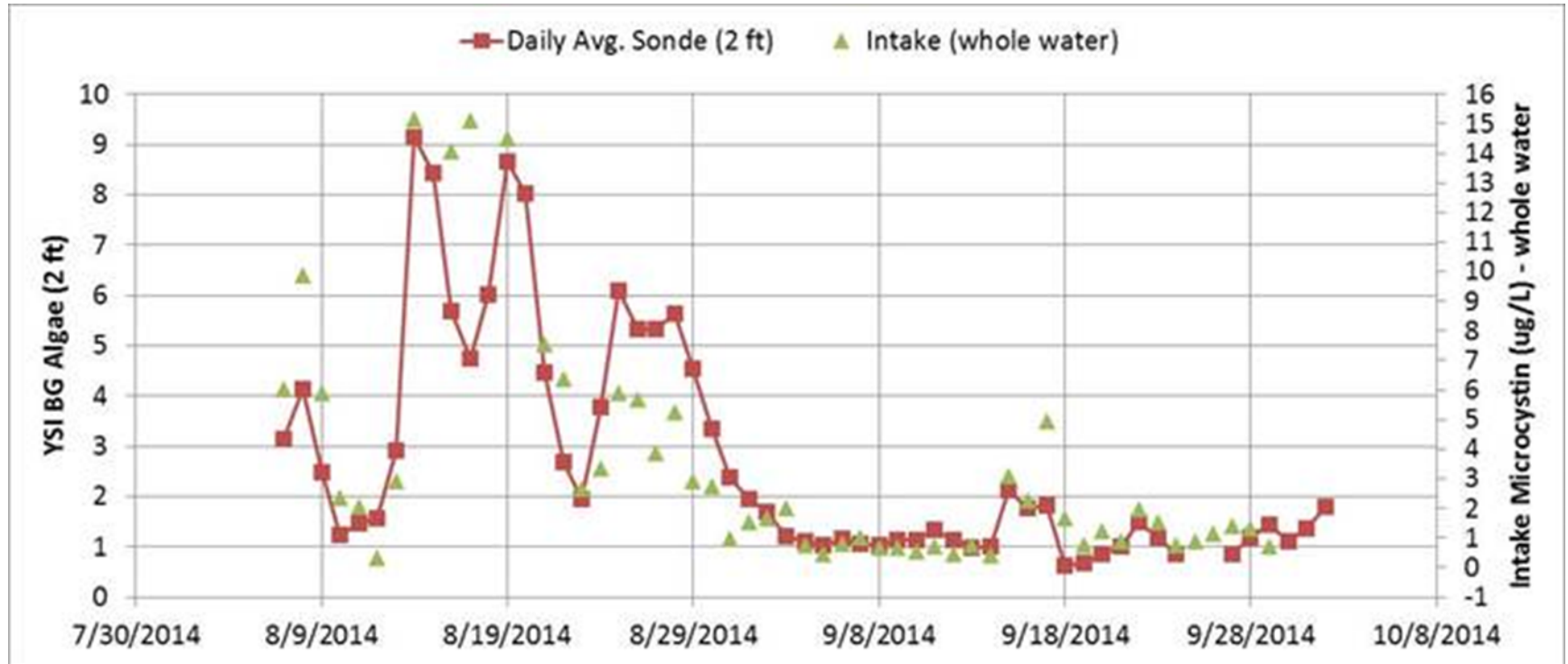


Phycocyanin/Chlorophyll-a Sensors

- Install at intake structure or wet well
- Lab Instruments
- Hand-held units
- Information available on DDAGW HAB Website



