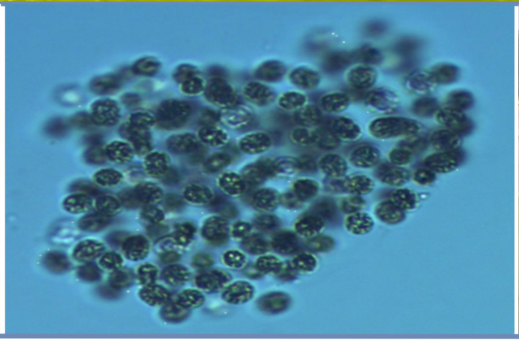
United States Environmental Protection Agency

2018 APHL Annual Meeting and Twelfth Government Environmental Laboratory Conference





Harmful Algal Bloom Response

Sandhya Parshionikar, Acting Director
Water Supply Division, National Risk Management Research Laboratory
Office of Research and Development

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Overview

- What are HABs
- Health and economic impacts of cyanotoxins
- Types of cyanotoxins
- Monitoring of HABs
- Impacts of HABs to drinking water
- Treatment for removal of toxins
- 2014 Toledo crisis
- EPA's role in partnering with Ohio EPA
- What worked during the crisis

EPA

Harmful Algal Blooms (HABs)

- Overgrowth of autotrophs close to the shore of a water body.
- Wide variety of taxa can produce blooms and toxins.
- Typically detrimental to the aquatic system and can be harmful to humans and land animals (contact and consumption).
- Blooms are dependent on numerous factors, including nutrient loading, temperature, and weather patterns.

Cyanobacterial HAB (CyanoHAB)

Often referred to as "blue-green algae"

Cyanobacteria are bacteria that produce a wide variety of toxins and exhibit some similar characteristics with algae, such as photosynthesis, so they are considered harmful algae that can produce HABs.

Social, Environmental, and Economic Impacts

Harmful Effects Without Toxins

- Unpleasant appearance
- Taste and odor problems
- Block photosynthesis in bottom-dwelling plants
- Deplete dissolved O_2 as bloom material dies



Harmful Effects Due to Toxins

- Illness and deaths in humans, wildlife, livestock, and pets
- Skin and airway irritation



Cyanobacteria Strains & Associated Toxins

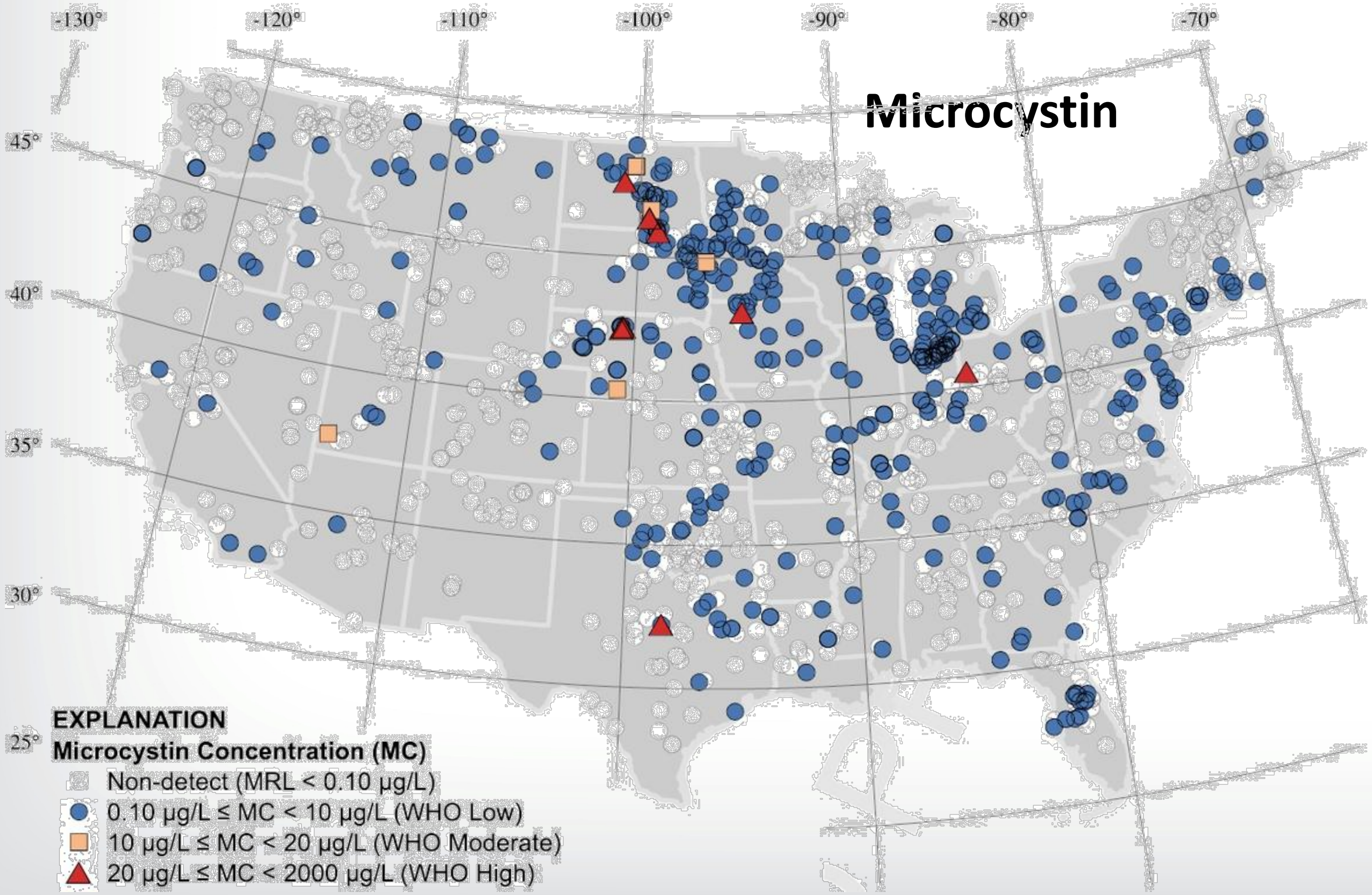
- Strains produce different toxins at different amounts
- Toxins can have multiple variants

