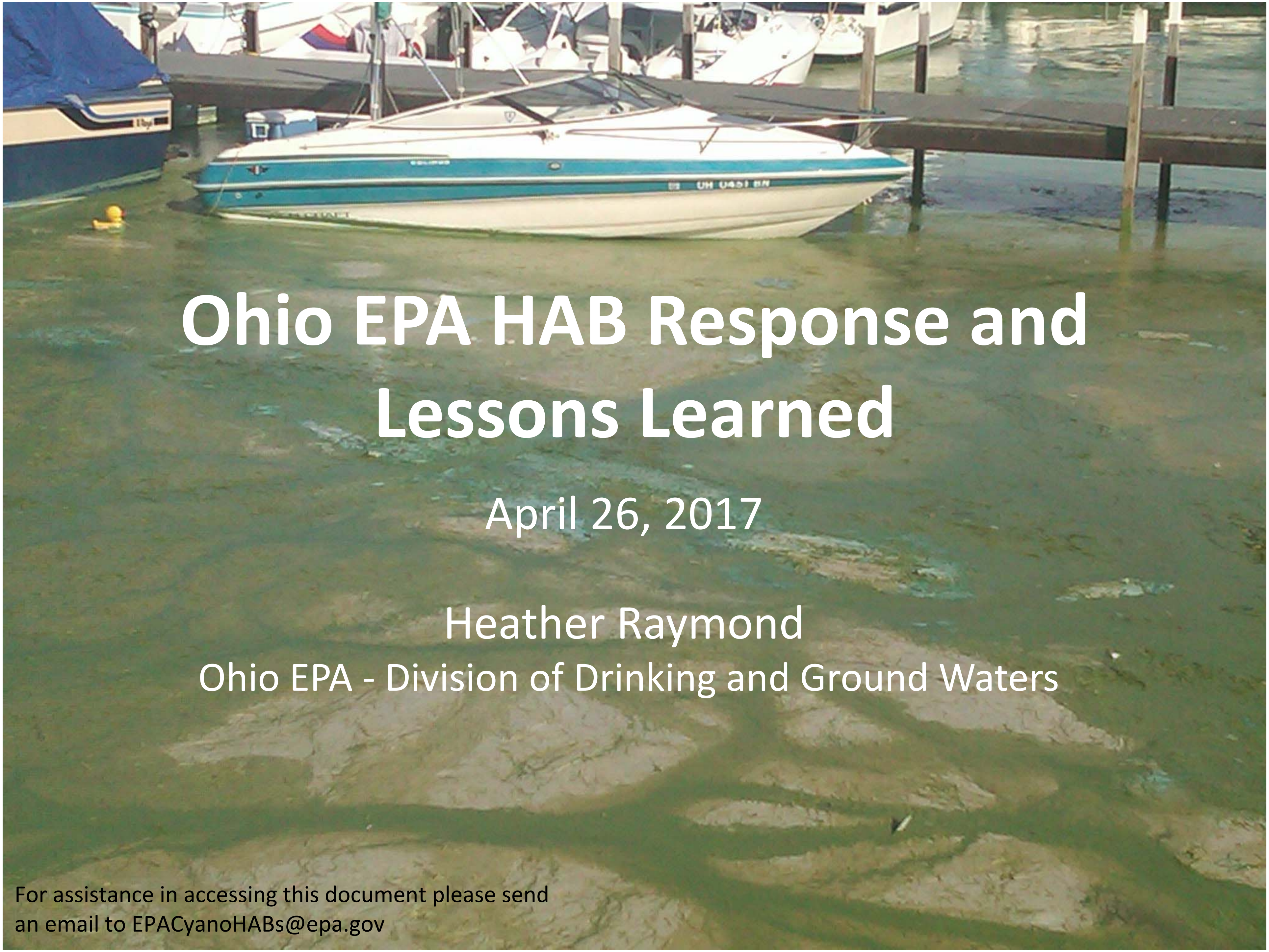


Ohio EPA HAB Response and Lessons Learned

April 26, 2017

Heather Raymond
Ohio EPA - Division of Drinking and Ground Waters

Summary of Ohio HAB Response

2010: Ohio EPA began sampling for cyanotoxins at public water systems (PWSs)

- Finished water detection at inland PWS.

2011: Ohio EPA/ODNR/ODH created Ohio HAB Response Strategy (updated annually)

2013: Finished water microcystins threshold exceedance at small PWS

- Drinking Water Advisory Issued.

2014: Finished water microcystins threshold exceedance at large PWS

- Drinking Water Advisory Issued.

2015: Revised Response Strategy to include U.S. EPA health advisories for microcystins and cylindrospermops

- Finished water microcystins detections at 5 PWSs
  - No Drinking Water Advisories Issued.
- Ohio Senate Bill 1 passed

2016: HAB Monitoring and Reporting Rules

- Effective June 1, 2016
- Updated response strategies, new treatment optimization and general plan guidance for PWSs

Ohio Environmental Protection Agency

Ohio HAB Rules Overview

HAB Rules: epa.ohio.gov/ddagw/rules.aspx

- PWS requirements - new rules in OAC Chapter 3745-90
  - Microcystins action levels in drinking water
  - Monitoring requirements: Microcystins and Cyanobacteria Screening
  - 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

epa.ohio.gov/Portals/28/documents/labcert/TotalMicrocystins.pdf

Ohio Environmental Protection Agency

Ohio Monitoring Requirements

- <u>Total Microcystins</u>

  May – October

  – Weekly raw and finished water
    - Eligible for monitoring reductions starting May 2017

  – Raw water detections >5 ug/L and any finished water detections trigger additional sampling

  November – April

  – Raw water only every other week

  – Detections trigger additional monitoring

- <u>Cyanobacteria Screening (qPCR)</u>

  All year

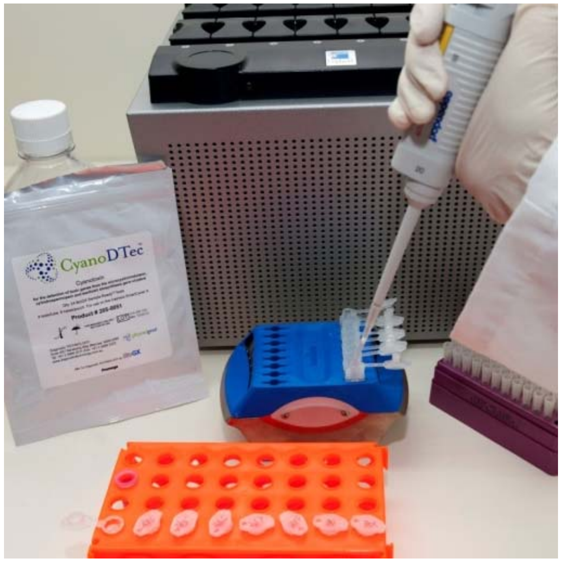
  – Biweekly raw water

  – Triggers follow up sampling by Ohio EPA for other cyanotoxins

Ohio Environmental Protection Agency

Cyanobacteria Screening: Molecular Methods (Multiplex qPCR)

- Quantitative polymerase chain reaction (qPCR) – identifies and quantifies the presence of genes unique to:
    - Cyanobacteria (16S rDNA)
    - Microcystin and Nodularin production (mcyE gene)
    - Cylindrospermopsin production (cyrA gene)
    - Saxitoxin production (sxtA gene)
  - Test completed within 2-3 hours
  - Scalable
  - Cost-effective
  - Utilizes certified reference material
  - Specific
- Ohio EPA method and certification in 2017
- Ohio EPA uses the data to trigger saxitoxins and cylindrospermopsin sampling and in 2017 will be used as trigger for microcystins monitoring.
- ***www.phytoxigene.com/products/***



Ohio Environmental Protection Agency

Rule Implementation & Monitoring Results

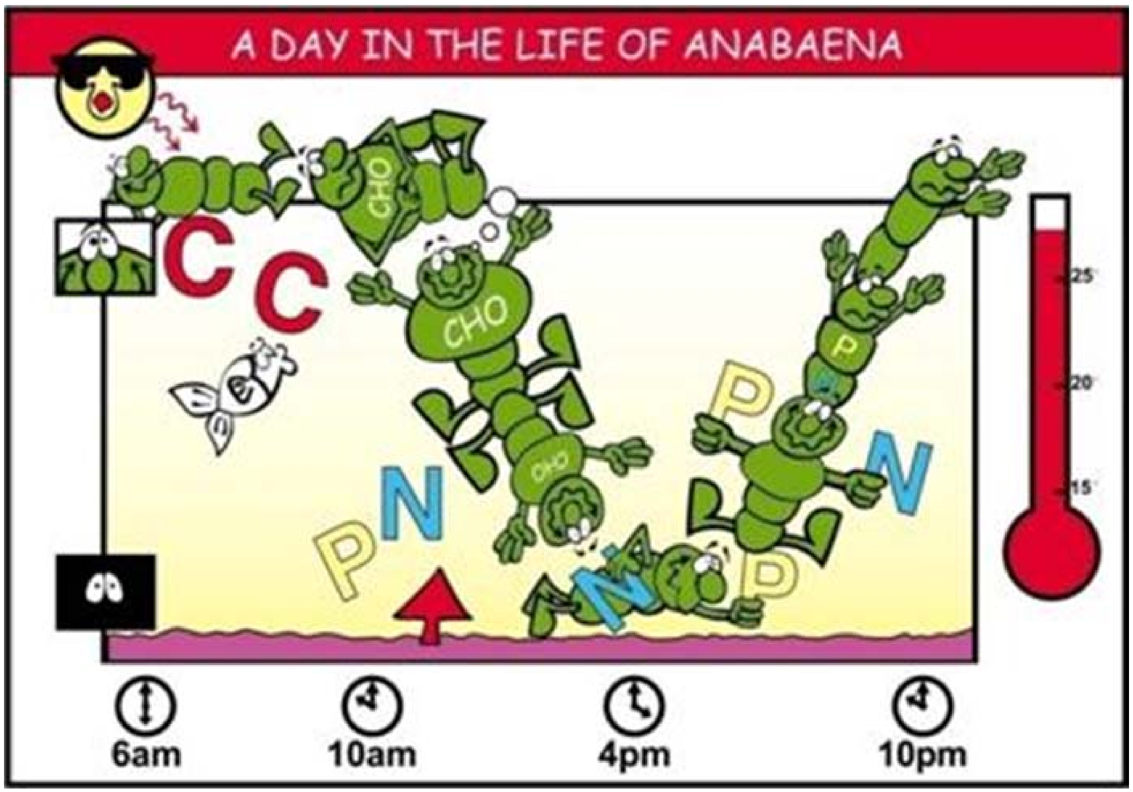
- 100% compliance with rules!
- Microcystins detected in raw water at 41 PWSs (33% of surface water systems)
- No finished water microcystins detections
- Saxitoxin genes (sxtA) detected in 33 PWSs (27%)
- Saxitoxins detected in raw water at 15 PWSs (12%); 6 finished water saxitoxins detections (none above threshold)
- Cylindrospermopsin genes detected at 1 PWS, no cylindropspermopsin detections.
- qPCR is an effective screening tool for microcystins and saxitoxins.



