Monitoring for Toxic Algae (HABs) to Protect Watershed Communities

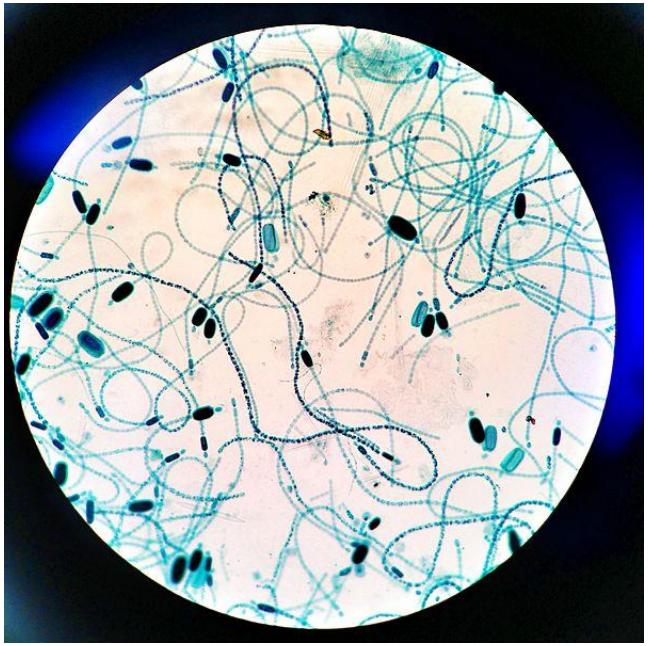
Dana Oleskiewicz

Citizen Lake Awareness and Monitoring

Sponsored by Ohio Lake Management Society

Toxic Algae

- Cyanobacteria = Blue-green algae
- Single-cell bacteria that photosynthesize
- Move up and down water column
- Feed on phosphorus
  - nonpoint source pollution
- Lakes, streams, ponds, lagoons
  - All surface water



Cylindrospermopsis

Harmful Algal Blooms (HABs)

- Produce cyanotoxins
  - Acute or chronic
- Blooms with rapid increase or accumulation
  - Water discoloration or >4,000 cells/mL
- HAB when toxic or harmful to species
- 1000 species; 40 freshwater produce toxins

Cyanotoxins

- Why toxins are produced
  - Primary role in cellular process
  - Secondary metabolism by-products
  - Allelopathy - germinates or growth inhibitor
  - Defense mechanism
- When toxins are produced
  - Toxin as a strain, not species dependent (genetics)
  - Not related to cell density, but are found in scums
  - Released during cell death (algaecides, in stomachs)

Identification

- Variety of colors
  - Blue-green, bright green
  - Red, brown, and purple
  - Black and white
- Many types of textures
  - Streaked paint
  - Puff balls or like grass clippings
  - Slimy, foamy, wooly, pea soup
  - Scum at surface or dispersed color

Kelley's Island, 2011


09/12/2011

Grand Lake St. Marys, 2010

Grand Lake St. Marys, 2010

Lake Mac O-Chee (Camp Wilson)
Planktothrix and *Aphanizomenon*

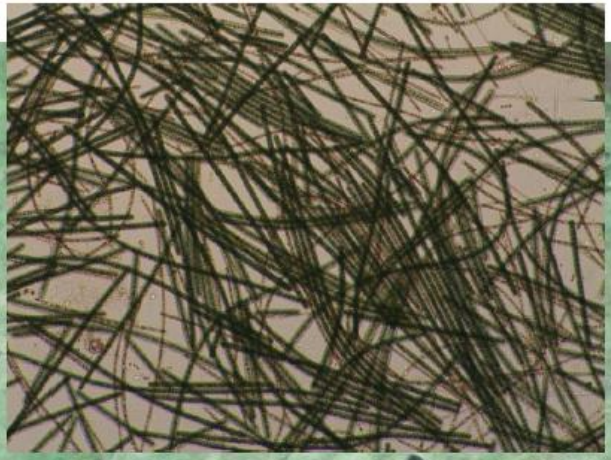


Photo By Linda Merchant- Masonbrink
Camp Wilson ,2010

Photo By Anne Brienza, Camp Wilson, 7/2010

Burr Oak Lake (*Anabaena*)

Photo By Linda Merchant- Masonbrink
Anabaena-Burr Oak, 2010

Photo By Ohio DNR-Burr Oak 7/2010

Woodsfield Reservoir (*Microcystis*)

September 2010 Microcystis Bloom
Microcystin = 360 ppb in the bloom, 0.68 ppb near intake, below detection in Finished Water

Photos By – Dan Imhoff
DSW-SEDO

Lake Erie

Grand Lake St. Marys, 2010

Lyngbya sp.

Ohio River

Photos by Jim Crawford, Ohio EPA 8/2008

Microcystis sp.

Tappan Lake – Cylindrospermopsis Bloom 9/2011

Tributary to Muddy Creek, Warren County

Photo by Dale Farmer, Ohio EPA 7/2009

LAKE ERIE

Ohio Sea Grant – Lake Erie

Photo by Thomas Archer, 2009 Pelee Island

Not HABs

Cladophora

Spirogyra

Duckweed

Green algae come in many forms and may look like underwater moss, thick stringy mats or floating slimy scum. Duckweed are tiny aquatic plants with a grainy or couscous-like texture and rootlets.

Adverse Impacts

- Health issues
- Taste and odor problems
- Increased organic carbon load, more treatment
- Reduced dissolved oxygen, fish kills
- Creates nuisance, odor, and economic impacts
- Out-competes desirable aquatic species

Toxin Exposure

- Water recreation
  - Ingestion
  - Swimming
  - Boating or fishing
  - Irrigation, boat spray
- Food web
  - Bioaccumulation in fish
- Dietary supplements
- Drinking water

Health Impacts

Increase in spatial and temporal prevalence worldwide- USEPA

"…significant hazard for human health and ecosystem viability"

Hepatotoxin (liver)

- Microcystin
- Cylindrospermopsin
- Nodularins

Dermatoxins (skin)

- Lyngbatoxin-a
- Aplysiatoxin
- Lipopolysaccharides

Neurotoxins (nerve)

- Anatoxin
- Saxitoxin and Neosaxitoxin
- Beta-n-metholamino-L-alanine – BMAA

Hepatotoxins

- Vomiting, diarrhea, death, liver tumors
- Microsystin
  - Most commonly detected
  - 80 kinds with range of toxicities
  - Microcystin-LR is only toxin with risk-based criteria established by World Health Organization (WHO)
    - 1 ppb for drinking water
    - 20 ppb for recreational contact
- Cylindrospermopsin
  - 9 ppb detected at Grand Lake Beach
  - LD50 about 2,100 mg/kg
  - No national standard

Neurotoxins

- Staggering, gasping, convulsions, diarrhea, death
  - Rarely associated with human illness or death
- Saxitoxin
  - Marine (pufferfish poisoning) and freshwater
  - Most lethal non-protein toxin (suicide capsules)
  - No national standard
- Anatoxin
  - Originally called Very Fast Death Factor
  - Many animal poisonings (dogs and cattle)
  - 4 ppb detected at Grand lake beaches in 2010
  - No national standard

Dermatotoxins

- Swimmers' itch, skin rashes, eye irritations
- Most species produce cytotoxins
- *Lyngbya* human health impact
  - Skin inflammation and blisters
  - Oral / gastrointestinal inflammation
  - Skin tumor promoters

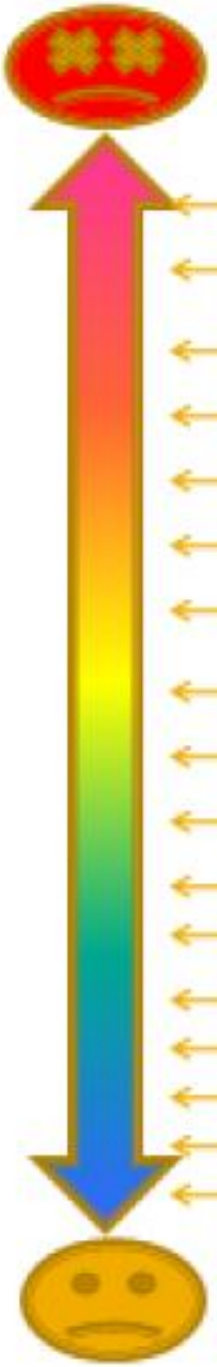
Rash associated with *Lyngbya majuscula* bloom in Australia.