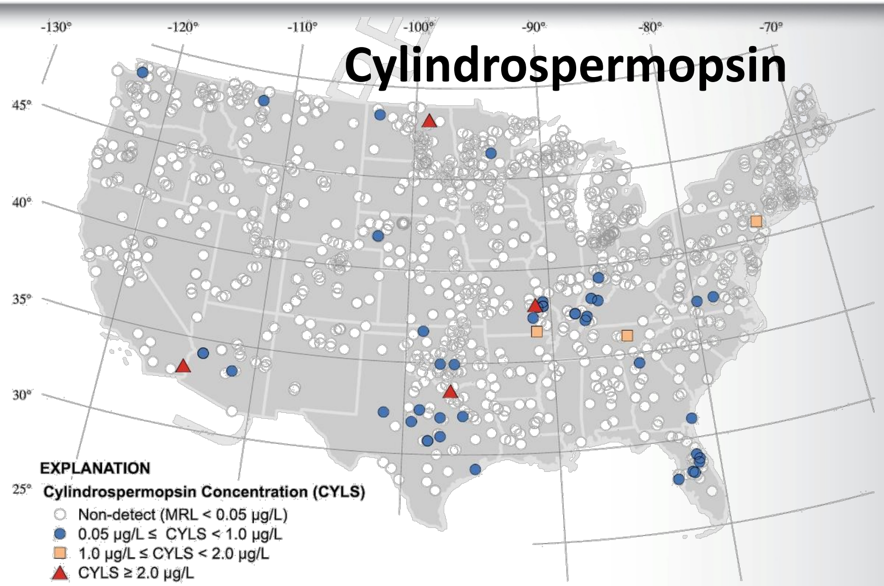
Toxins analyzed in Toledo samples

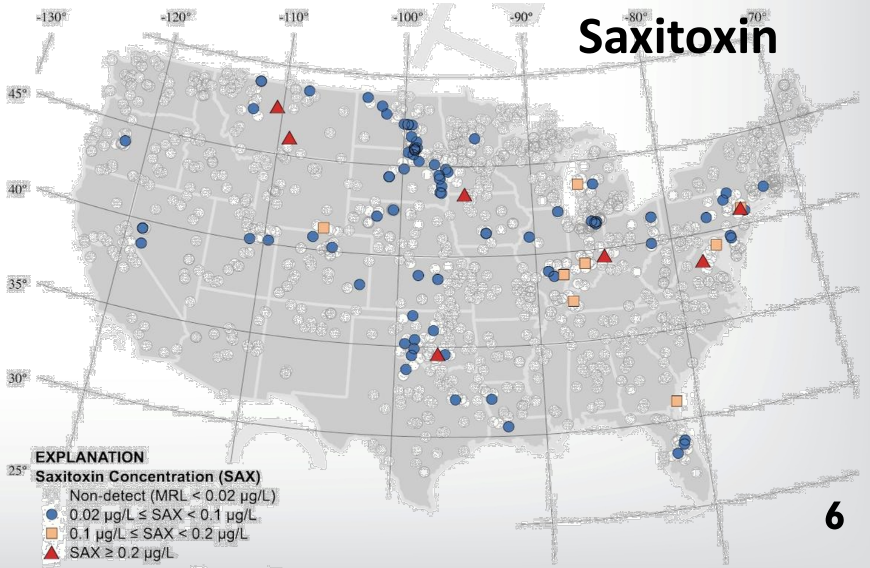
Adapted from : Paerl and Otten 2013. Harmful Cyanobacterial Blooms: Causes, Consequences, and Controls. Microbial Ecology 65:4 995–1010	Cyanobacteria Strain											
Toxin	Anabaena	Aphanizomenon	Aphanocapsa	Chroococcus	Cylindrospermopsis	Limnothrix	Merismopedia	Microcystis	Planktolyngbya	Planktothrix	Pseudanabaena	Nodularia
Aeruginosin								X		X		
Anatoxin-a/homoanatoxin-a	X	X			X				X	X		
Anatoxin-a(S)	X											
Aplysiatoxins									X			
BMAA	X	X			X			X	X	X		
Cyanopeptolin	X							X		X		
Cylindrosp[illegible]ps[illegible]	X	X			X							
Jam[illegible]									X			
Lyngbyatoxin									X			
Microcystin	X	X	X		X	X	X	X		X	X	
Nodularin												X
Saxitoxin	X	X			X					X		

Nationwide HABs Issue

National Lakes Assessment survey conducted by EPA and the U.S. Geological Survey sampled 1161 inland lakes and reservoirs throughout the United States (2012 survey).