Ohio Environmental Protection Agency

Lessons Learned – HABs are Not Always Visually Apparent

- Many cyanobacteria do not produce surface scums
- Some cyanobacteria occur at depth in the water column or attach to a substrate (benthic)
- Some cyanobacteria move up and down in the water column

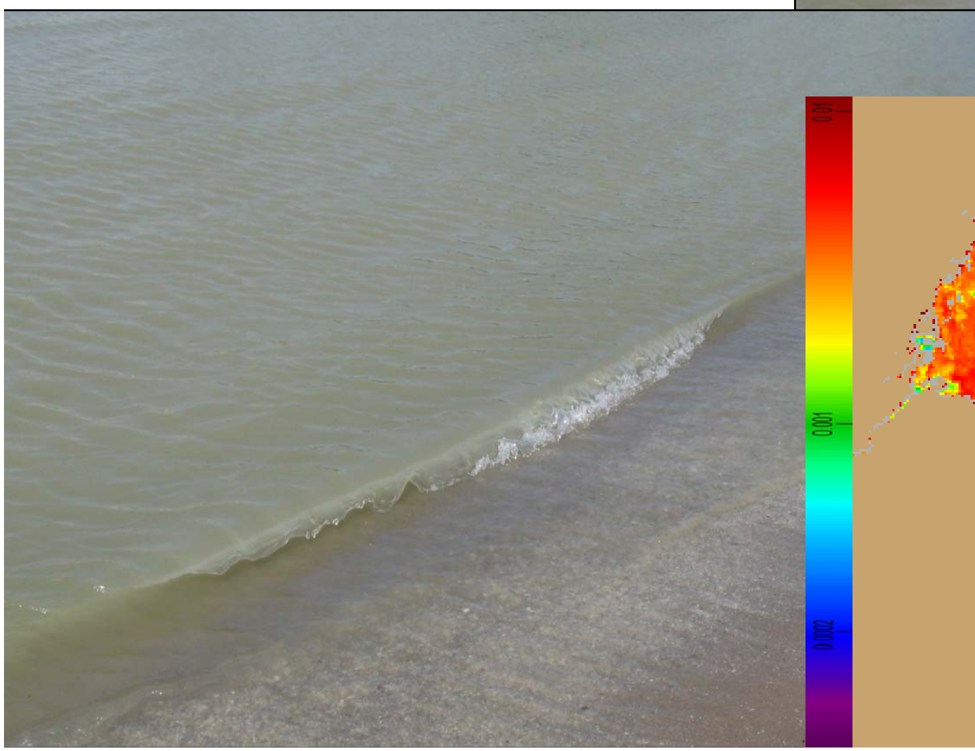


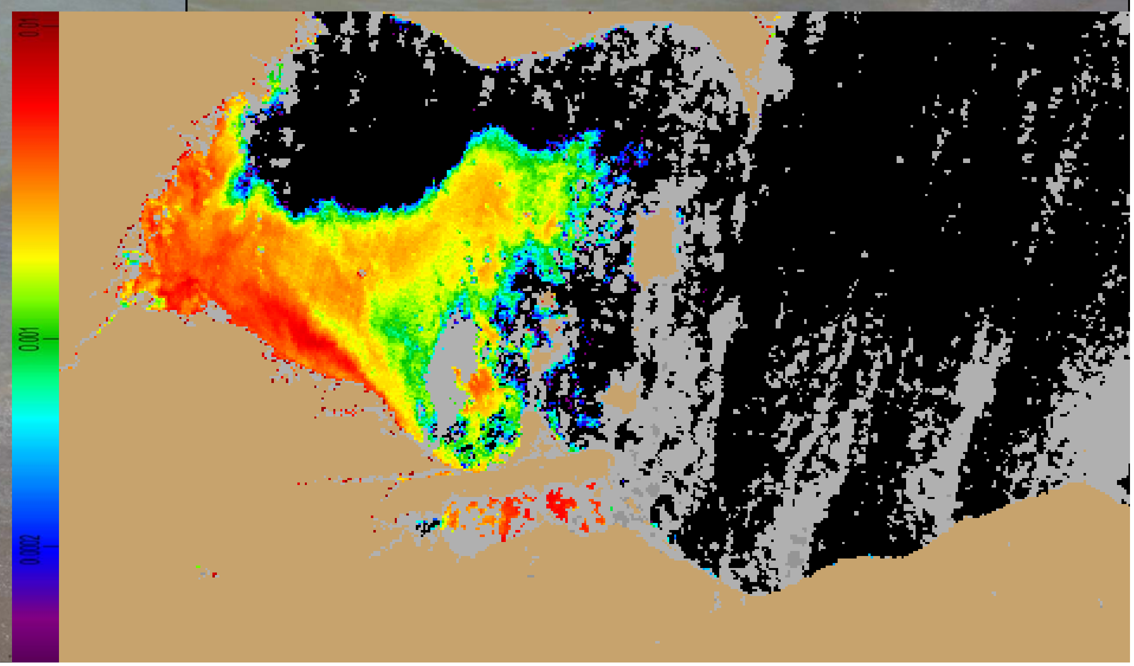
Complicates Monitoring

Ohio Environmental Protection Agency

Lake Erie Beach
Microcystis bloom
August 31, 2011

Microcystins >100 ug/L





Celina Intake on Grand Lake Saint Mary, September 2015, *Planktothrix* bloom

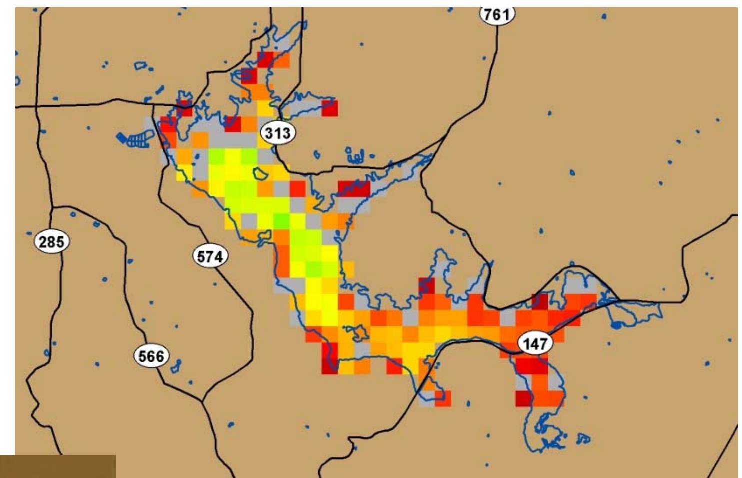
Microcystins 185 ug/L

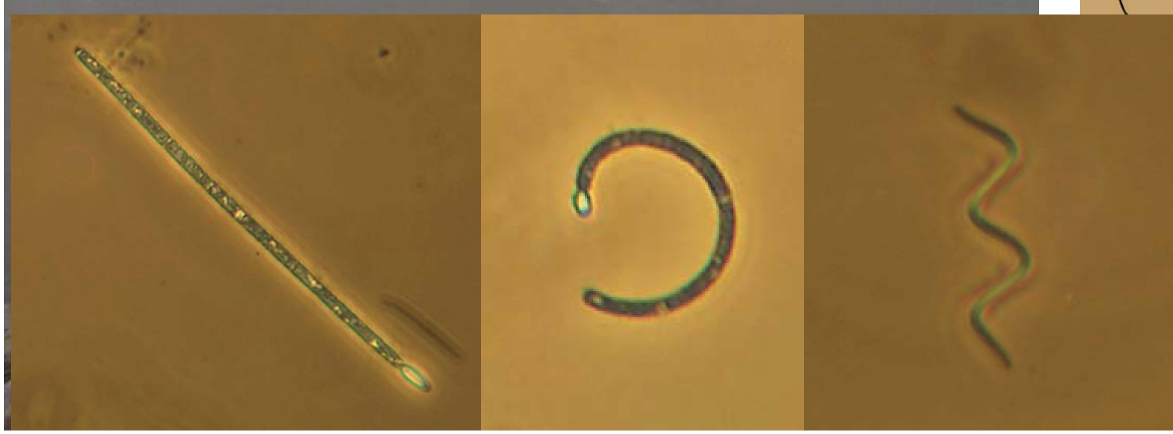