Cyanotoxin	Number of known variants or analogues	Primary organ affected	Health Effects[1]	Most common Cyanobacteria producing toxin[2]
Microcystin-LR	80~90	Liver	Abdominal pain Vomiting and diarrhea Liver inflammation and hemorrhage Acute pneumonia Acute dermatitis Kidney damage Potential tumor growth promotion	*Microcystis* *Anabaena* *Planktothrix* *Anabaenopsis* *Aphanizomenon*
Cylindrospermopsin	3	Liver		*Cylindrospermopsis* *Aphanizomenon* *Anabaena* *Lyngbya* *Rhaphidiopsis* *Umezakia*
Anatoxin-a group[3]	2-6	Nervous System	Tingling, burning, numbness, drowsiness, incoherent speech, salivation, respiratory paralysis leading to death	*Anabaena* *Planktothrix* *Aphanizomenon* *Cylindrospermopsis* *Oscillatoria*

"Cyanobacteria and Cyanotoxins: Information for Drinking Water Systems", U.S. Environmental Protection Agency, Office of Water, July 2012 (EPA-810R11001) (water.epa.gov)

Toxicity of Algal Toxins Relative to Other Toxic Compounds found in Water

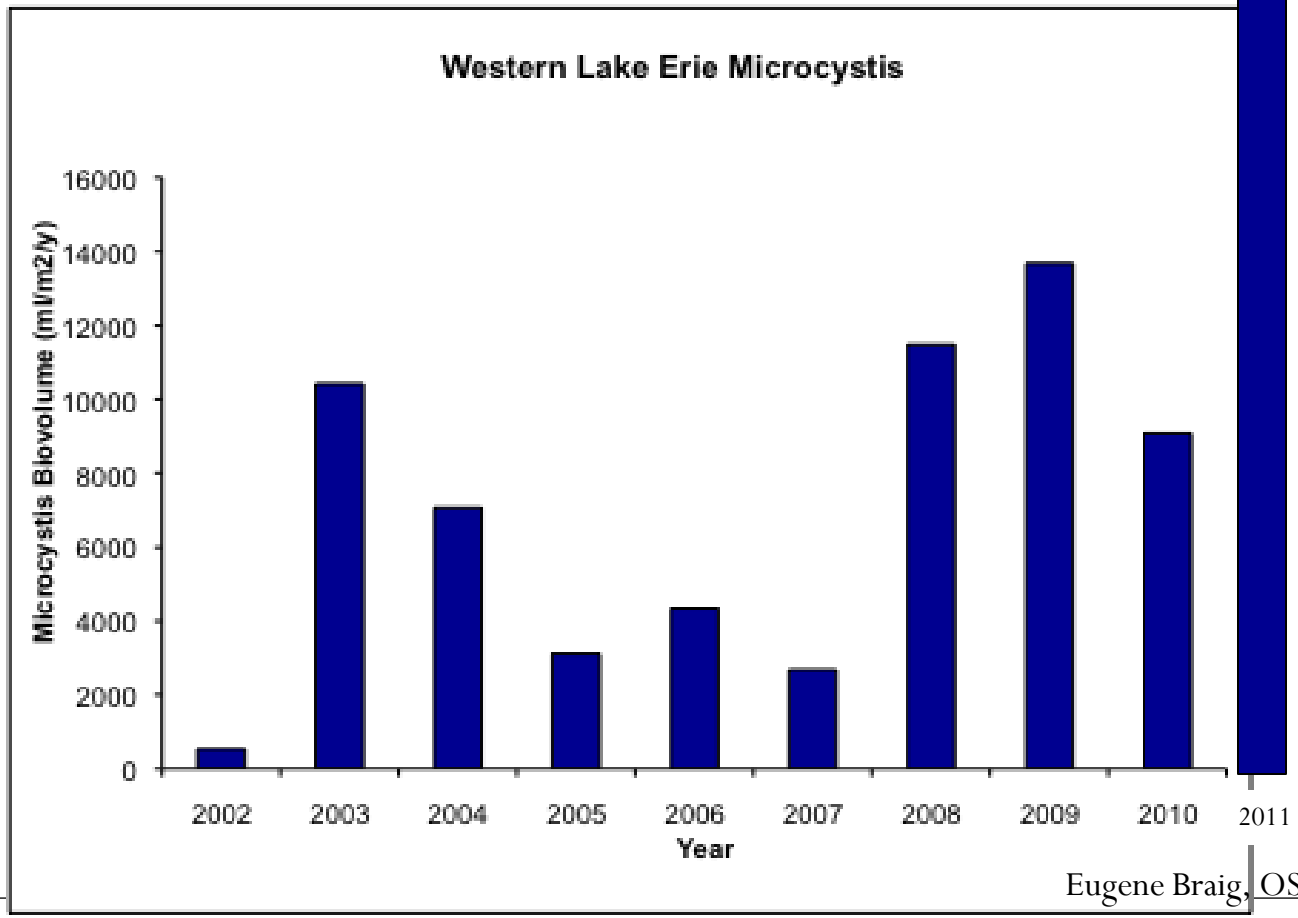
- Reference Dose = amount that can be ingested orally by a person, above which a toxic effect may occur, on a milligram per kilogram body weight per day basis.



Ohio Environmental Protection Agency

Microcystis in Lake Erie

The *Microcystis-Anabaena* bloom of 2009 was the largest in recent years in our sampling region (Tom Bridgeman, University of Toledo, 2012).....until 2011!



October 9, 2011

Photo: MERIS Satellite Image

Causes

- Nutrient problem, nonpoint source pollution
- Excess Phosphorus
  - Sudden influx or release of P in July-September
  - Early season nutrient inputs can “prime” system
- Low water levels, rainfall
- Calm water
- Warm water temperatures
- Selective grazing by zooplankton and mussles

Cyanobacterial Toxicity

- People tend to avoid icky-looking water
- Some animals may be attracted to cyanobacteria
- Toxic or non-toxic? ….until it's too late
- Use common sense

No Deaths (1999) = Chorus, & Bartram, eds. 1999. Toxic cyanobacteria in water: a guide to their public health consequences, monitoring and management. Routledge, London. World Health Organization.

52 Deaths (2008) = Lopez, C.B., Jewett, E.B., Dortch, Q., Walton, B.T., Hudnell, H.K. 2008. Scientific Assessment of Freshwater Harmful Algal Blooms. Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health of the Joint Subcommittee on Ocean Science and Technology. Washington, DC.