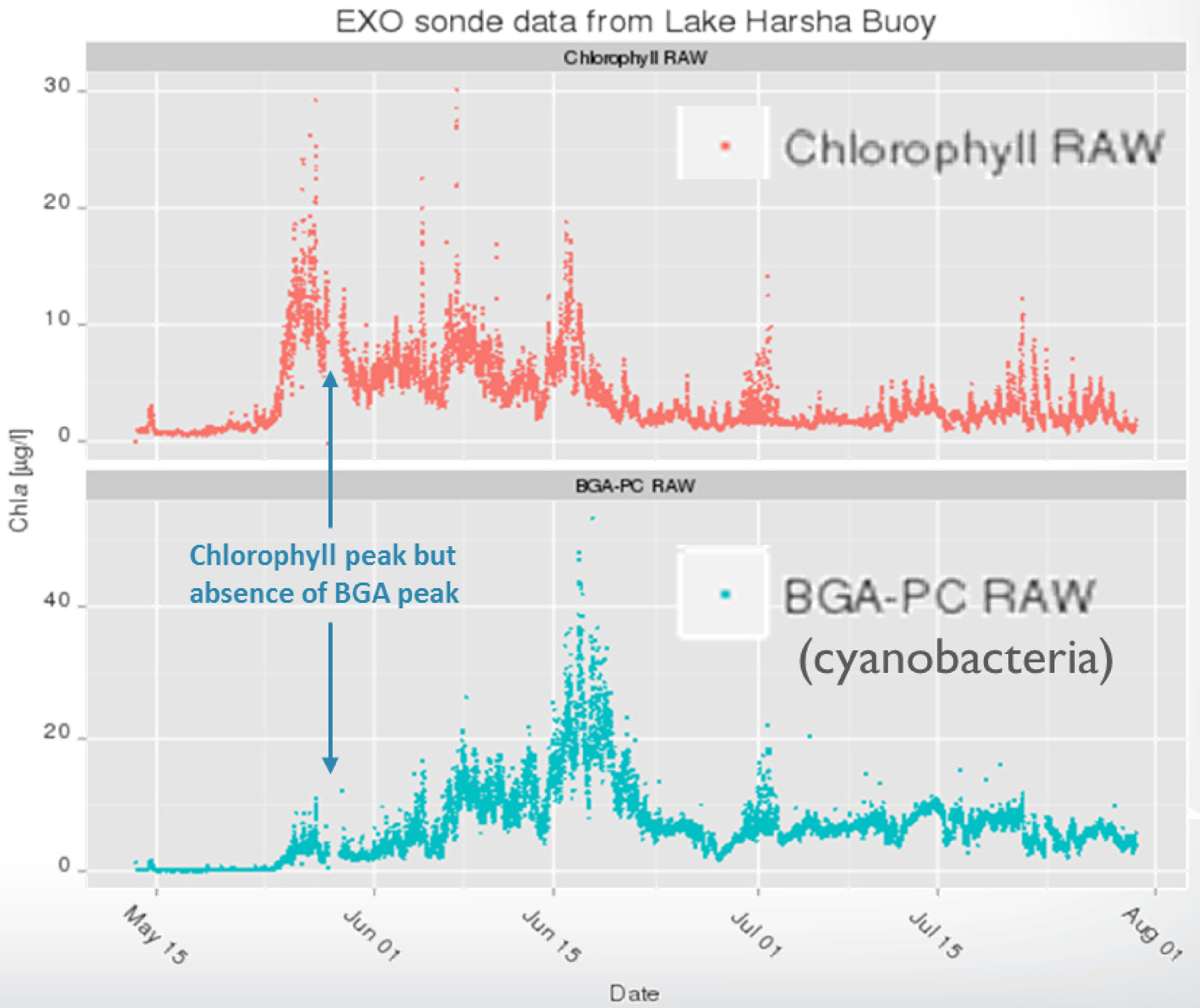






Monitoring for HABs

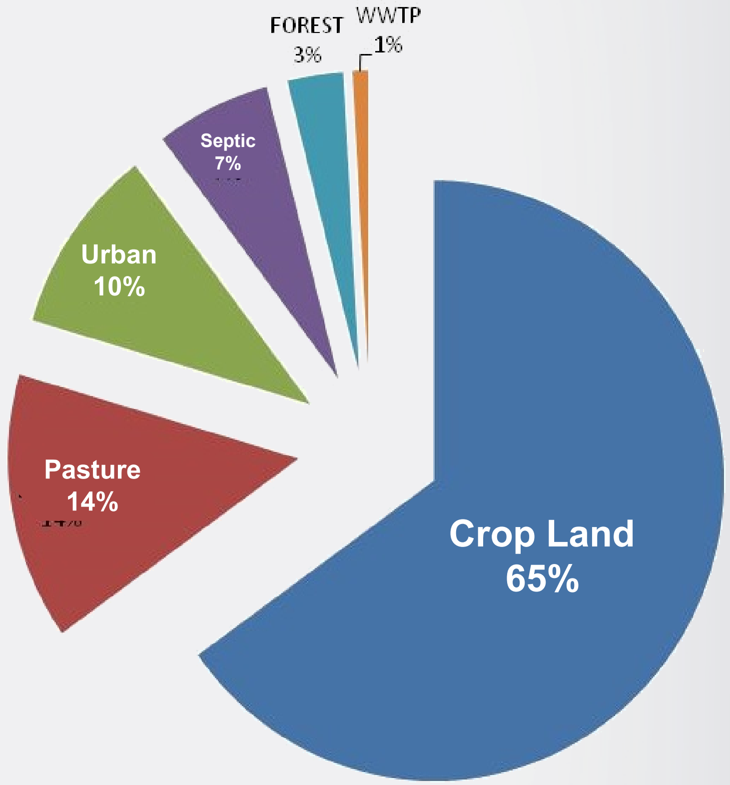
- Different algal/ cyanobacterial strains bloom under different conditions, at different times
- Chlorophyll peak may be detected without cyanobacteria peak



Source Water Impacts to Drinking Water

Problem:

- Excessive nitrogen and phosphorous levels can cause harmful algal blooms.
- Algal/cyanobacteria strains bloom under different conditions, at different times.
- Different strains produce different toxins at varying amounts.
- Algal blooms put pressure on drinking water facilities, requiring operational changes that can be costly and not well understood.