Ohio Environmental Protection Agency

Chippewa Lake, November 2016
Aphanizomenon and *Planktothrix* bloom

Average Microcystins at Beaches 48-58 ug/L

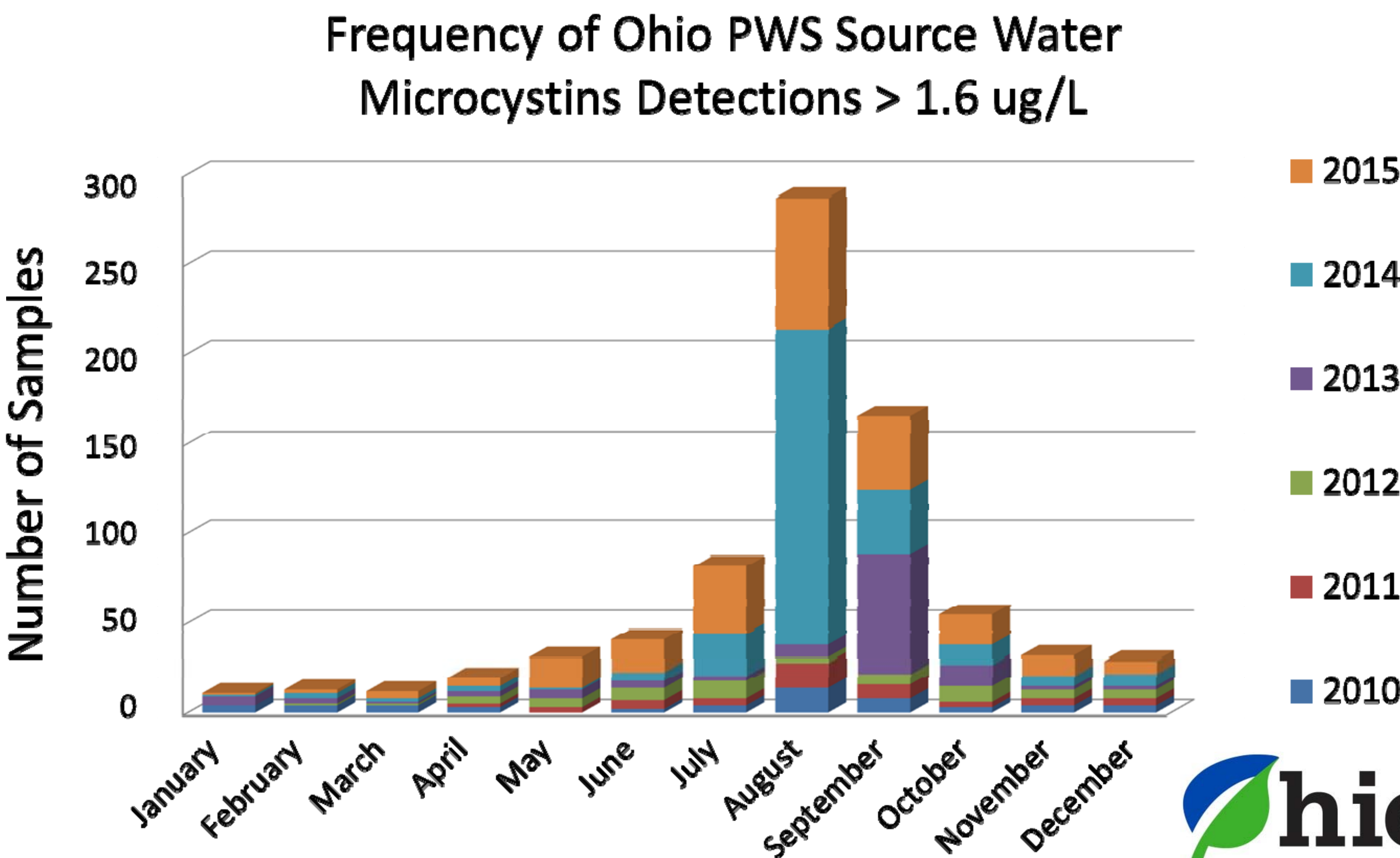
Ohio Environmental Protection Agency





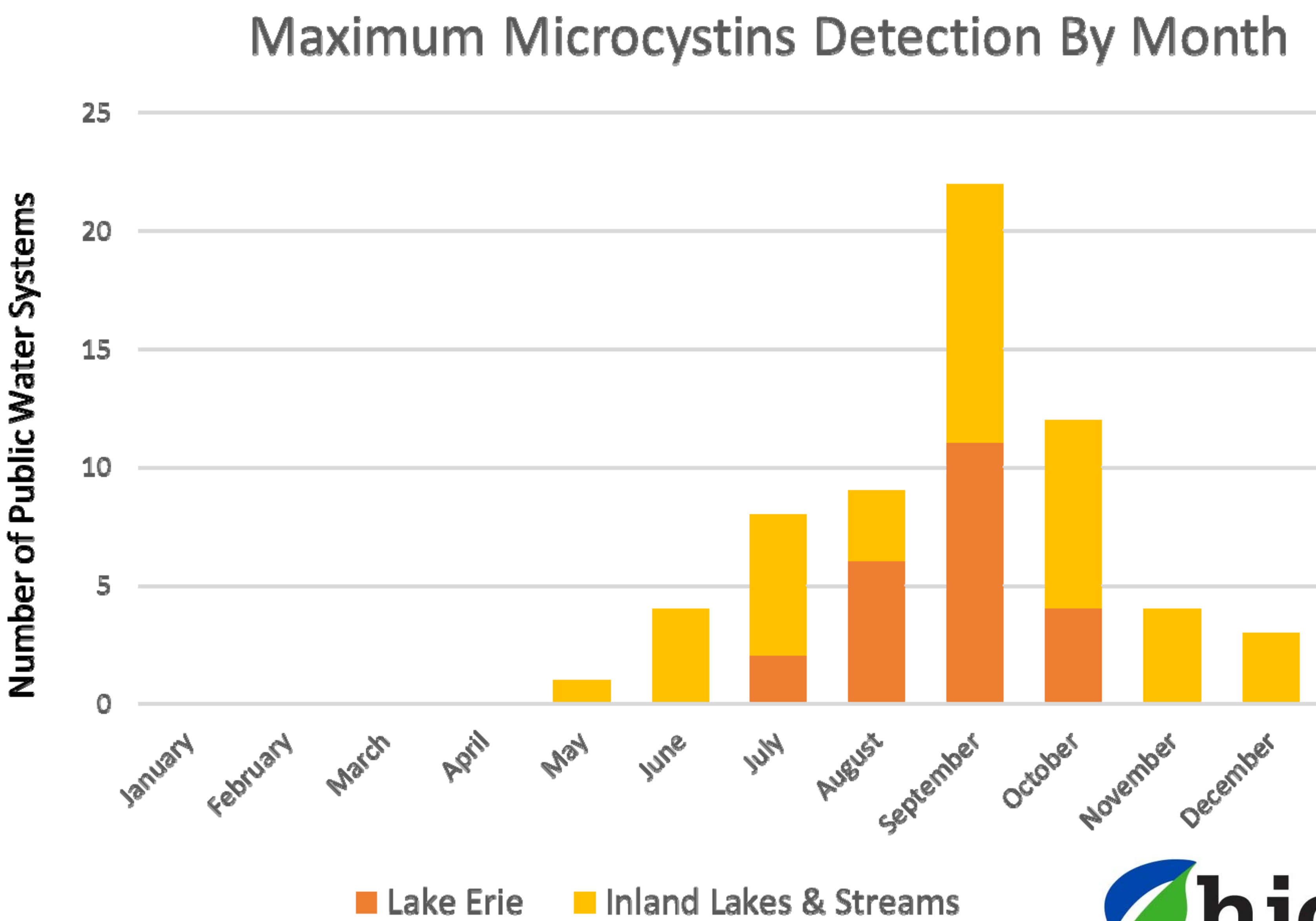
Ohio Environmental
Protection Agency

Lessons Learned – HAB Occurrence Year-Round



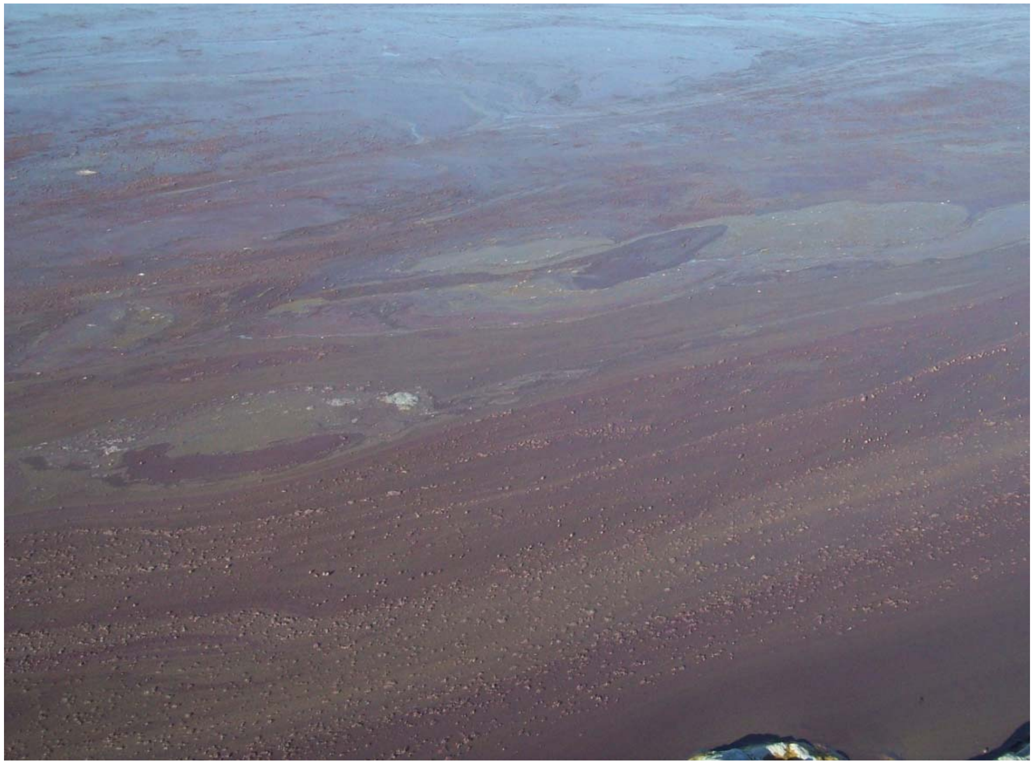
745 samples >1.6 ug/L microcystins, out of 3583 total samples (21 %).
44% of samples were > 0.30 ug/L microcystins. Does not include 2016 results.

Ohio Environmental Protection Agency



Based on Microcystins Detections at 62 Public Water Systems (2010 - 2016)