Keeping Safe as Individuals

- Avoid contact
- Rinse off
- Do not drink natural water sources
- Be aware boiling does not work
- Don't cook with natural water sources
- Never let pets or livestock drink water
- Be careful of fish consumption
- Help prevent the problem

What To Do as Communities

- Help promote best management practices
- Learn more about HABs (ohioalgaeinfo.com)
- Report HAB blooms, OEPA on-line form
- Report human and animal illness to ODH
- Advise public about HABs
- Educate medical personnel on HAB illnesses
- Be vigilant and raise awareness
- MONITOR!

HAB Tracking

- Blooms are difficult to track
  - Transient, not always visible or look like turbidity
  - Toxins not always produced, not all the time
  - Cyanobacteria produce multiple toxins
  - Reason for toxin production unknown
  - Toxins persist
- Innovative techniques explored
  - Use of satellite imagery
  - New in-field protocols
  - Volunteer monitors
  - Citizens send in information

Citizen Scientists

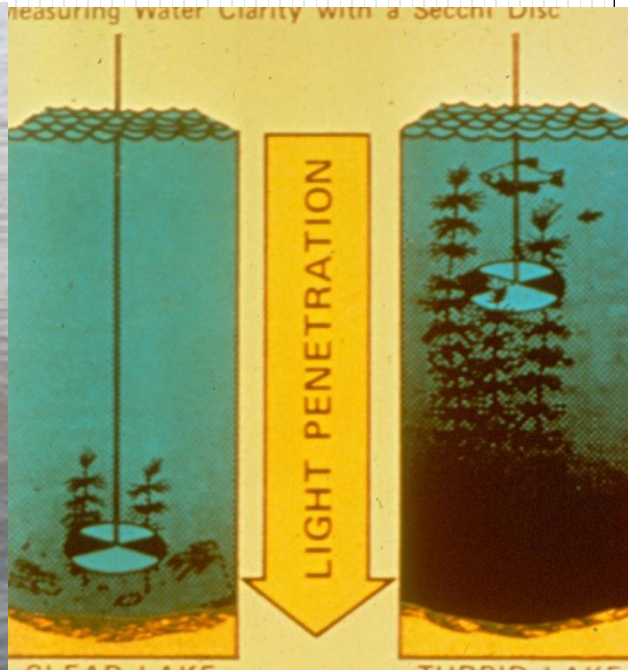
- Enhanced datasets
- Reliable and engaged
- Baseline and long-term
- Local and immediate
- Leads to Action

Portage Lakes CLAM Training, 2010.

Photo by Lew Stamp: LewStampPhotography.com

Training Citizen Scientists since 1991.....

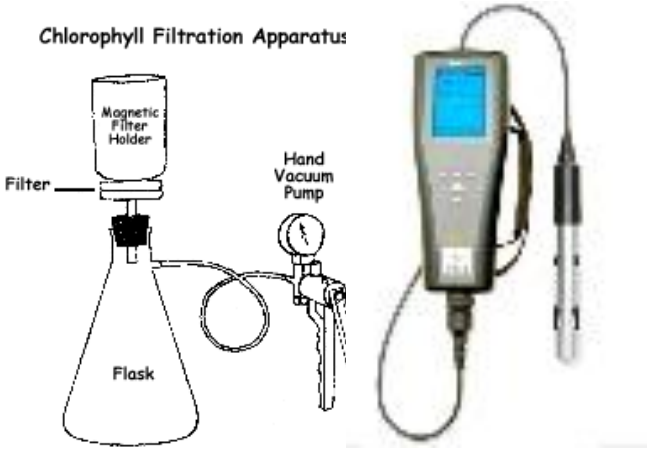
Citizen Lake Awareness and Monitoring



CLAM Parameters in QDC Program

Level 2 data

- Transparency
- Water temperature
- Water color
- Quality and lake use



MUSKINGUM WATERSHED CONSERVANCY DISTRICT

OLMS

OHIO DEPARTMENT OF NATURAL RESOURCES DIVISION OF WILDLIFE

Level 3 data

- Temp. / DO profiles
- Total nutrients
- Total suspended solids
- Chlorophyll *a*