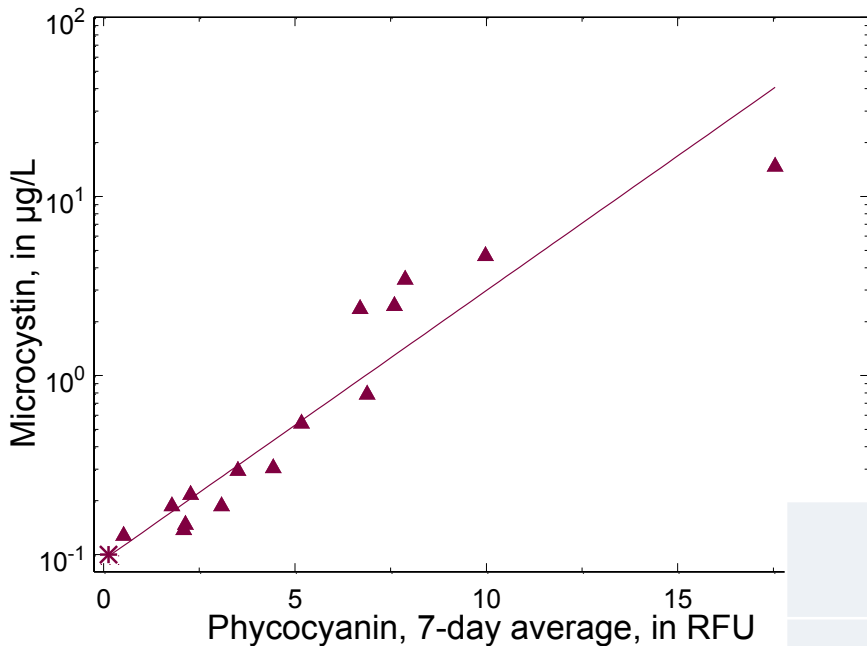
Correlation Between Microcystin Concentration and Phycocyanin Fluorescence at Toledo's Intake



-Graph provided to Ohio EPA by Ed Verhamme, Limnotech.



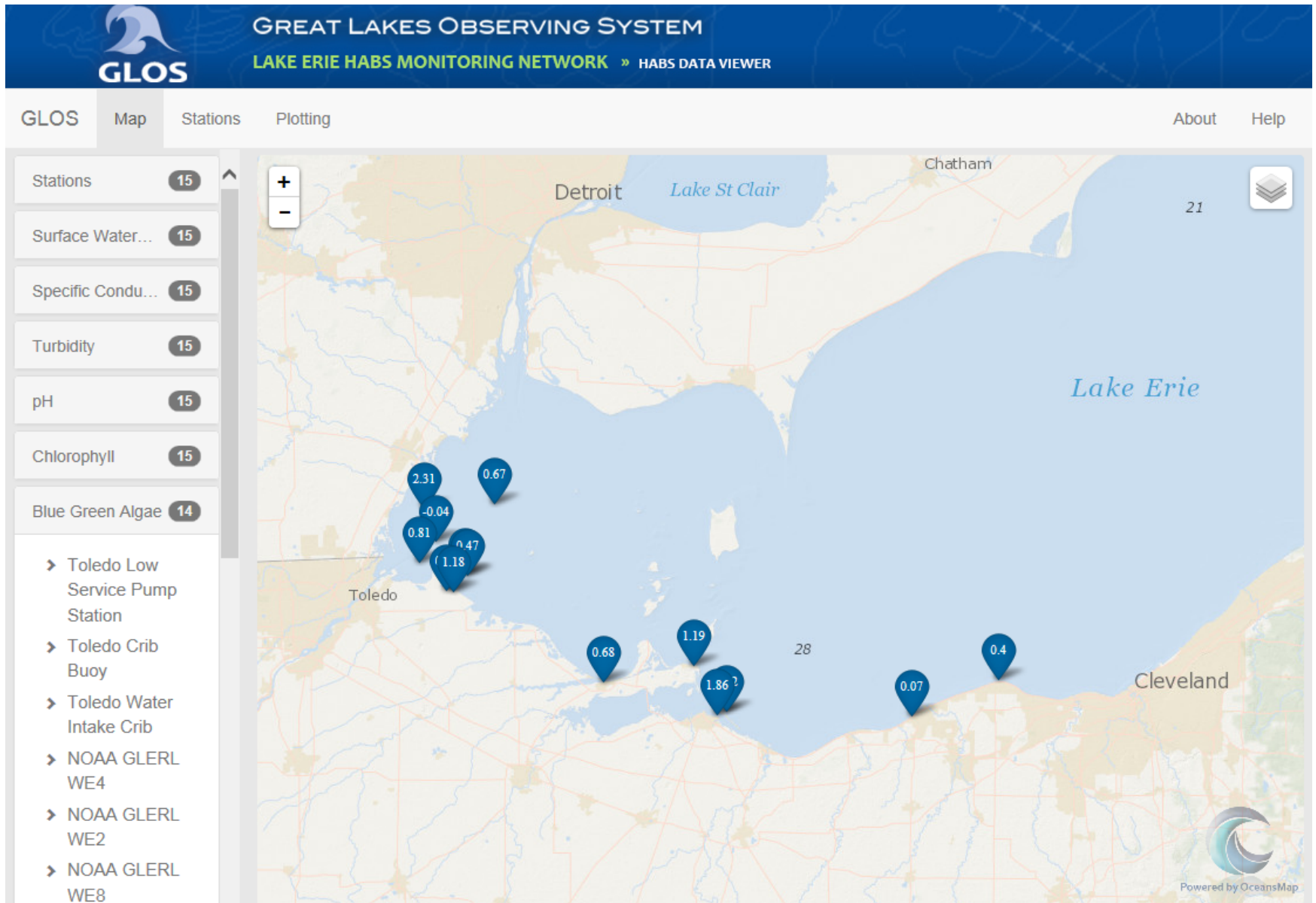
Harsha Main 2014— USEPA Continuous Monitor