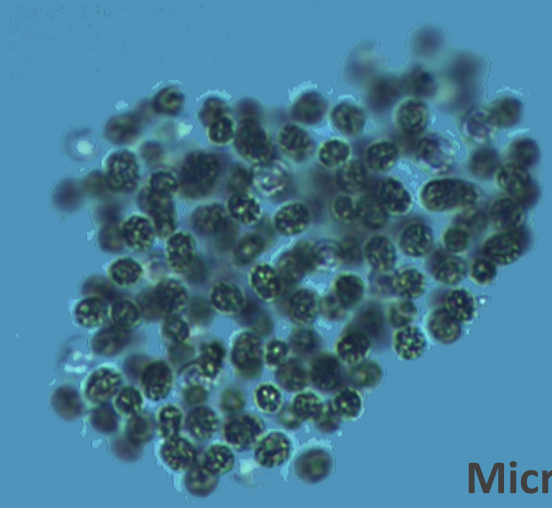
Nutrient Loading Example
Nitrogen Load Source Distribution to Harsha Lake in Ohio

Treatment for Cyanobacteria & Their Toxins

Particulates (cell) and the dissolved toxins (toxins have been released) require different treatment processes

Particulates (toxin in cell)

- Solids removal processes effective
- Do not want to lyse cell or toxin will be released

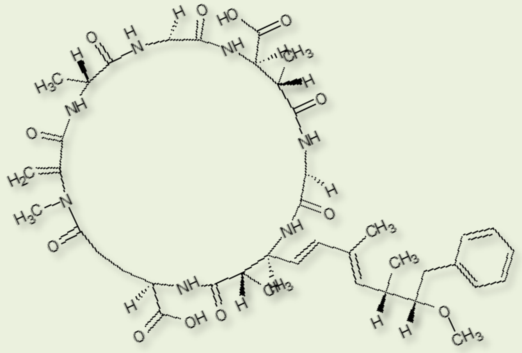


Microcystis (cells)

Dissolved (toxin released from cell)

- Solids removal processes ineffective
- Typical disinfectants may not be effective enough (e.g., chlorine)
- More effective treatments are expensive and plants typically do not have them in place (e.g., GAC)