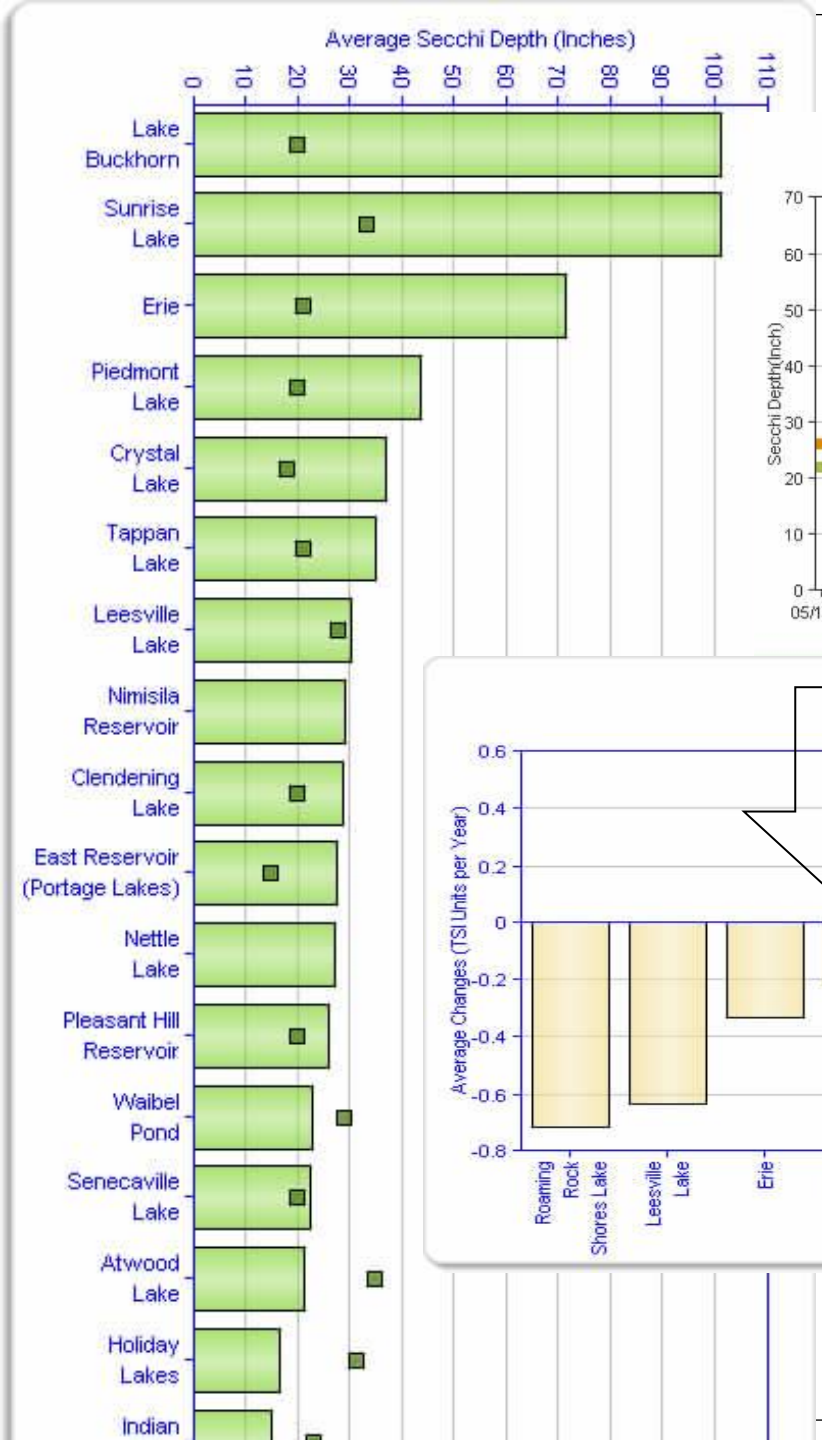
www.eyesonthewater.org/olms

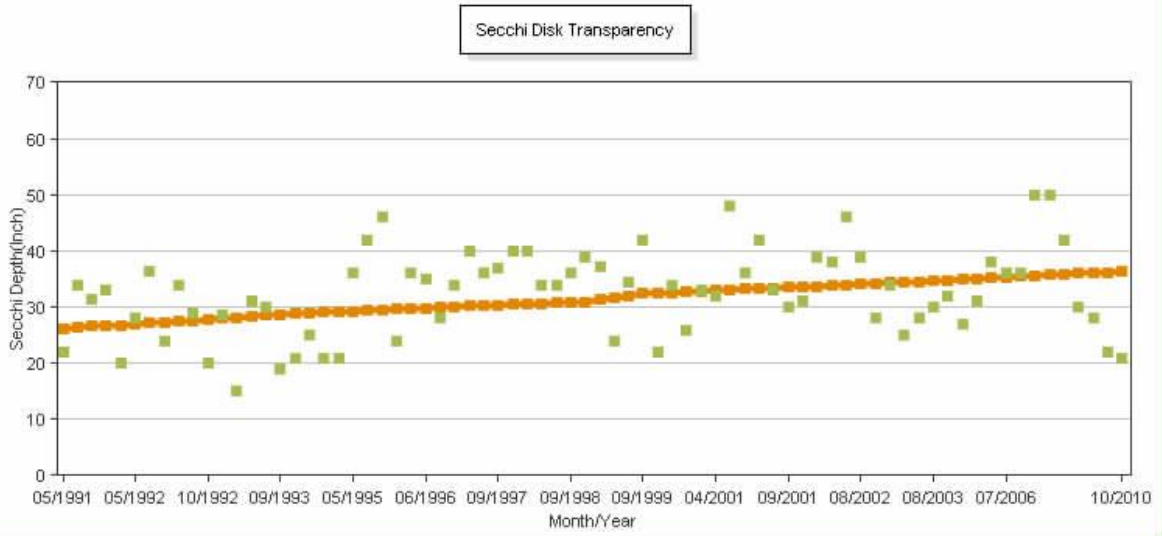
Ohio Lake Management Society

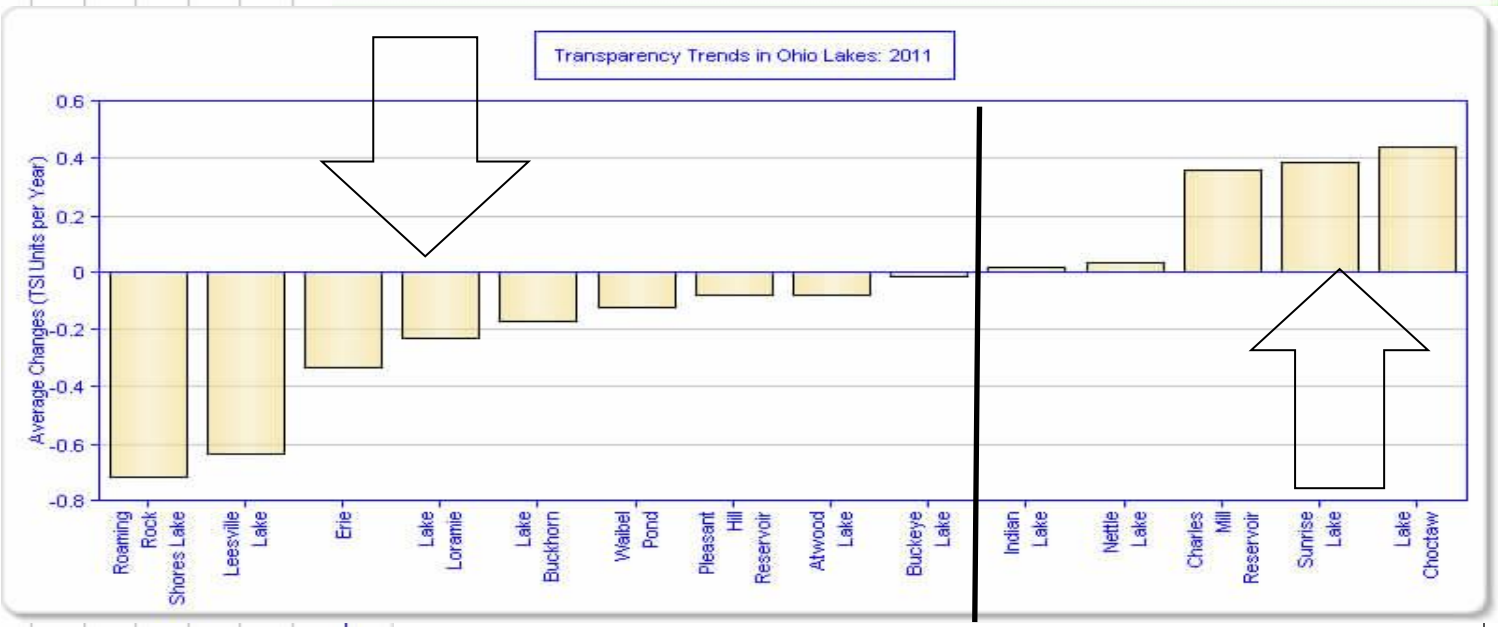
11 November 2010

Lake Summary — Charles Mill Reservoir — ID: 210

YEAR	SITE	Volunteer	Samples	SECCHI Avg	SECCHI Min	SECCHI Max	Water Depth (FT)	Water Color	Water Temp.
1995									
	0	Marion Zaugg	5	15.20	11	20	7.20	6.20	79.80
	1	Roger Clay	1	20.00	20	20	6.50	5.00	79.00
	10	Jim and Bev Pelc	10	8.00	6	12	3.75	3.30	74.60
	11	Larry Giannetto	3	13.67	11	16	23.37	6.33	74.67
	2	Robert Ledvina	3	23.33	18	26	12.93	5.00	74.00
	3	Robert Ledvina	3	25.33	16	30	9.77	3.33	73.33
	4	Dick and Marlene Groff	10	11.80	8	17	6.00	7.00	70.80
	5	Dick and Marlene Groff	10	12.80	10	19	6.55	7.20	70.40
	6	Nelson Shogren	8	10.63	5	15	5.36	4.88	70.50
	7	Nelson Shogren	8	9.38	4	12	4.27	4.50	74.63
	8	Jim and Bev Pelc	10	9.10	6	12	5.45	3.20	74.10
	9	Jim and Bev Pelc	10	9.20	6	12	4.05	3.40	74.20
	Averages for 1995		81	11.75	10.08	17.58	6.37	4.89	73.41
1996									
	10	Jim and Bev Pelc	8	6.75	6	8	3.63	4.38	79.13