Ohio Environmental Protection Agency



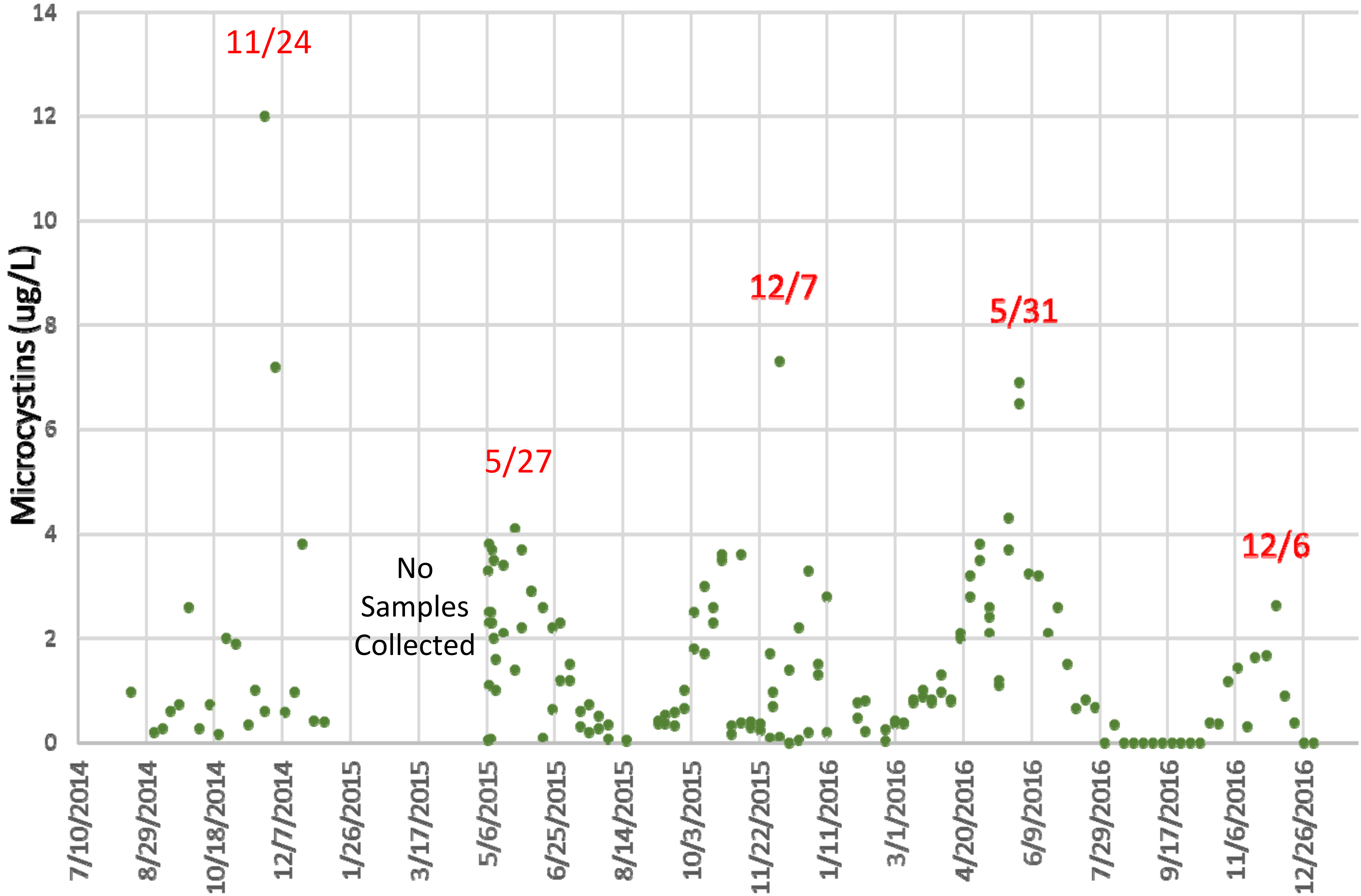
William's Reservoir
November, 2012

Microcystin
Concentration: 1400 ug/L

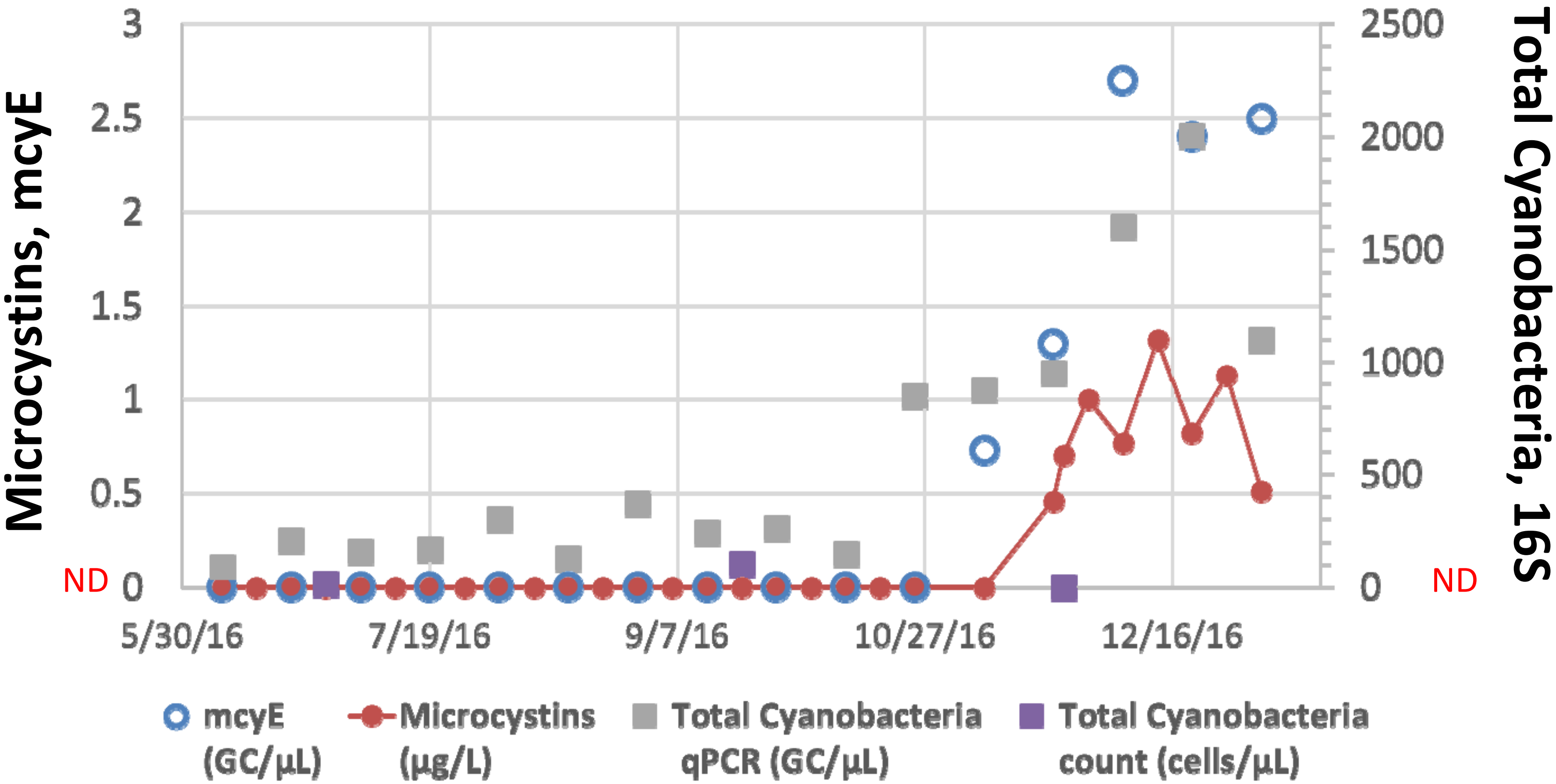
Ohio Environmental Protection Agency

Raw Water Microcystins at an Inland PWS –

Microcystins Do Not Always Peak in Summer

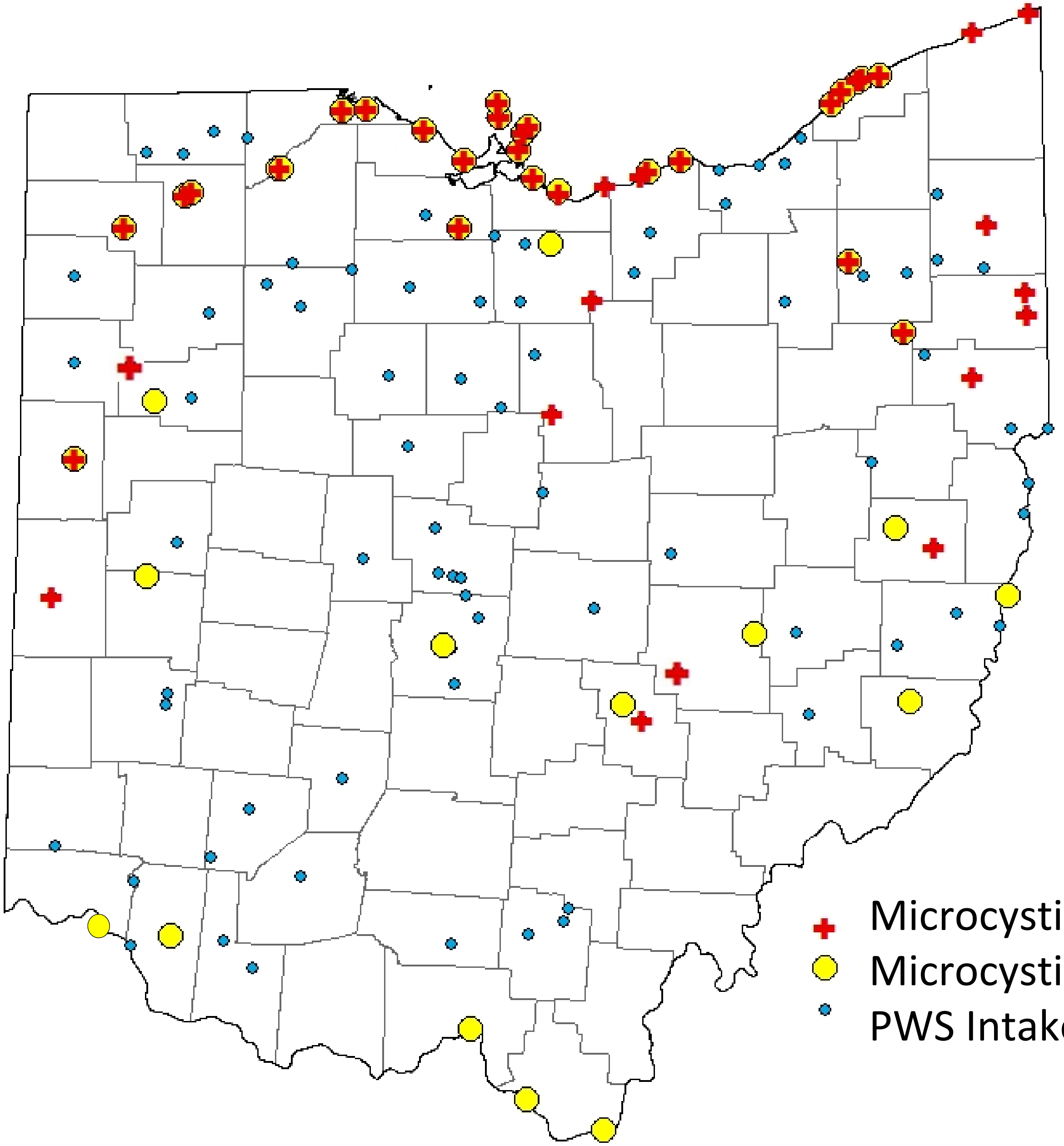


Late Fall-Winter Microcystins and qPCR Trends



Ohio Environmental Protection Agency

Widespread Microcystins Occurrence in Ohio



Source Water Microcystins Detections at Ohio PWSs

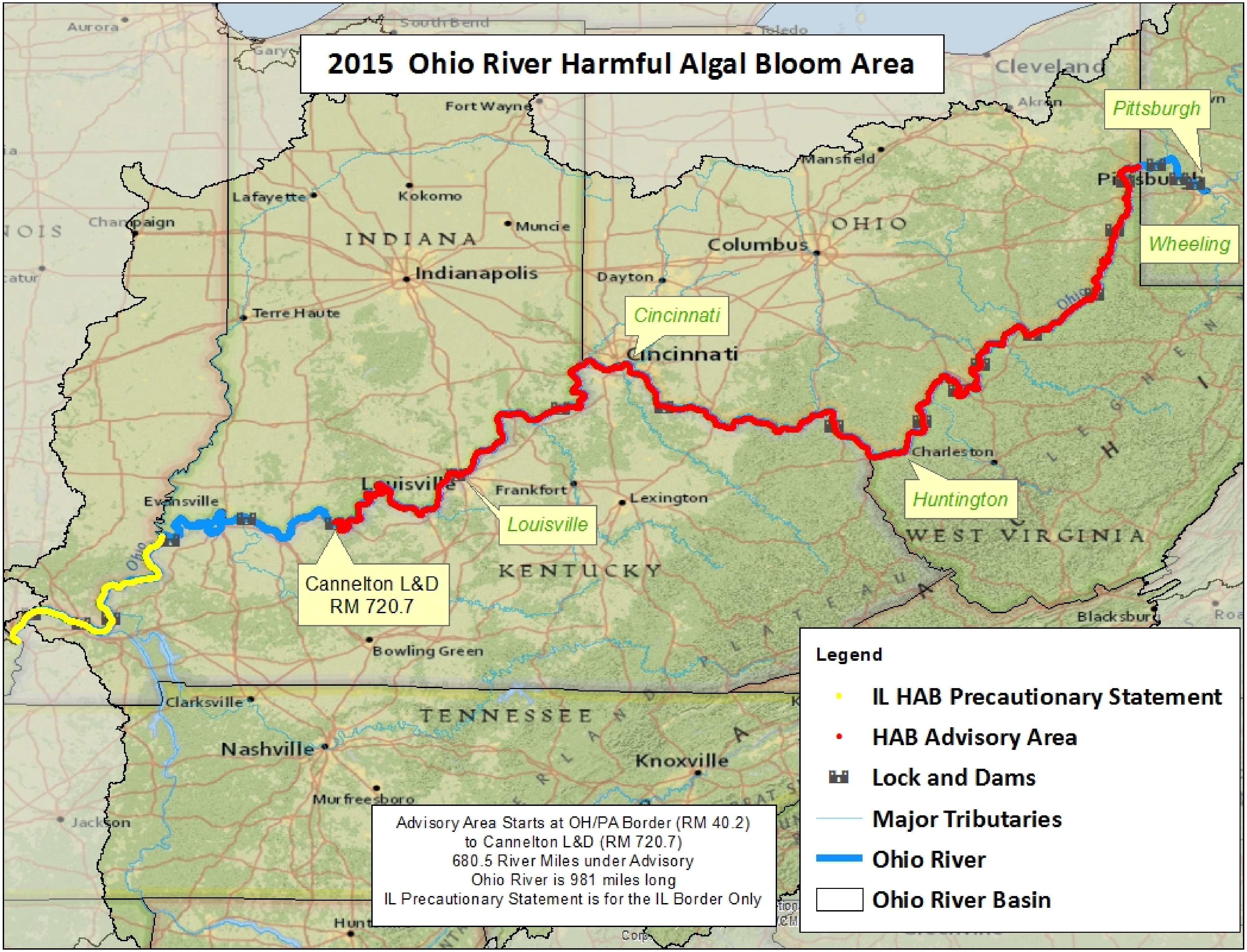
Data Available for 119 Public Water System Source Waters

(includes ~2000 compliance samples collected in 2016)