Microcystin Toxin

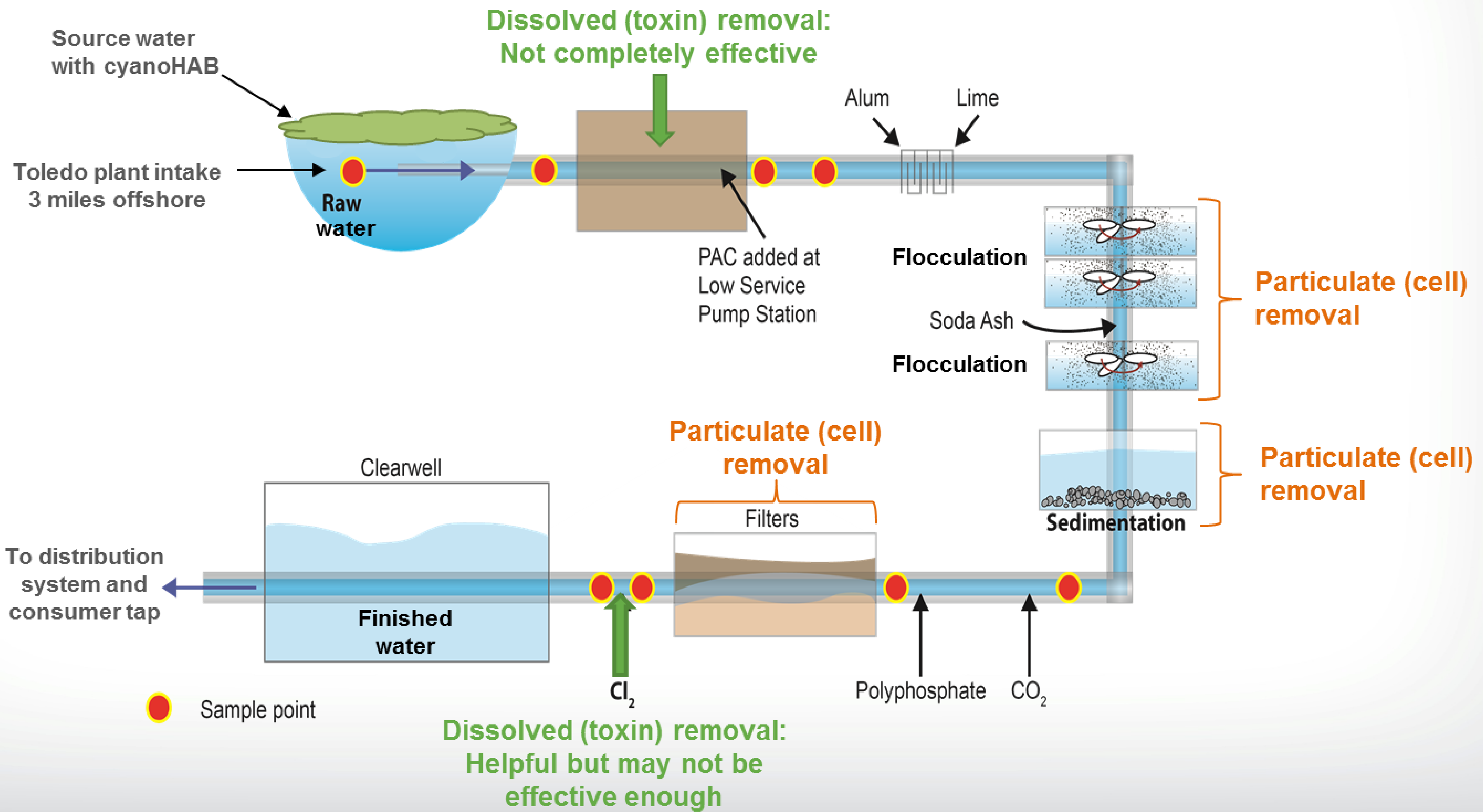


There is not an established federal standard for microcystin in drinking water

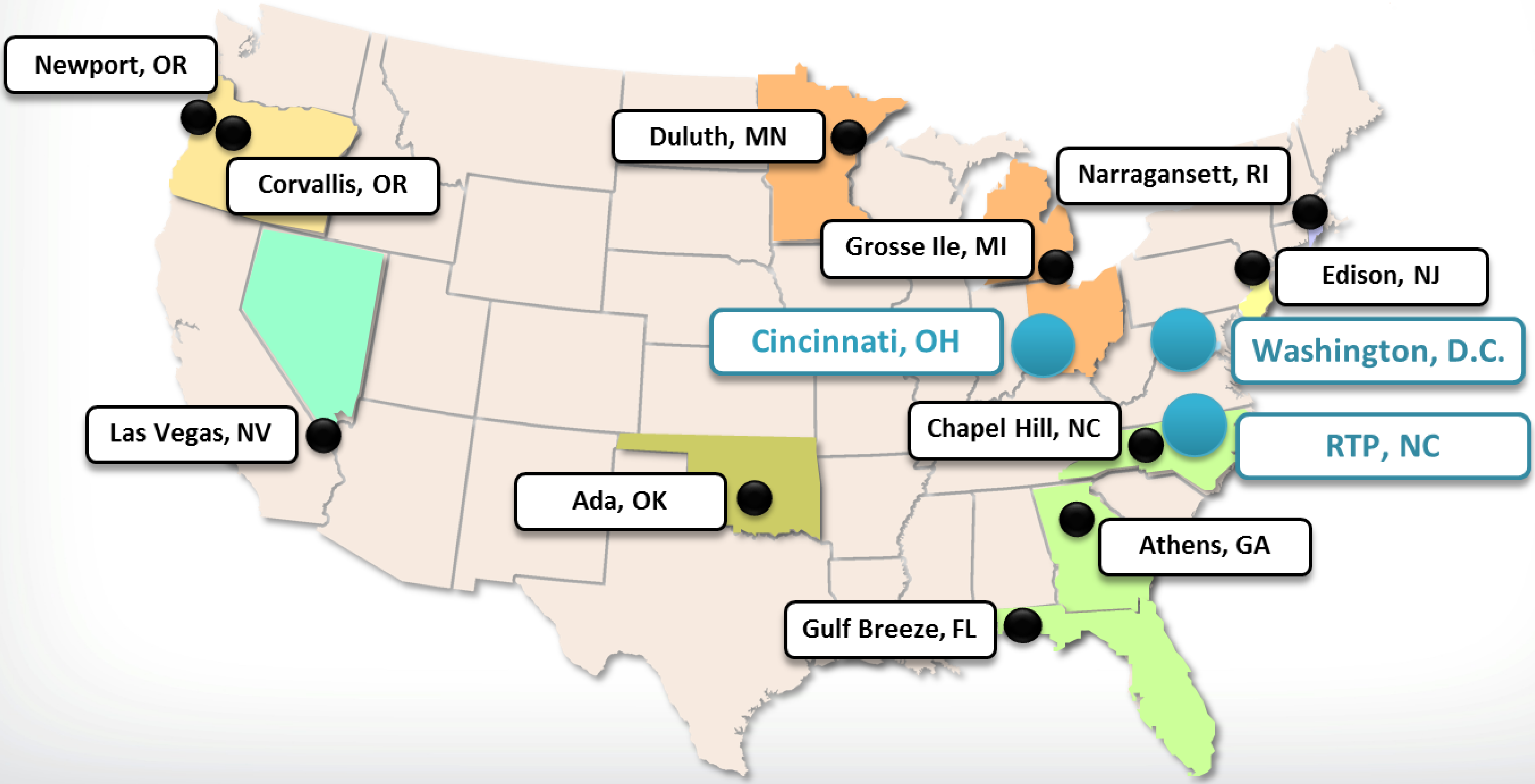
2014 Toledo, Ohio Drinking Water Crisis

- **Toxins detected in treated drinking water:** Toledo's water utility detected cyanobacterial toxins in their treated drinking water.
- **HAB in source water:** Lake Erie experiencing a large CyanoHAB.
- ***Do Not Drink Order* issued:** On August 2, 2014, the Mayor of Toledo, Ohio issued order for almost 500,000 people. Boiling the water only makes the situation worse.