Average Secchi Depth (Inches)
0
10
20
30
40
50
60
70
80
90
100
110
Lake Buckhorn
Sunrise Lake
Erie
Piedmont Lake
Crystal Lake
Tappan Lake
Leesville Lake
Nimisila Reservoir
Clendening Lake
East Reservoir (Portage Lakes)
Nettle Lake
Pleasant Hill Reservoir
Waibel Pond
Senecaville Lake
Atwood Lake
Holiday Lakes
Indian


Secchi Disk Transparency
Secchi Depth(Inch)
0
10
20
30
40
50
60
70
05/1991
05/1992
10/1992
09/1993
05/1995
06/1996
09/1997
09/1998
09/1999
04/2001
09/2001
08/2002
08/2003
07/2006
10/2010
Month/Year


Transparency Trends in Ohio Lakes: 2011
Average Changes (TSI Units per Year)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
Roaming Rock Shores Lake
Leesville Lake
Erie
Lake Loramie
Lake Buckhorn
Waibel Pond
Pleasant Hill Reservoir
Atwood Lake
Buckeye Lake
Indian Lake
Nettle Lake
Charles Mill Reservoir
Sunrise Lake
Lake Choctaw

Harmful Algal Blooms in Ohio
Human Health Issue

- 2009 high microcystin in Grand Lake St. Marys
- 2009 OEPA - Cyanotoxin monitoring
- 2010 ODH - 41 human illnesses, 5 dog deaths
- 2011 response strategy - ODH, ODNR, and OEPA
- 2012 strategy updated (**www.ohioalgaeinfo.com**)

Citizen Lake Awareness Monitoring

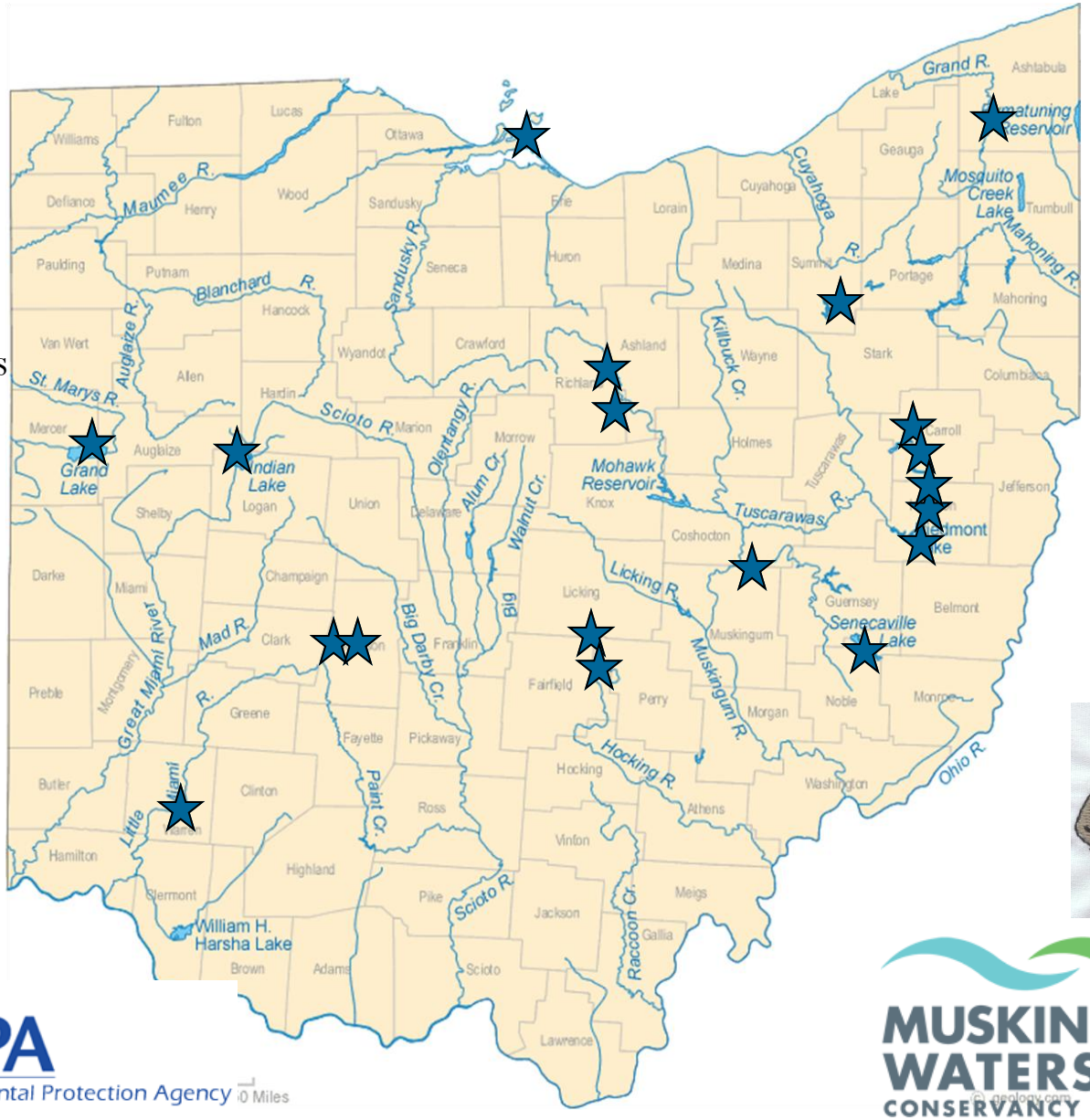
- **2011-2013 MWCD lakes being watched**
- **2013 expanded watch in Ohio with OEEF project**

Raymond, H., Merchant-Masonbrink, L, and Shaskus, M. (2012). *Ohio's Experience with HABs*. LakeLine, NALMS publication, vol.32: no.3, pgs. 26-30

HABs – 19 Lakes in 2013

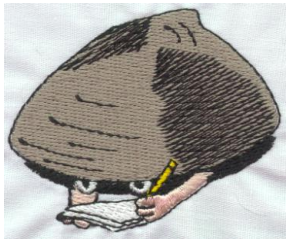
OEEF

Buckeye Lake
Choctaw Lake
Lake Erie
Grand Lake St. Mary's
Indian Lake
Portage Lakes
Lake Roaming Rock
Sunrise Lake
Lake Sylvan
Waibel Pond



MWCD

Atwood
Charles Mill
Clendening
Leesville
Piedmont
Pleasant Hill
Seneca
Tappan
Wills Creek



OhioEPA
Ohio Environmental Protection Agency

MUSKINGUM WATERSHED CONSERVANCY DISTRICT

Bloom Report Form

Please provide information about the potential blue-green algae bloom observed. Information can be entered into this electronic form and saved on your computer using Word or Adobe Reader (version 9+).
Please save and email a completed copy of this form to HABmailbox@epa.state.oh.us.
You are encouraged to include digital photographs as additional email attachments (close-up, and landscape showing extent and location of bloom). If possible, consider including an image from an online mapping application such as Google, Bing or Yahoo Maps, with a marker at the bloom location. For more information go to the ohioalgaeinfo.com website.