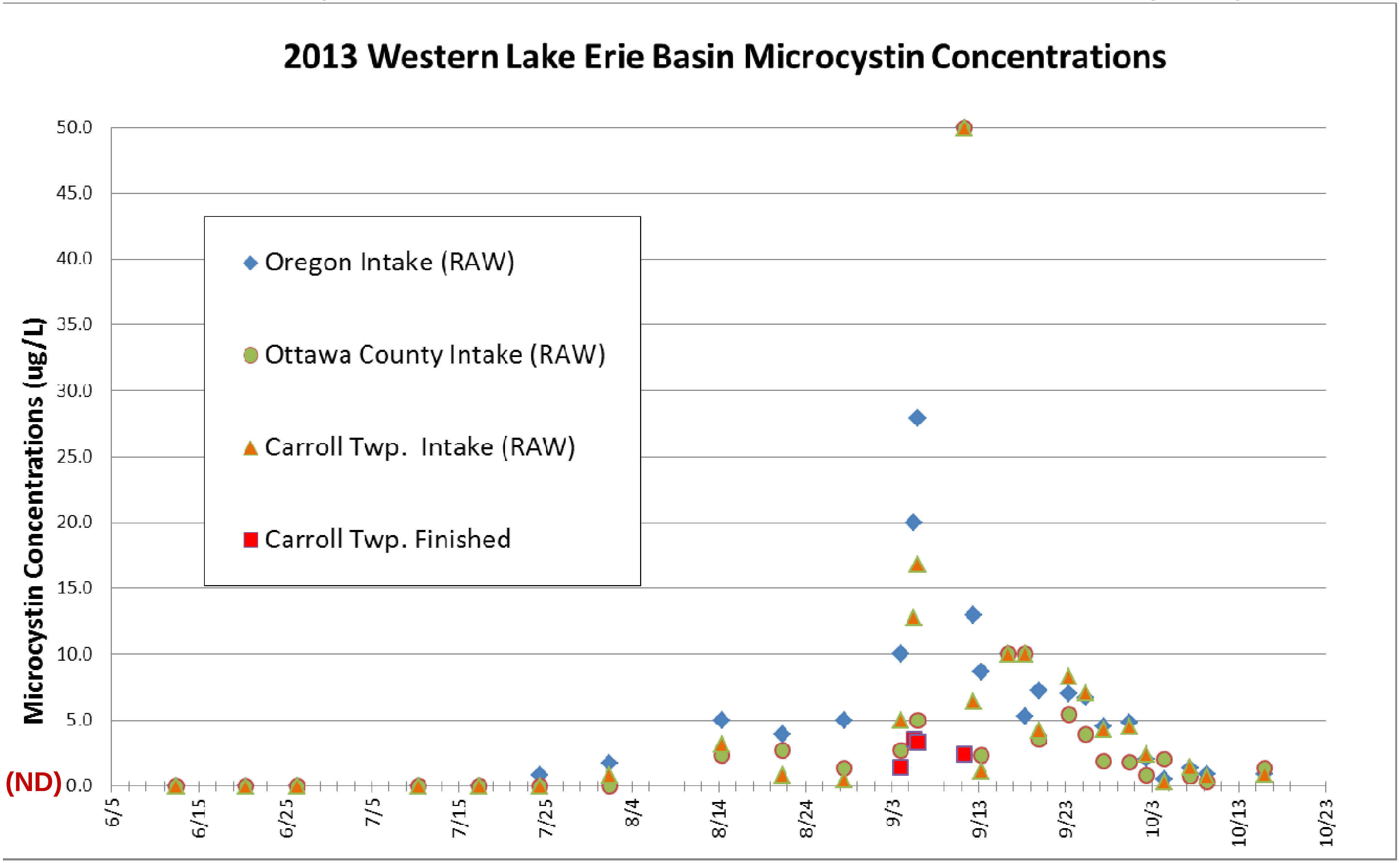
- Microcystins Detections June –Dec. 2016
- Microcystins Detections 2010-2015
- PWS Intakes

Ohio Environmental Protection Agency

Widespread Occurrence: Lake Erie, Inland Lakes, Upground Reservoirs, Quarries, and Rivers


2015 Ohio River Harmful Algal Bloom Area
Pittsburgh
Wheeling
Cincinnati
Huntington
Louisville
Cannelton L&D
RM 720.7
Legend
IL HAB Precautionary Statement
HAB Advisory Area
Lock and Dams
Major Tributaries
Ohio River
Ohio River Basin
Advisory Area Starts at OH/PA Border (RM 40.2)
to Cannelton L&D (RM 720.7)
680.5 River Miles under Advisory
Ohio River is 981 miles long
IL Precautionary Statement is for the IL Border Only
INDIANA
OHIO
KENTUCKY
WEST VIRGINIA
TENNESSEE
Indianapolis
Columbus
Cincinnati
Louisville
Evansville
Frankfort
Lexington
Charleston
Nashville
Knoxville
Bowling Green
Clarksville
Murfreesboro
Jackson
Dayton
Terre Haute
Lafayette
Kokomo
Muncie
Champaign
Fort Wayne
Cleveland
Akron
Mansfield
Toledo
South Bend
Gary
Aurora
Blacksburg
Ohio

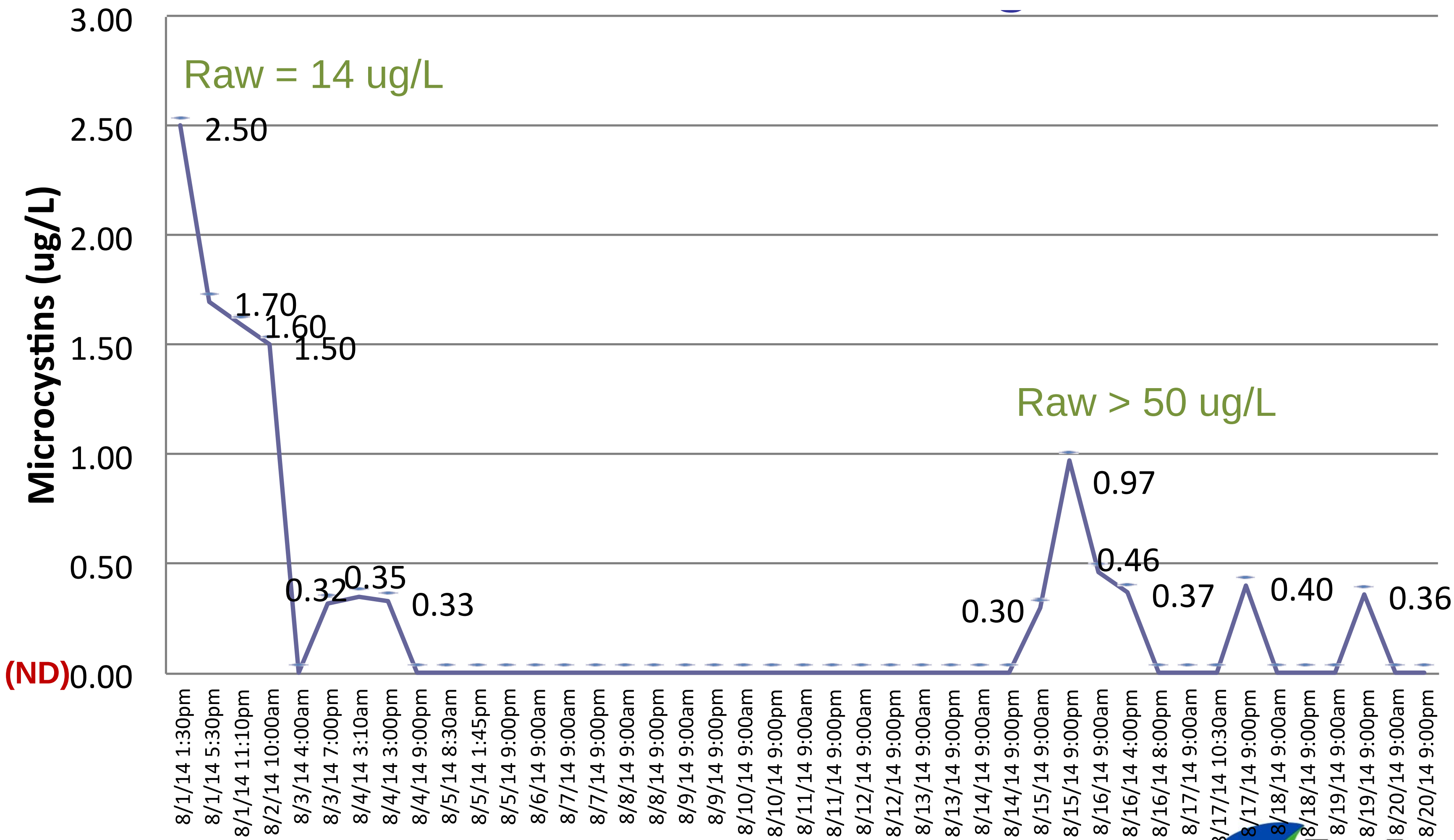
Microcystins Concentrations Can Increase Rapidly



ND= Not Detected (Concentration <0.3)

Source: Oregon

Microcystin Source Concentration and Treatment Capacity (Finished Water Concentrations Lake Erie PWS)



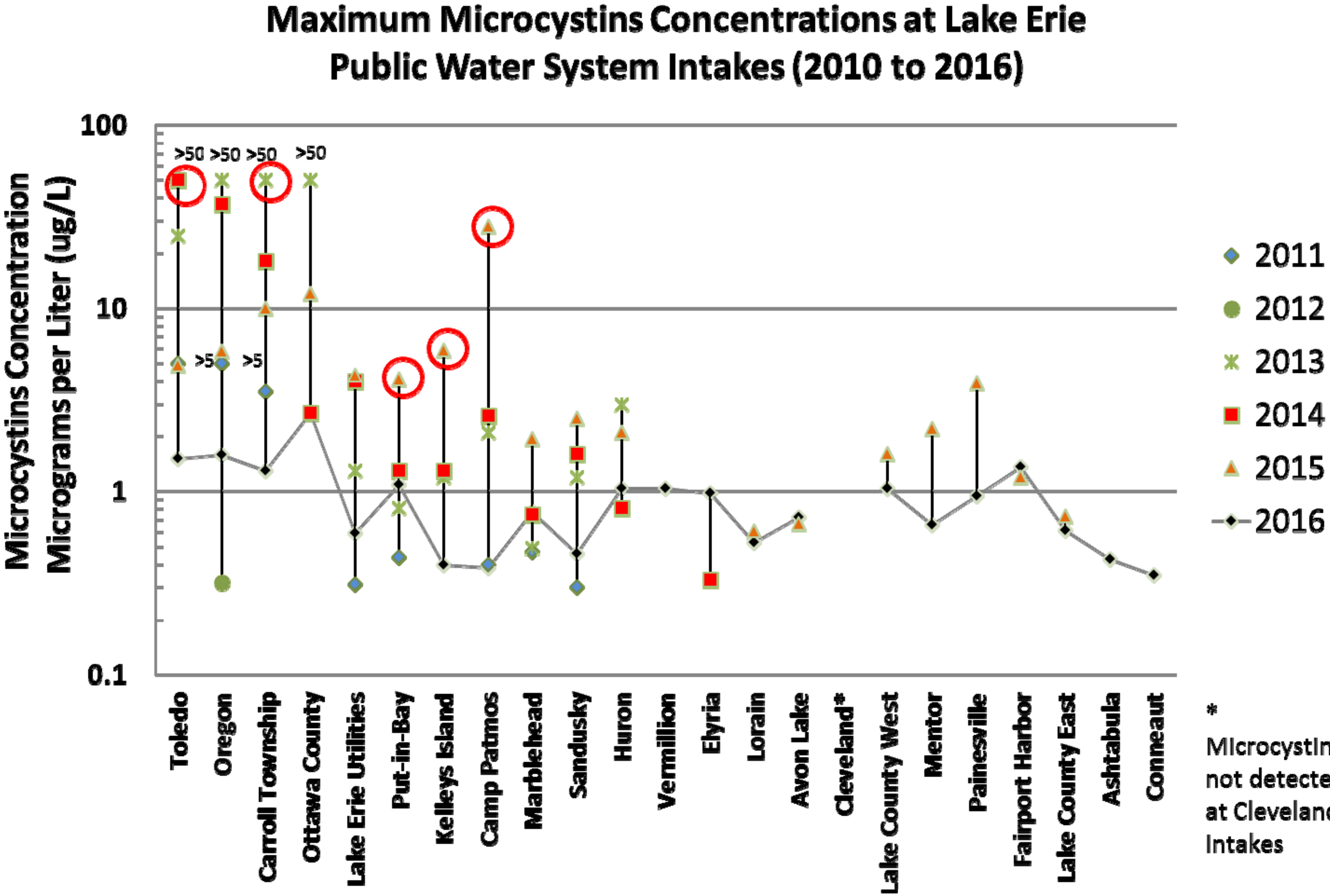
Microcystins also detected at 31 distribution sites