- **Emergency actions taken:** Governor declared an emergency in the area, Ohio National Guard was mobilized to distribute bottled water, and hundreds of water dependent businesses in the Toledo metro area closed.
- **Other recommendations issues:** Officials also told some residents to avoid showering with the water, and to make sure that children and pets avoid the water.

Drinking Water Treatment System Similar to Toledo plant



ORD Labs and Centers



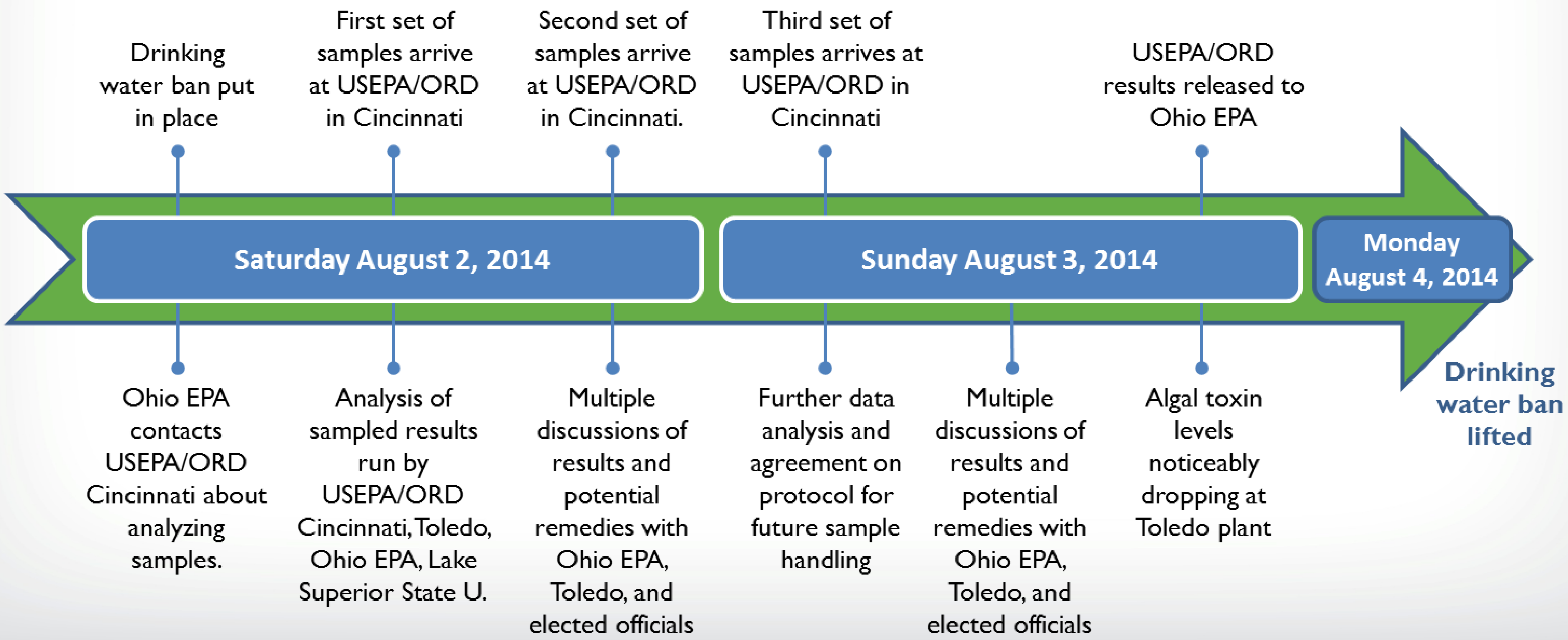
Cincinnati Research Center

Why were EPA staff in Cincinnati contacted?