Bloom Location:

Water body:	Date bloom observed: / /
County (optional):	Drinking water source? Yes ☐ No ☐ Unknown ☐
Publicly Owned Lake? Yes ☐ No ☐ Unknown ☐	Attached map with bloom location noted (e.g. Google Map image)? Yes ☐ No ☐ Digital photos attached? Yes ☐ No ☐

Report Completed By:

Name:	Organization:	
Title:	Phone: ( ) - ext.	Email:

Bloom Description and Sampling Information:

Please describe the location of the bloom in the water body (e.g. center of lake, at the boat dock, at the beach):

Do you notice any colors in the water column? Yes ☐ No ☐

Please check any colors you see, or describe the color(s) below: Green ☐ Blue ☐ Red ☐ Rust ☐ Brown ☐ Milky White ☐ Purple ☐ Black ☐

Please estimate the size (sq. feet) or the extent of bloom:

Can you see a surface scum (an accumulation at the surface) or algae floating near the water surface?
Algae floating at the surface can look like grass clippings, green cottage cheese curds, or spilled paint. Yes ☐ No ☐ Uncertain ☐

Is the bloom near a public beach? If yes, please specify the beach name or location below. Yes ☐ No ☐ Unknown ☐

Is the bloom near a drinking water intake? (Specify water system name if known) Yes ☐ No ☐ Unknown ☐

Were samples taken? Yes ☐ No ☐
If yes, what type of samples; when and where were they collected; and where were they sent for analysis?

Do you know if other water quality information is available? (Specify what data is available and where) Yes ☐ No ☐

HAB Monitoring Protocol

Robert David and Jim Swihart, Choctaw Lake, Aug 2013

- Modified from OEPA methods
- Equipment bag, 6-7 mailing boxes
- Site selection, beaches, contact areas
- Composite, along a shoreline transect
- Twice per month, Jul - Aug - Sep
- Mail to BSA Environmental Services
- Toxin data weekly
- Phytoplankton data monthly
- 2014 - add parameters and 'hot spots'

Quality Assurance / Quality Control

Site	Time	Date Sampled	Date Analyzed	Microcystin (µg/L)
Sippo - Driven	10:05	7/26/2011	8/10/2011	0.381
Sippo - Driven	10:07	7/26/2011	8/10/2011	0.838
Sippo - Driven	10:09	7/26/2011	8/10/2011	0.451
			average:	**0.557**
Sippo - Mailed	10:05	7/26/2011	8/10/2011	0.399
Sippo - Mailed	10:07	7/26/2011	8/10/2011	0.603
Sippo - Mailed	10:09	7/26/2011	8/10/2011	0.612
			average:	**0.538**
Sippo - Driven	10:05	8/1/2011	8/10/2011	0.295
Sippo - Driven	10:10	8/1/2011	8/10/2011	0.240
Sippo - Driven	10:15	8/1/2011	8/10/2011	0.380
			average:	**0.305**
Sippo - Mailed	10:05	8/1/2011	8/10/2011	0.307
Sippo - Mailed	10:10	8/1/2011	8/10/2011	0.483
Sippo - Mailed	10:15	8/1/2011	8/10/2011	0.442
			average:	**0.410**
Sippo - Driven	10:45	8/2/2011	8/10/2011	2.015
Sippo - Driven	10:50	8/2/2011	8/10/2011	1.961
Sippo - Driven	10:55	8/2/2011	8/10/2011	2.290
			average:	**2.089**
Sippo - Mailed	10:45	8/2/2011	8/10/2011	2.328
Sippo - Mailed	10:50	8/2/2011	8/10/2011	2.120
Sippo - Mailed	10:55	8/2/2011	8/10/2011	2.892
			average:	**2.447**

Robert David and Betty Lyle Kaser , Indian Lake, Aug 2013

Cyanobacteria Bloom Densities

4,000 - 10,000 cells/mL	=	Minor Bloom
10,000 - 100,000 cells/mL	=	Moderate Bloom
>100,000 cells/mL	=	Severe Bloom

Ohioalgaeinfo.com

Cyanotoxin Genera

2011

Density (cells/mL)	Piedmont 7/10/2011 12:15	Piedmont 7/26/2011 17:30	Piedmont 8/8/2011 17:15	Piedmont 8/22/2011 17:00	Piedmont 9/12/2011 17:23	Piedmont 9/28/2011 17:15
Anabaena	1198	5113		13223	4584	1693
Anabaenopsis		617	15163	1410	1146	741
Aphanizomenon						
Cylindrospermopsis	20406	92035	27328	258297	310309	159386
Microcystis						
Oscillatoria		2292		1322		
Planktothrix						
TOTAL CYANOS	**95,269**	**100,057**	**42,491**	**275,840**	**319,390**	**168,484**

2012

Density (cells/mL)	Piedmont 7/10/2012 17:05	Piedmont 7/24/2012 17:00	Piedmont 8/12/2012 15:15	Piedmont 8/27/2012 17:00	Piedmont 9/10/2012 17:05	Piedmont 9/17/2012 17:20
Anabaena	1176	2709	20		4991	2042
Anabaenopsis	72	998	327	2597	381	2625
Aphanizomenon	864	668	472		8556	18959
Cylindrospermopsis	83152	205340	154718	62641	93223	45307
Microcystis						
Oscillatoria						110
Planktothrix						
TOTAL CYANOS	**240,635**	**447,875**	**380,118**	**260,800**	**649,339**	**451,750**

Microcystin Cyanobacteria

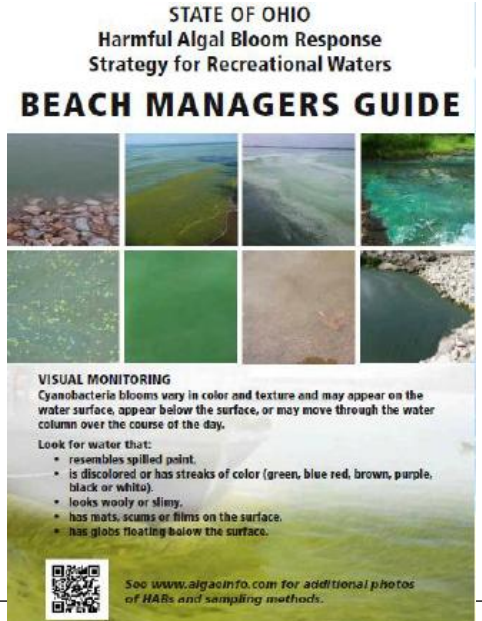
Cylindrospermopsin Cyanobacteria

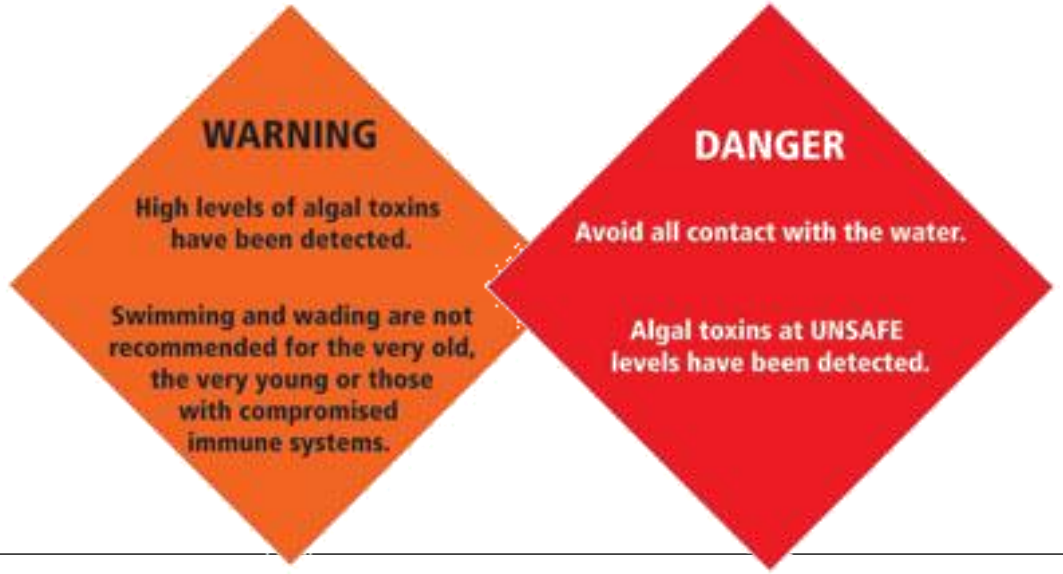
Cyanotoxin Thresholds

ohioalgaeinfo.com

Threshold (ug/L)	Microcystin	Cylindrospermopsin
Algae Bloom Advisory	identified	identified
Recreational Public Health Advisory	6	5
Recreational No Contact Advisory	20*	20*
Drinking Water - Do Not Drink	1	1
Drinking Water - Do Not Use	20	20

*Concentration levels, along with confirmed illness or death.