Ohio Environmental Protection Agency

ND= Not Detected (Concentration <0.30)

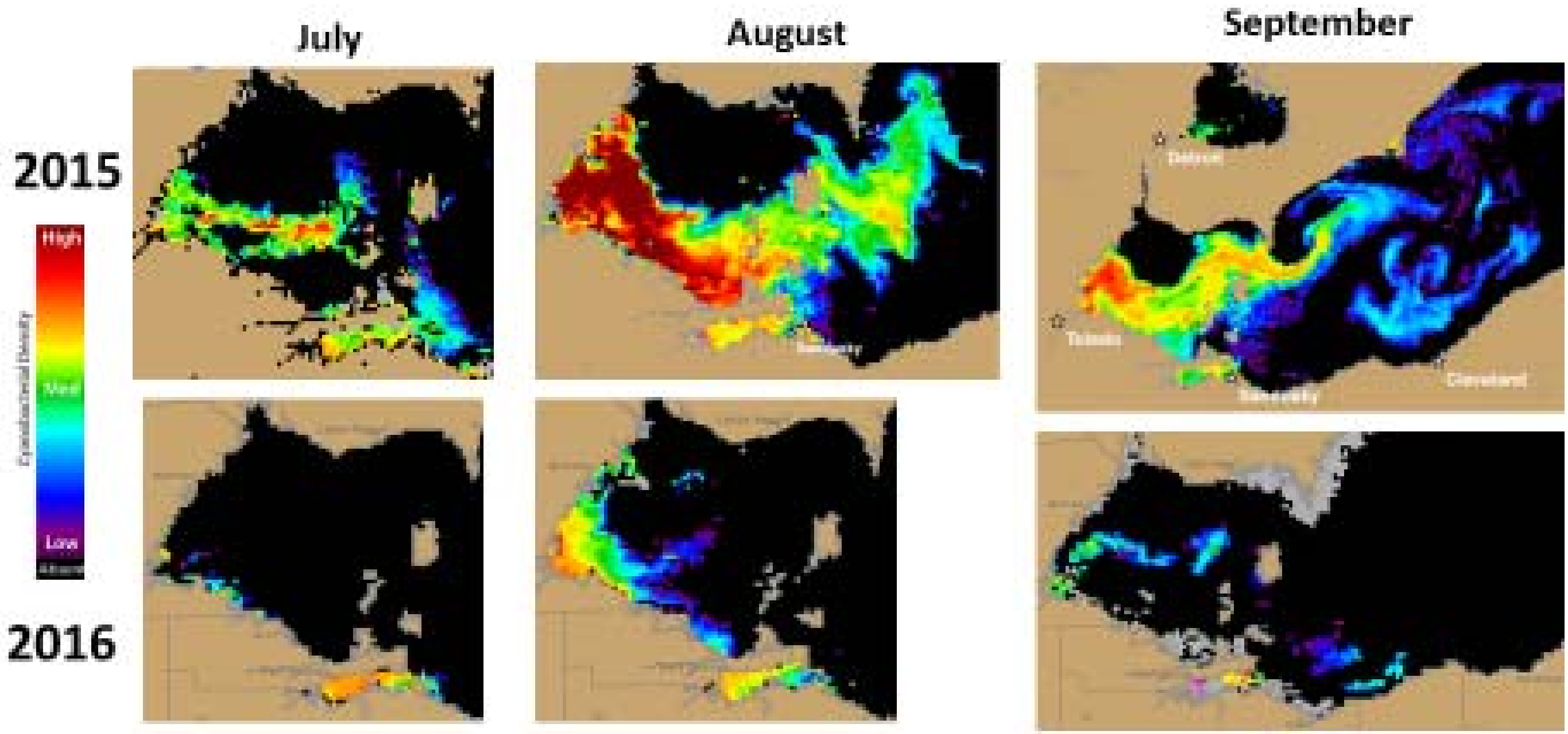
Data Source: Toledo PWS

HAB Severity Can Vary Year to Year



* Microcystins not detected at Cleveland Intakes

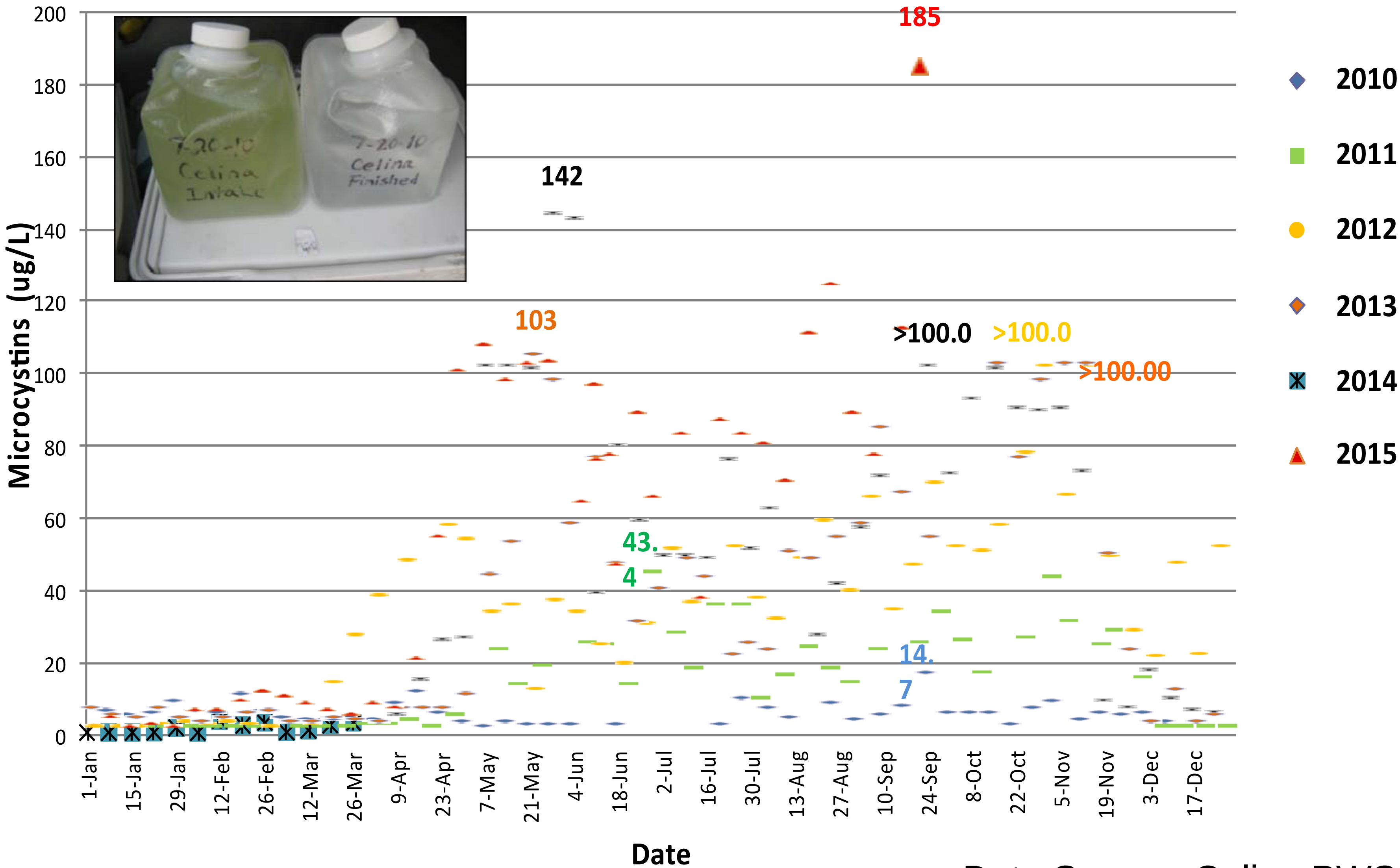
Lake Erie HAB Comparison 2015 and 2016



Was 2016 a good year to benchmark?

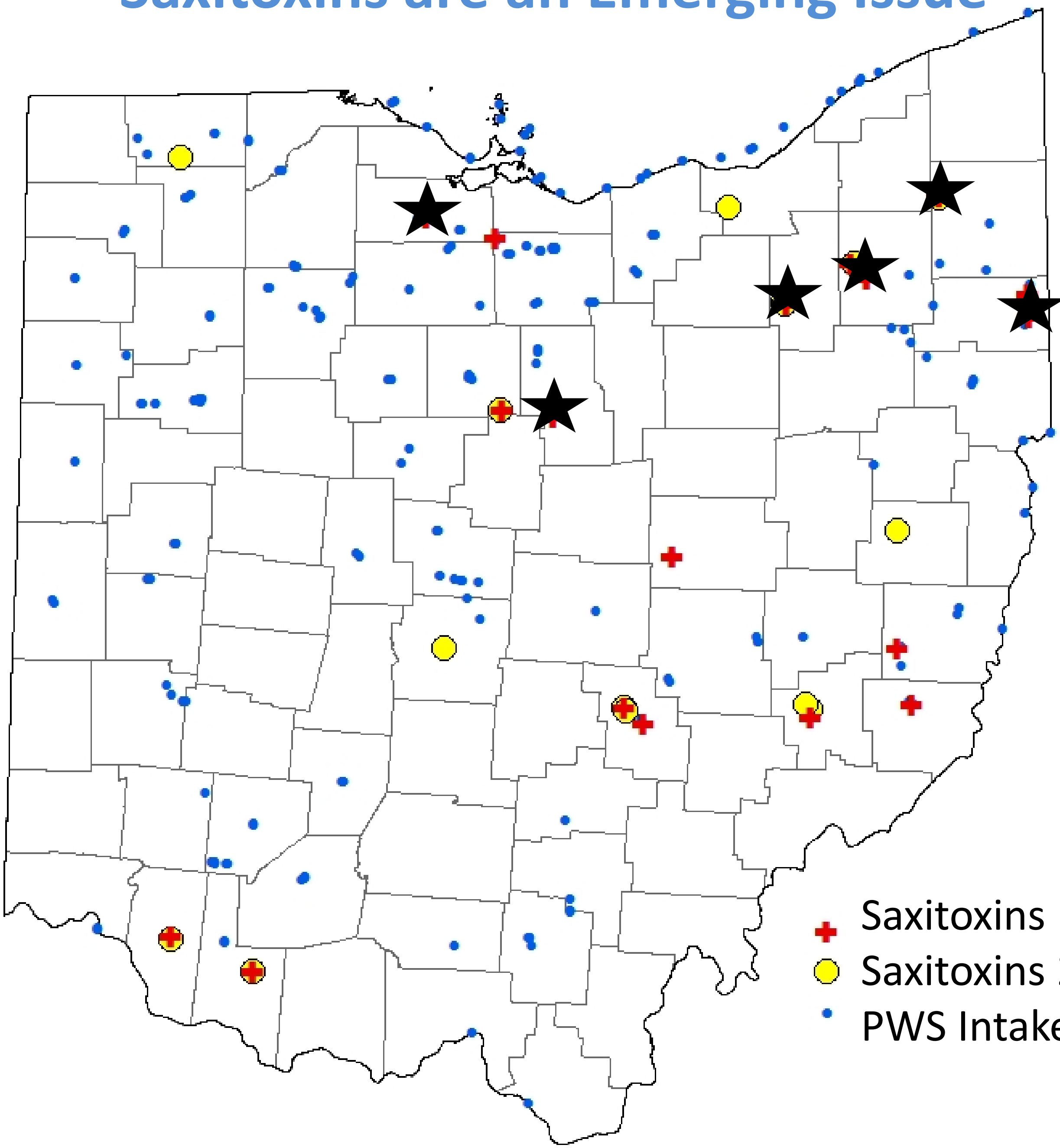
Ohio Environmental Protection Agency

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



Data Source: Celina PWS

Saxitoxins are an Emerging Issue



★ 2016 Finished Water Saxitoxins Detections (below threshold)

Benthic cyanobacteria may be a source of freshwater saxitoxins.