- Ohio EPA personnel were aware of EPA's expertise, analytical capabilities, and research in drinking water treatment and cyanobacterial toxins.
- ORD was already conducting research studies on the proliferation and treatment of algal toxins at numerous drinking water treatment plants along Lake Erie
- Expert scientists and engineers with decades of experience in drinking water treatment.

Timeline of Events for Toledo Analysis

<u>Action</u>: Worked with Toledo and the Ohio EPA to analyze samples, make sense of the data from the three organizations testing the samples, and recommended treatment changes.



Test Methods used for Toledo Analysis

ELISA

- Broad-based method
  (measures 80+ toxin congeners/variants)
- Ohio's ELISA standard is 1 ug/L
- EPA ran ELISA under different sample handling procedures
- The results helped to confirm the original readings and to determine the best handling protocol to avoid data variability

LC/MS

- EPA used three separate LC/MS methods
  (2 triple quad and 1 high resolution MS)
- At the time, there was no official EPA method for microcystin toxins
- Tested for 7 microcystin congeners/variants
- Analyses were completed to potentially help with guidance on how the plant could be further optimized to control the toxin

  (Guidance was never needed—plant came into compliance with the original treatment changes)

Analytical Methods

Draft method used during crisis is now a published method:

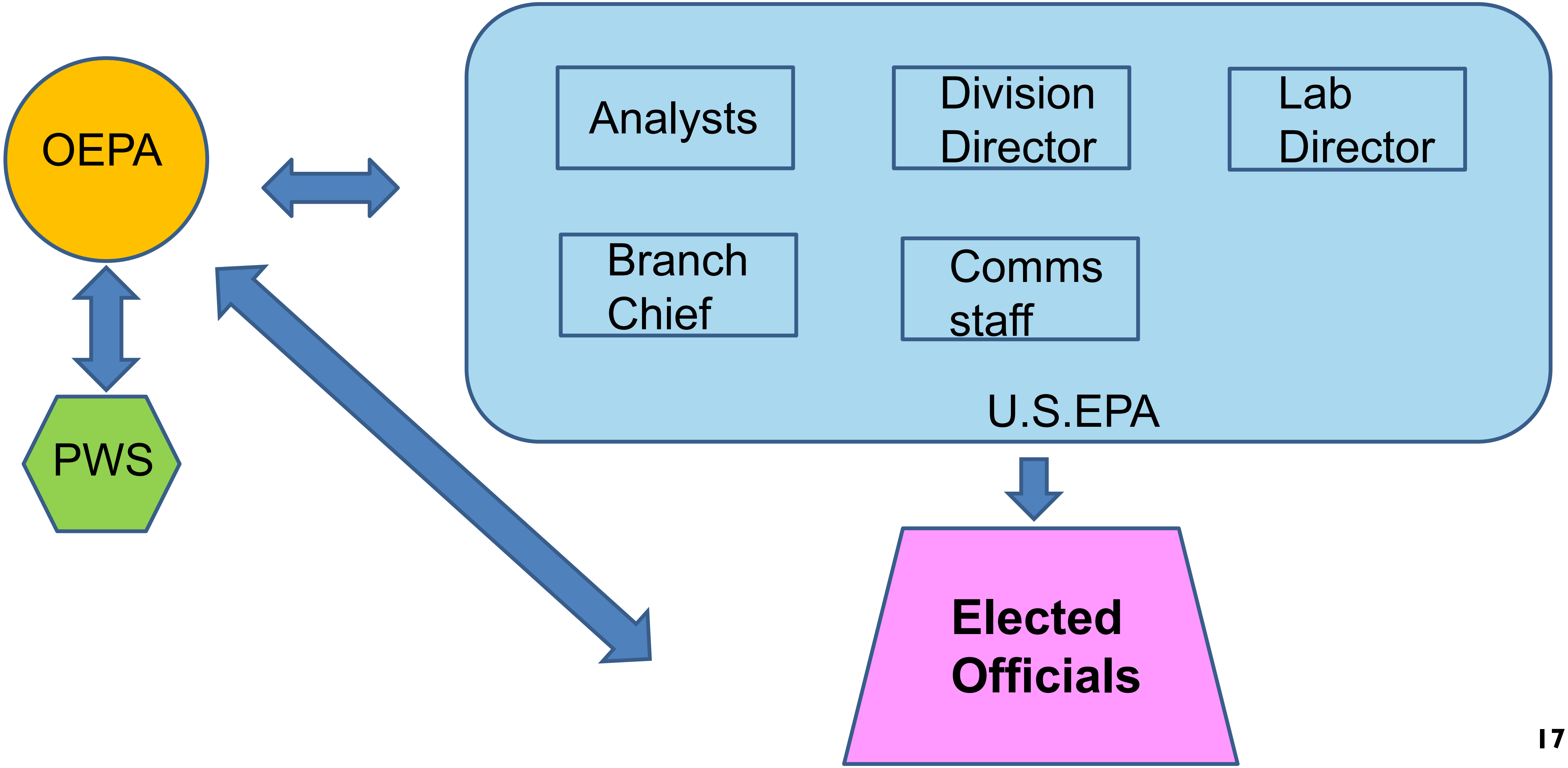
- **Method 544:** Determination of microcystins and nodularins in drinking water by LC/MS/MS

Other available published methods:

- **Method 545:** Determination of cylindrospermopsin and anatoxin-a in drinking water by LC/ESI-MS/MS
- **Method 546:** Determination of microcystins and nodularins in drinking water and ambient water by ELISA
- **Single Laboratory Validated Methods:** Determination of cylindrospermopsin and anatoxin-a and for microcystins and nodularins in ambient freshwaters by LC/MS/MS

www.epa.gov/water-research/methods-models-tools-and-databases-water-research#cyanotoxins

How we communicated



What Worked During the Crisis

"Your efforts were instrumental in restoring safe drinking water to over ½ million Ohioans and exemplifies a great example of how local, state and federal agencies are able to work together, mobilize essential resources and address critical issues."