Microcystin Results

- 75% of samples = limited detection
- 5 lakes with values
- < 6 ug/L threshold
- 2011 with more 'hits'
- Tappan Lake with greatest frequency and highest value

Lake	Time	Date Sampled	Microcystin (ug/L)
Charles Mill	17:45	8/24/2011	0.225
Charles Mill	14:00	7/9/2012	0.19
Leesville	11:15	7/5/2011	0.239
Leesville	10:45	9/6/2011	0.203
Pleasant Hill	14:00	7/5/2011	0.153
Pleasant Hill	14:30	7/5/2011	0.149
Pleasant Hill	13:39	7/25/2011	0.220
Pleasant Hill	14:32	8/9/2011	0.253
Pleasant Hill	13:40	8/29/2011	0.749
Pleasant Hill	11:30	9/27/2011	0.216
Tappan	14:32	7/5/2011	0.692
Tappan	14:51	7/5/2011	0.526
Tappan	14:40	7/19/2011	0.813
Tappan	10:53	8/2/2011	0.170
Tappan	10:28	8/29/2011	0.540
Tappan	11:50	9/12/2011	0.512
Tappan	14:00	9/27/2011	0.991
Tappan	10:05	7/17/2012	0.56
Tappan	14:30	7/29/2012	1.45
Tappan	16:04	8/7/2012	0.18
Tappan	10:25	8/21/2012	0.90
Tappan	10:30	9/3/2012	0.91
Tappan	15:05	9/24/2012	0.32
Wills Creek	14:00	8/28/2011	0.349
Wills Creek	14:00	7/22/2012	0.18
Wills Creek	16:00	8/5/2012	0.15

Cylindrospermopsin Results

Lake	Time	Date Sampled*	Cylindrospermopsin (ug/L)	Comments
Atwood	11:42	7/2/2012	<0.10	Concentration below limit of quantification
Atwood	9:45	10/4/2012	ND	Concentration below limit of detection
Charles Mill	14:00	7/9/2012	ND	Concentration below limit of detection
Clendening	17:50	7/10/2012	ND	Concentration below limit of detection
Leesville	10:45	7/10/2012	ND	Concentration below limit of detection
Piedmont	17:05	7/10/2012	<0.10	Concentration below limit of quantification
Piedmont	17:00	7/24/2012	ND	Concentration below limit of detection
Piedmont	15:15	8/12/2012	0.12	< 5 ug/L threshold
Piedmont	17:00	8/28/2012	0.65	< 5 ug/L threshold
Piedmont	15:05	9/10/2012	1.21	< 5 ug/L threshold
Piedmont	17:20	9/17/2012	1.14	< 5 ug/L threshold
Pleasant Hill	14:49	7/8/2012	ND	Concentration below limit of detection
Seneca	13:45	7/10/2012	ND	Concentration below limit of detection
Tappan	10:05	7/17/2012	ND	Concentration below limit of detection
Tappan	16:04	8/7/2012	<0.10	Concentration below limit of quantification
Wills Creek	19:00	7/1/2012	<0.10	Concentration below limit of quantification
Wills Creek	14:00	7/22/2012	ND	Concentration below limit of detection

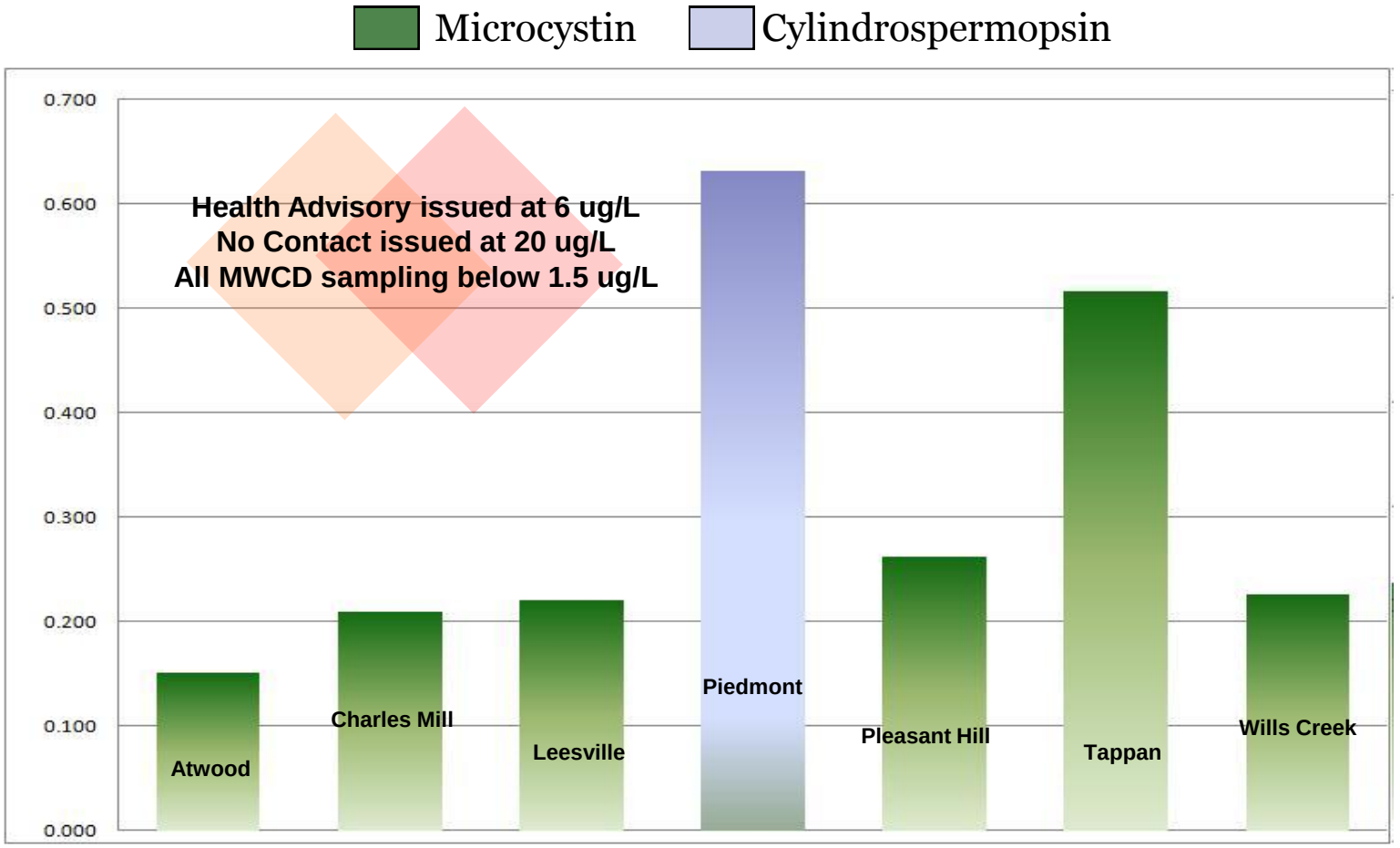
*Not all samples shown. Except Piedmont Lake, all samples were below limit to detect or quantify.