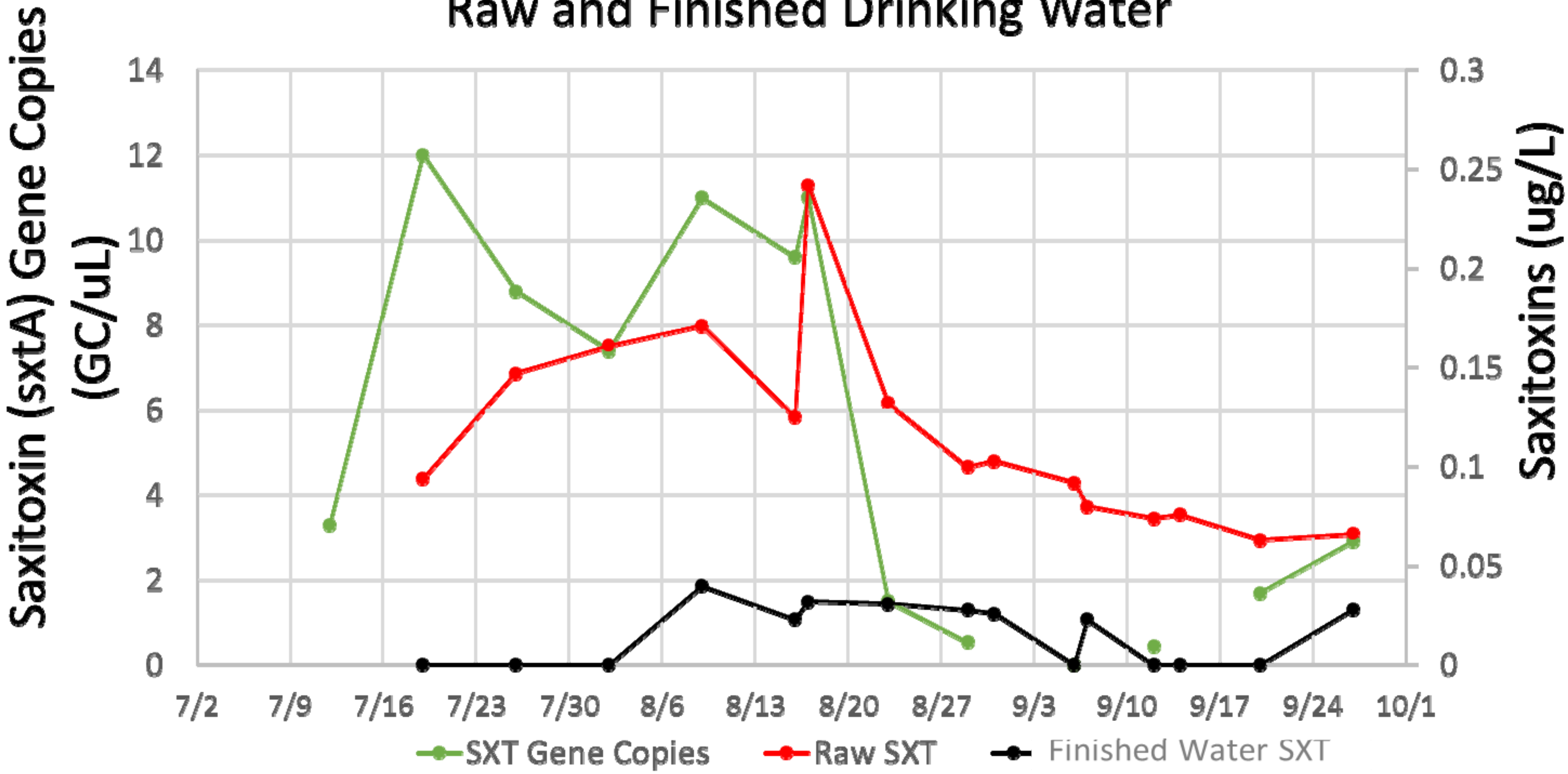
✚ Saxitoxins Detections 2016

● Saxitoxins 2010-2015

• PWS Intakes

Ohio Environmental Protection Agency

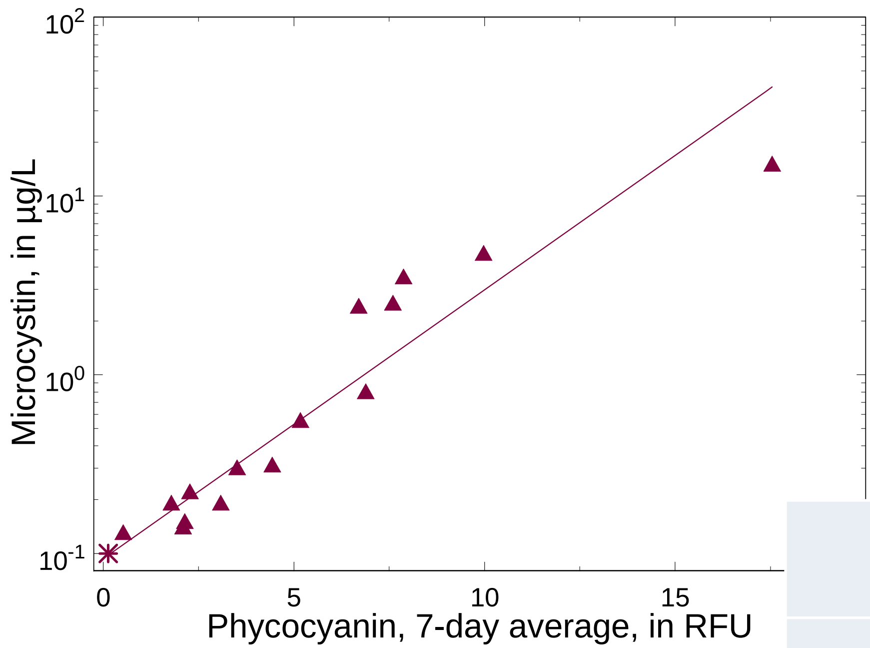
Saxitoxin Gene and Saxitoxins Detections in Raw and Finished Drinking Water



Multiplex Assay Works: Microcystin (mcyE) genes and microcystins also detected; Cylindrospermopsin (cyrA) genes also detected (cylindrospermopsin was not detected)

Ohio Environmental Protection Agency

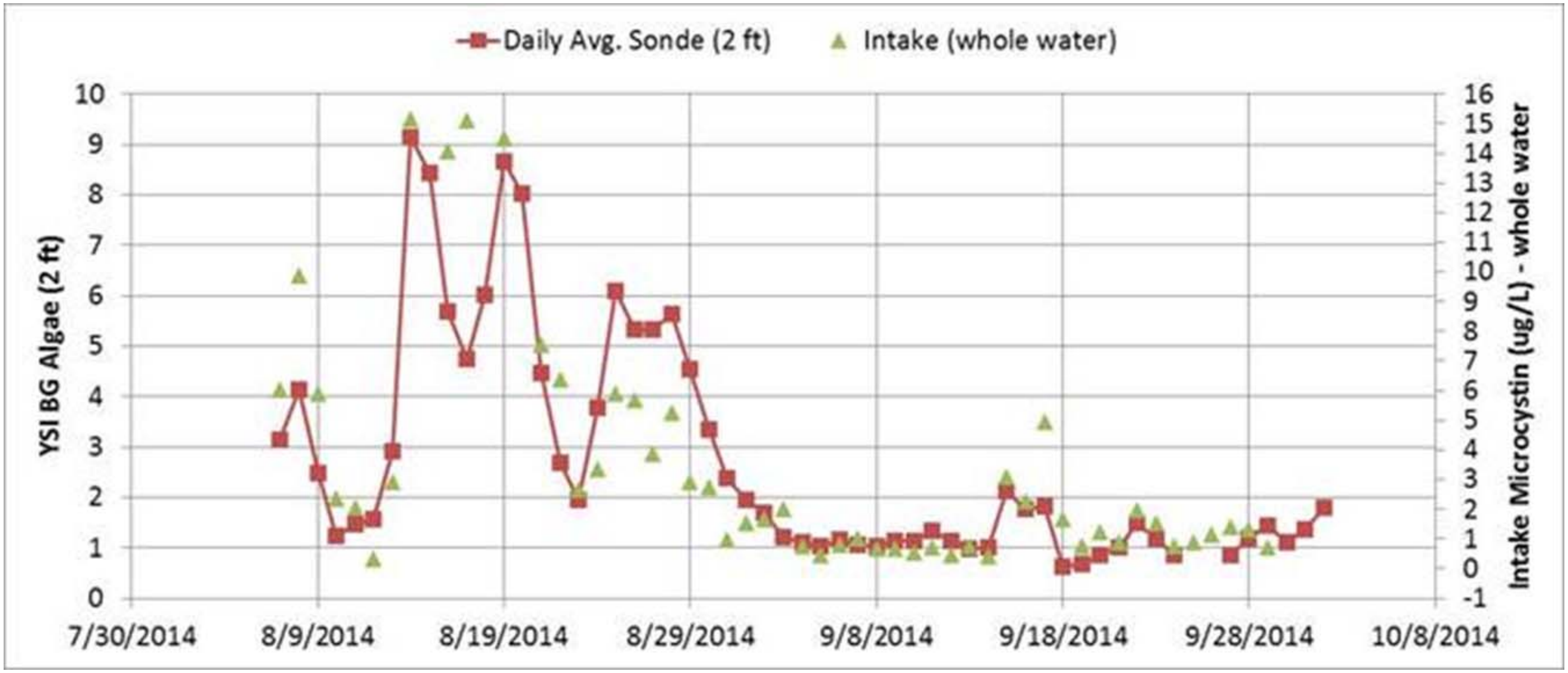
Use of Multi-Parameter Datasondes for Continuous Monitoring



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 Donna Francy, USGS

Microcystin Concentration and Phycocyanin Fluorescence at Toledo’s Intake



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

Ohio EPA provided funding to 36 PWSs for purchase of phycocyanin sondes or readers

Ohio Environmental Protection Agency

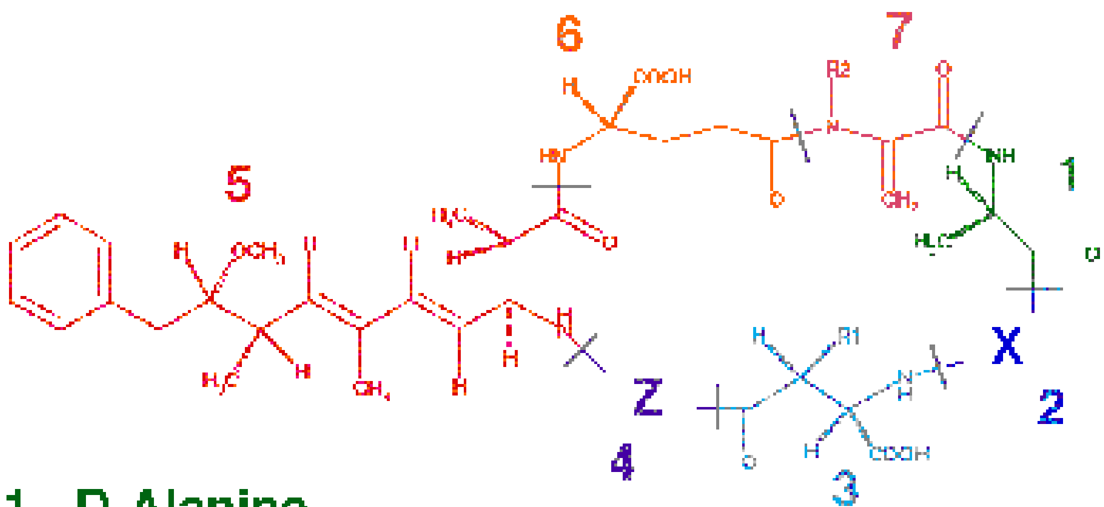
Phycocyanin Data Interpretation

- Phycocyanin Concentrations vary based on type of cyanobacteria present, turbidity of the water and other factors.
- Relative/Raw Fluorescence Units (RFUs) better than Cell Counts.
  - Can calibrate to cell counts in source water, but this can change if cyanobacteria genera shift or turbidity changes.
- Evaluate trends, not absolute values.