—Governor John R. Kasich (in a letter to USEPA staff)

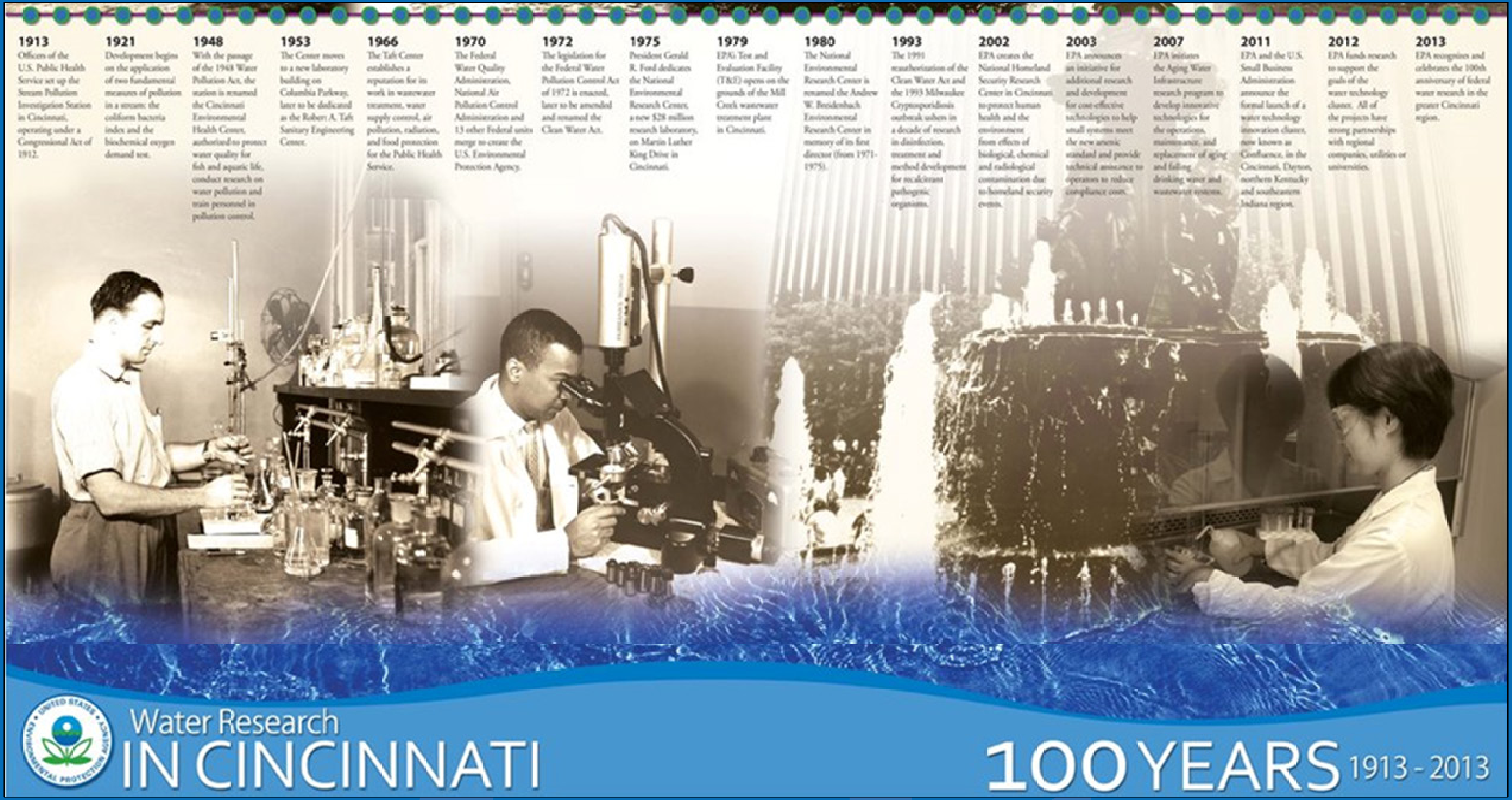
What worked

- Ohio EPA knew to contact ORD
- Being hands-on and available when crisis happened
- Constant communication with utility and state
- Involved in communications with elected officials
- Example of true partnership between federal, state and local agencies!

"When we were faced with an emergency in Toledo due to cyanobacterial toxins detected in their treated drinking water, ORD staff was a great partner and exceeded our expectations in understanding science and helping optimize treatment and restore safe drinking water to our residents."

—Craig Butler, Ohio EPA Director

United States Environmental Protection Agency



Questions?