Spearman's correlation to microcystin concentrations	rho	p
Phycocyanin, 7-day average	0.98	<0.0001
Dissolved oxygen, 14-day average	0.88	<0.0001
pH, 7-day average	0.83	<0.0001
Temperature, instantaneous 10 a.m.	0.73	0.0031
Chlorophyll, 24-hour average	0.53	0.0358
Specific conductance, 3-day average	-0.20	0.4473

Data Courtesy USGS

GLOS Lake Erie HAB Data Repository



Draft Rules: Increased Monitoring

- 3 days/week, if microcystins above 5 µg/L in the raw water
- Daily if microcystins detected in finished water
- Action level exceedance in finished water: Initiate 3 R's
 - **Reanalyze.** As soon as possible but no later than 24 hours, reanalyze sample with finished water detection
 - Refer to Contingency Plan; optimize treatment
 - **Resample.** As soon as possible but no later than 24 hours, collect and analyze another raw and finished water sample
 - Consider extracellular and intracellular toxin analysis; treatment train sampling
 - **Repeat.** Collect and analyze raw and finished repeat samples within 24 hours of receiving resample results.
 - If a finished water resample or repeat sample exceeds an action level, notify any consecutive systems and collect distribution samples

Draft Rules: Tier 1 Public Notification

- Repeat finished water sample exceeds an action level
 - unless Director approves extension or waiver based on extenuating circumstances
- Based on the results of resamples or distribution system samples, if required by the Director
- Failure to collect repeat samples
- May limit distribution of public notice (see Policy revisions)
 - Demonstrate cyanotoxins remain below the action level in portions of the distribution system which would not be included
 - Ongoing daily distribution monitoring (microcystins and chlorine residual)
 - Modeling, finished water travel time, and chlorine residual contact time
 - Include procedures for making this demonstration in Contingency Plan
 - Obtain written permission (email is acceptable)

Draft Rules: Treatment Technique Requirements – Treatment Optimization Protocols

- Required if microcystins are detected in raw or finished drinking water in samples
 - Detected between 7/16/15 and effective date of rule, submit within 30 thirty days of the effective date of the rule
 - Detected after effective date of rule, submit within 30 days of detection (unless previously required)
- Describe treatment adjustments that will be made under various raw and finished water conditions
- Review and optimize existing treatment for microcystins
 - avoid lysing cyanobacterial cells
 - optimize removal of intact cells
 - optimize barriers for extracellular cyanotoxin removal or destruction
 - optimize sludge removal
 - discontinue or minimize backwash recycling

Treatment Optimization

- Draft Optimization Guidelines Available
- Ongoing Treatment Optimization Site Visits at Susceptible PWSs
- Ohio EPA – AWWA White Paper
- AWWA Cyanotoxin Oxidation Calculators
- Ongoing Ohio Research Projects

Treatment Optimization Strategies for Public Water Systems with HABs

- Reduce/eliminate Pre-oxidant (minimize cell lysis)
- Reduce pH (for microcystins)
- Increase PAC feed, Optimize Type of PAC, Improve Mixing, Consider Additional Feed Points
- Maximize Coagulation
- Increase Sludge Removal
- Increase Filter Backwash Frequency & Discontinue Backwash Recycling
- Maximize Post Filtration Chlorine Feed
- Reduce Flow Through Plant (increase contact time)

Quick Response Reservoir Management Strategies for public water systems with HABs

- If there are multiple sources of raw water, isolate affected source and use others.
- If there are intakes at multiple levels, use the least affected intake (usually lower intake, sample to confirm).
- Physically remove scums.
- If sampling indicates cyanotoxins in reservoir are mostly extracellular, consider applying algaecides.