Ohio Environmental Protection Agency

Lessons Learned – Analytical Methods Matter

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

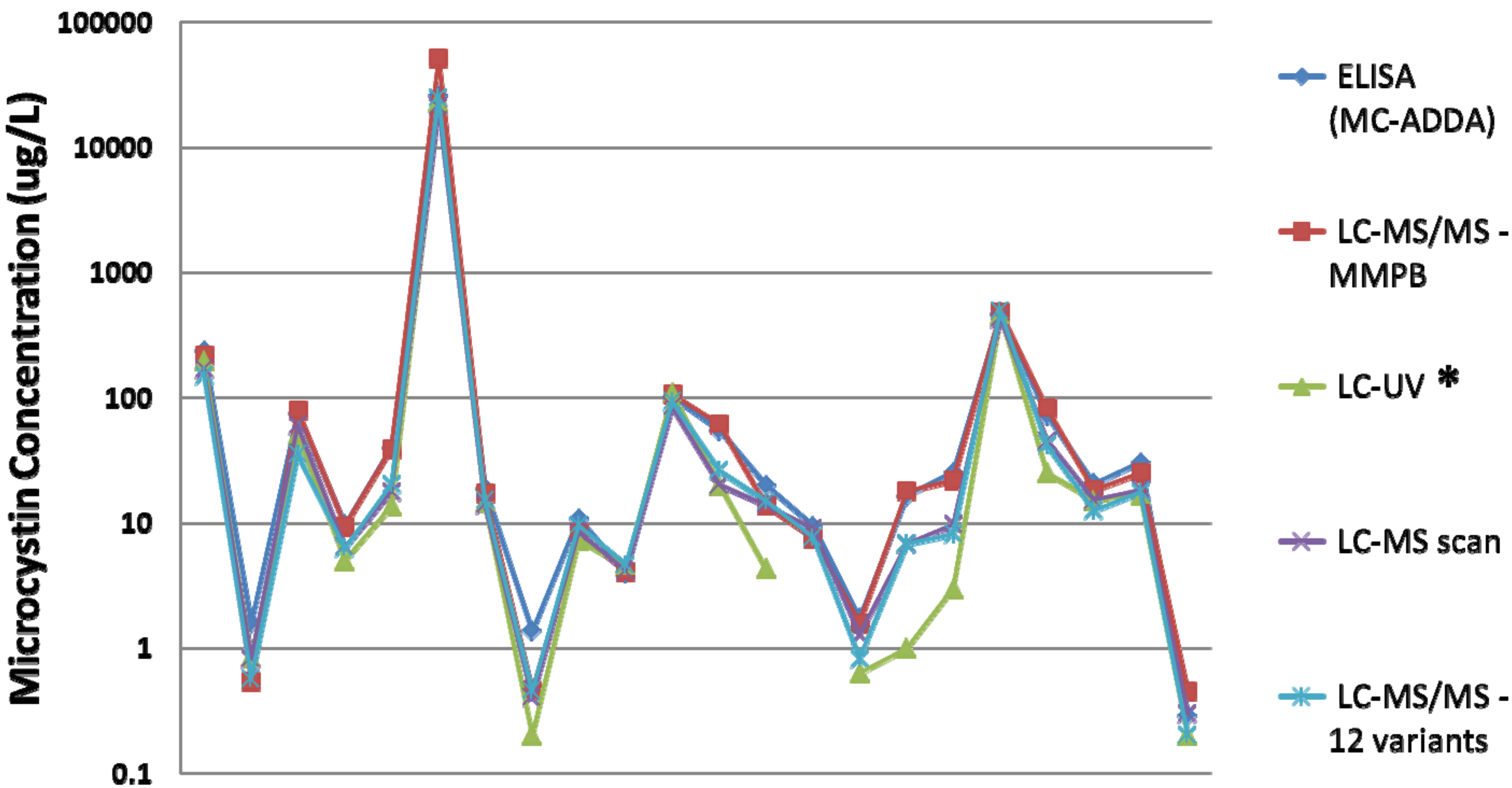
Ohio Environmental Protection Agency

Analytical Method Comparison & Microcystin Variant 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 ELISA-MC-ADDA, LC-UV/PDA, LC-MS/MS – individual variant (12), LC-MS/MS-MMPB, LC-MS scan

Ohio Environmental Protection Agency

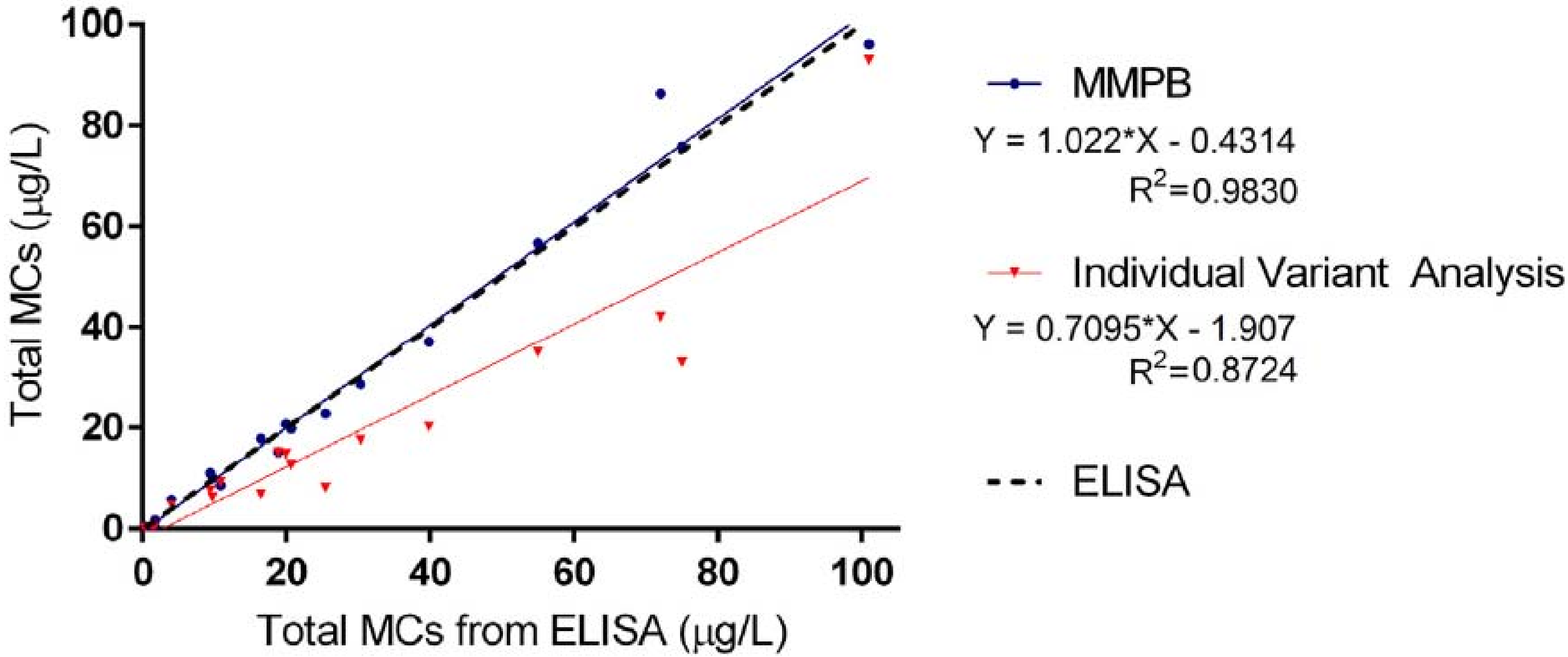
Results of Method Comparison



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

Ohio Environmental Protection Agency

Results of LC-MS/MS MMPB and Individual Variant Analysis Compared to ELISA



Ohio Environmental Protection Agency

Microcystins Methods - Key Findings

- 16 different MC-variants detected
- MC-LR was only detected at 5 of 11 sites (45%)
- Most commonly detected variants were: MC-YR, [Dha7] MC-LR and [DAsp3] MC-RR
- LC-PDA methods prone to interference, potential for false positives and false negatives
- LC-MS/MS MMPB method confirmed ELISA results (raw water)
- 91%-100% of samples had MC-variants not detectable by U.S. EPA Method 544 (including dominant MC-variant in some samples)
- LC-MS/MS individual variant analysis under-reported <u>total</u> microcystins, based on MMPB, LC-UV/MS scans, and ELISA data
- No perfect method for TOTAL Microcystins

Ohio Environmental Protection Agency

Analytical Methods Utilized by Ohio EPA

	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

Ohio Environmental Protection Agency

Ohio HAB Initiatives & Resources

PWS Funding: $1.5 million in grants for analytical kits, microscopes, and raw water quality sensors and $100 million in zero-interest loans for drinking water infrastructure improvements including additional treatment, alternative sources and storage.

Technical Assistance: Site visits with all susceptible surface water systems on treatment optimization and contingency planning. Numerous presentations, webinars and workshops have been held with PWSs, stakeholders, and partners.

Guidance: Developed Cyanotoxin Treatment White Paper, Cyanotoxin Treatment Optimization Protocol, Cyanotoxin General Plan, Algaecide Application Fact Sheet, Distribution Cyanotoxin Monitoring; ELISA SOPs, Response Strategies; Website.

Emergency Response: Established PWS-specific HAB incident action plans and coordinated with partner agencies during multiple table top exercises and drills.

Clean Water Act Integration: Established cyanotoxin indictors of impairment for determining public drinking water supply beneficial use attainment

Research: Partnered with university and government researchers to address data gaps.

www.epa.ohio.gov/ddagw/HAB.aspx

Ohio Environmental Protection Agency

Summary

- HABs are Not Always Visually Apparent
- HABs Can Occur Year-Round, in a Variety of Source Waters, and can be Different (or similar) Every Year
- Early Warning Monitoring Helps
- Methods Matter
- Saxitoxins are an Emerging Issue
- Plan Ahead!

Ohio Environmental Protection Agency


Questions?
www.epa.ohio.gov/ddagw/HAB.aspx
Heather.Raymond@epa.ohio.gov
(614) 644-2752