Microcystin Concentrations ug/L OEEF Lakes - 2013

- 27% of samples = limited detection
- 50% above .15 ug/L but < 6 ug/L
- 23% above 6 ug/L representing 4 lakes
- 12% above 'no contact' threshold of 20 ug/L

Site	Date Sampled	Microcystin (µg/L)
Choctaw Lake	9/17/2013	6.563
Choctaw Lake	7/15/2013	7.95
Choctaw Lake	8/12/2013	10.002
Buckeye Lake	7/8/2013	11.18
Choctaw Lake	8/27/2013	12.562
Grand Lake St. Mary's	7/29/2013	12.833
Choctaw Lake – QAQC	8/27/2013	13.844
Grand Lake St. Mary's	7/1/2013	25.954
Grand Lake St. Mary's	8/26/2013	31.739
Grand Lake St. Mary's	7/15/2013	34.180
Indian Lake	7/29/2013	38.1531
Grand Lake St. Mary's – QAQC	8/15/2013	42.407
Grand lake St. Mary's	9/9/2013	50.896
Buckeye Lake	8/18/2013	68.736
Buckeye Lake – QAQC	9/9/2013	106.41
Buckeye Lake	9/9/2013	107.14

Average Toxin Concentration (2011 - 2013) ug/L



- Average concentration from 2011 to 2013.
- Only samples with a measurement above .15 ug/L are included.
- Clendening and Seneca lakes did not measure above .15 ug/L.

Monitoring for a Harmful Algal Bloom at Muskingum Watershed Lakes

Most recent HAB TOX results from BSA Environmental Services

MWCD Lakes are sampled every 2 weeks July - September by Citizen Lake Awareness and Monitoring (CLAM) volunteers through Ohio Lake Management Society (OLMS) and a grant awarded by MWCD The samples are sent to a certified lab (BSA Environmental Service, Inc) to be analyzed. All seasonal results are available by contacting OLMS at 330-466-5631 as only most recent results are displayed on the map.

Levels of advisory were developed following the Ohio EPA public health thresholds.

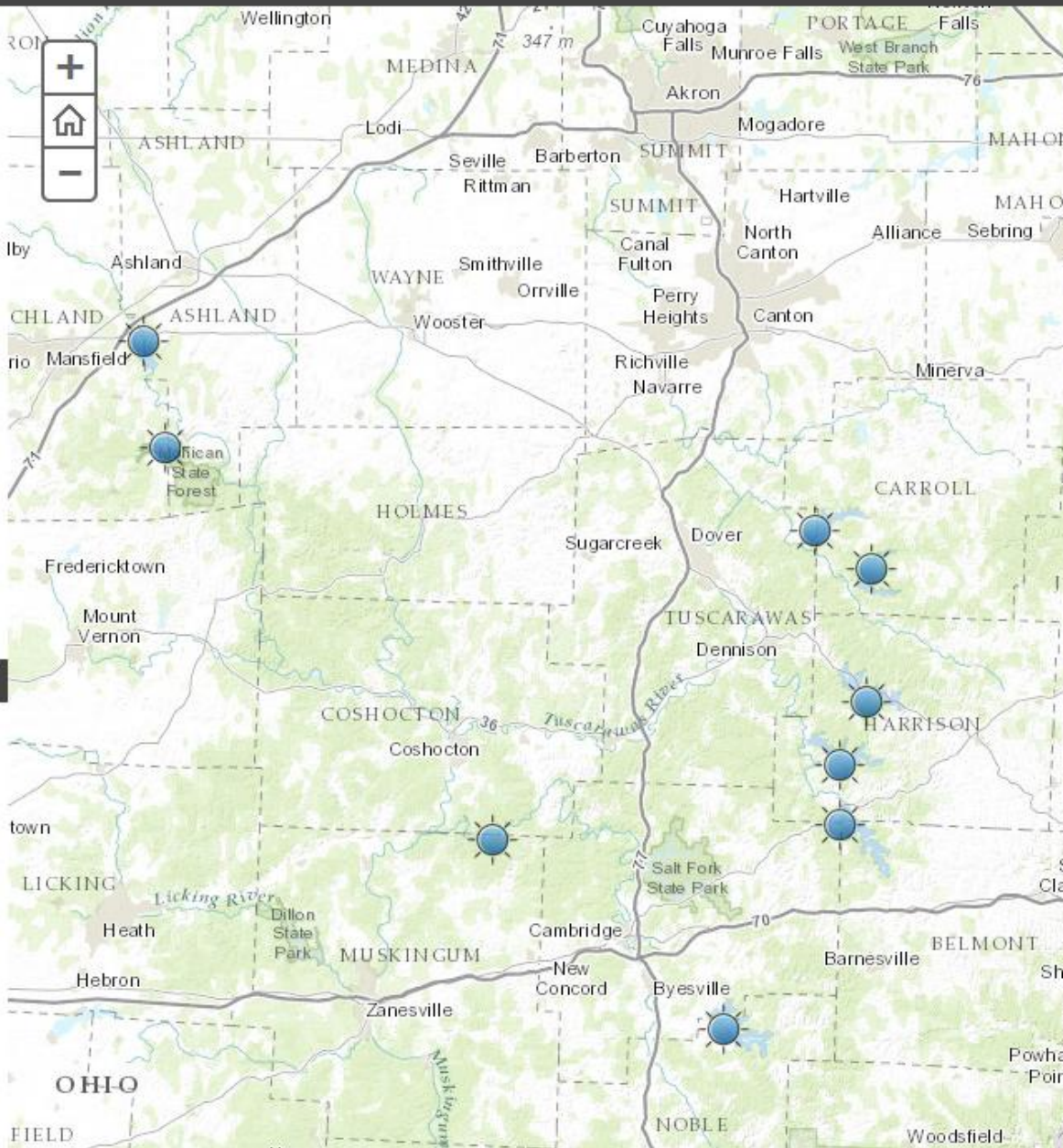
Map Compiled by
Skyler Dewey, MWCD

LEGEND

HAB Advisory- Most Current Results

- No Recreational Public Health Advisory
- Recreational Public Health Advisory
- Recreational No Contact Advisory

MUSKINGUM WATERSHED CONSERVANCY DISTRICT



Partnerships and Stewardship

- Nonprofit, public, and private working together
  - Combined resources, strengths are magnified
  - More legitimate, credible, and relevant
  - Increased ability for long-term effort towards desired result
- Longevity of effort leads to action
- Action (and only action) will protect our water and us!

WMAO Water Management Association of Ohio

OLMS

OHIO DEPARTMENT OF NATURAL RESOURCES DIVISION OF WILDLIFE

OhioEPA Ohio Environmental Protection Agency

BSA ENVIRONMENTAL SERVICES, INC.

MUSKINGUM WATERSHED CONSERVANCY DISTRICT

www.eyesonthewater.com/olms
www.olms.org

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