Draft Rules: Treatment Technique Requirement – Cyanotoxin General Plan

- Required if microcystins exceed 1.6 µg/L in raw water, or are detected in finished drinking water
- Within 120 days, submit general plan and implementation schedule for approval
 - \$150 fee for general plan
- Implement in accordance with approved schedule
- Include one or a combination of source water protection activities, reservoir management and in-plant treatment technologies
 - May document existing treatment is sufficient for cyanotoxin destruction or removal
 - Gives the PWS time to assess all its treatment objectives

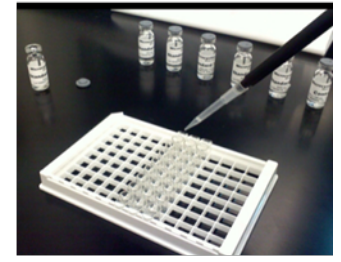
Draft Rules: Tiers 2 & 3 Public Notice (PN), Consumer Confidence Report (CCR) and Recordkeeping

- Tier 2 PN
 - Failure to submit treatment optimization protocols
 - Failure to submit or implement cyanotoxin general plan
- Tier 3 PN
 - Failure to monitor or report
- CCR
 - Include any finished water action level exceedance (including distribution sites)
- Recordkeeping
 - Keep records for 10 years



Rule Applicability

- Surface water systems
 - All requirements apply
- Consecutive (purchased) water systems
 - Routine monitoring and treatment technique requirements do not apply
 - If wholesale water system has an action level exceedance, conduct monitoring at distribution sampling points; may also be required to:
 - issue public notification
 - include in their Consumer Confidence Report
 - keep records
- Ground water systems
 - Routine monitoring requirements do not apply
 - If samples collected voluntarily by a ground water system or Ohio EPA exceed an action level, may be required to
 - issue public notification
 - include in their Consumer Confidence Report
 - fulfill treatment technique requirements
 - keep records

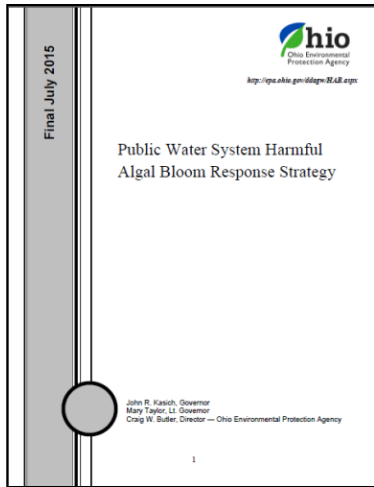


Other Cyanotoxin Occurrence

- Saxitoxin was detected in 38% of water system source water samples.
- Finished water saxitoxins detections at 3 public water systems.
- Cylindrospermopsin was detected in less than 1% of water system source water samples (maximum concentration 0.107 ug/L).
- No Finished Water Cylindrospermopsin or Anatoxin-a detections.

Integration of Rules with HAB Strategy

Ohio EPA will update the HAB strategy to incorporate the regulatory approach:



- Microcystins monitoring (and associated requirements if an action level is exceeded) will replace the current approach in the HAB Strategy
- Cyanobacteria screening will be used to determine if monitoring for cyanotoxins other than microcystins needs to be conducted by Ohio EPA (or voluntarily by the PWS)

Ohio's Public Water System Harmful Algal Bloom Response Strategy is available online at:

<http://epa.ohio.gov/ddagw/HAB.aspx>



Rulemaking Process and Timeline

- Early Stakeholder Outreach completed June 1 to 30, 2015
- Interested party review (comments by October 23)
 - Draft rules available at <http://epa.ohio.gov/ddagw/rules.aspx>
- Revise rules and BIA based on public comment and prepare response summary
- Propose rules to JCARR winter 2015/2016
- Adopt final rules by approximately June 2016
- Subscribe to our electronic mailing list at <http://ohioepa.custhelp.com/ci/documents/detail/2/subscriptionpage>

Ongoing & Future Activities

- Develop Cyanotoxin General Plan Guidance
- Coordinate Reservoir Management Training
- Continue Participation on National Workgroups
- Collaborate with Universities and Federal Partners on Applied HAB Research Projects
- Revise HAB Response Strategy

Questions?

Contact Information:

(614) 644-2752

Heather.Raymond@epa.ohio.gov

<http://www.epa.ohio.gov/ddagw/HAB.aspx>

