EPA Region 4 Harmful Algal Bloom
Southeastern Regional Workshop Agenda

Day 1 – Monday, May 14, 2018

Recording: **http://epawebconferencing.acms.com/p66ysfg1e3y/**

Source Water Protection and Drinking Water Management		
Time	**Presentation Title**	**Presenter**
12:30 – 1:00 pm	Registration	
1:00 – 1:10 pm	Welcome and Introductions	Region 4, EPA
1:10 – 1:20 pm	Opening Remarks	Becky Allenbach, EPA
1:20 – 1:50 pm	Impact of the 2015 Ohio River HABs in Kentucky's Drinking Water	Rob Blair, KYDEP
1:50 – 2:20 pm	State of Florida Response to the 2016 and 2017 Cyanobacteria Bloom Seasons	David Whiting, FDEP
2:20 – 2:50 pm	Q&A and Open Discussion	EPA
2:50 – 3:10 pm	Guidelines and Advisories for Cyanotoxins in Drinking Water	Lesley D'Anglada, EPA
3:10 – 3:30 pm	U.S. EPA's Support Tools for Managing Cyanotoxins in Drinking Water	Katherine Foreman, EPA
3:30 – 3:50 pm	Via Webinar: Cyanotoxins: EPA Analytical Methods and UCMR 4	William Adams, EPA
3:50 – 4:20 pm	Q&A and Open Discussion	EPA
4:20 – 4:40 pm	Conventional Treatment for Harmful Algal Blooms	Nicholas R. Dugan, EPA
4:40 – 5:00 pm	Q&A and Open Discussion	EPA
5:00 pm	Adjourn and Networking Opportunity at McCormick and Schmick's Seafood and Steaks in the CNN Center	

EPA Region 4 Harmful Algal Bloom
Southeastern Regional Workshop Agenda

Biographies of Presenters

Mr. Robert J. Blair has been the Source Water Protection (SWP) program coordinator at the Kentucky Division of Water since 2015. Prior to his work in SWP Rob coordinated Kentucky's groundwater monitoring programs for twelve years, with an emphasis on karst groundwater resources. He joined the Kentucky Division of Water in 2000 and has worked in various other groundwater-related programs. He is a graduate of the University of Kentucky with a B.S. in Geology, and is a registered professional geologist in the state of Kentucky.
Email: Robert.Blair@ky.gov; Phone: 502-782-6893

Mr. David Whiting works for the Florida Department of Environmental Protection as the Deputy Director over the Laboratory and Water Quality Standards Programs within the Division of Environmental Assessment and Restoration. Dave began his career with FDEP in 1994 as an Aquatic Toxicologist, having previously worked on Exxon Valdez Oil Spill research at the USEPA Laboratory in Gulf Breeze, Florida. In addition to administrating the laboratory and WQS programs, he is currently involved in FDEP's Microbial Source Tracking efforts to identify fecal sources, the department's Harmful Algal Bloom response activities, and the state's efforts to understand the potential impacts of emerging contaminants of concern. Dave has a B.A. degree in Fisheries and Wildlife Management and a M.A. in Ecology from the University of Missouri-Columbia.
Email: david.d.whiting@dep.state.fl.us, Phone: (850) 245-8191.

Dr. Lesley D'Anglada is a Senior Microbiologist with the United States Environmental Protection Agency (EPA). Dr. D'Anglada is the manager of the EPA Drinking Water Health Advisories for Cyanotoxins and the EPA CyanoHABs website. Dr. D'Anglada is the Office of Water representative on the Interagency Working Group for HABHRCA (Harmful Algal Blooms, Hypoxia, Research and Control Act). She is an expert member of the World Health Organization's Water Quality and Health Technical Advisory Group (WQTAG) and the National HABs Committee. Dr. D'Anglada is the author of the Freshwater HABs Newsletter and co-editor of the *Toxins* Journal. She received her Doctorate in Public Health, Masters in Environmental Health and Bachelor Degree in Industrial Microbiology from the University of Puerto Rico.
Email: danglada.lesley@epa.gov; Phone: 202-566-1125

Ms. Katherine (Katie) Foreman is a physical scientist with the EPA's Office of Ground Water and Drinking Water with a primary focus on harmful algal bloom issues and evaluating the national primary drinking water regulations. Before joining the EPA in August 2015, she led the development of new funding policies for Oregon's water infrastructure projects with the Oregon Department of Environmental Quality. Prior to her work with the State of Oregon, Ms. Foreman served for five years as a scientific and technical expert on water quality issues in the Chesapeake Bay Watershed with the EPA Region 3's Chesapeake Bay Program Office. She began her career as a scientist working for six years with the Iowa Department of Natural Resources focusing on watershed monitoring and assessment. Ms. Foreman has a bachelor's and a master's degree in geography from the University of Iowa.
Email: foreman.katherine@epa.gov; Phone: 202-564-3403

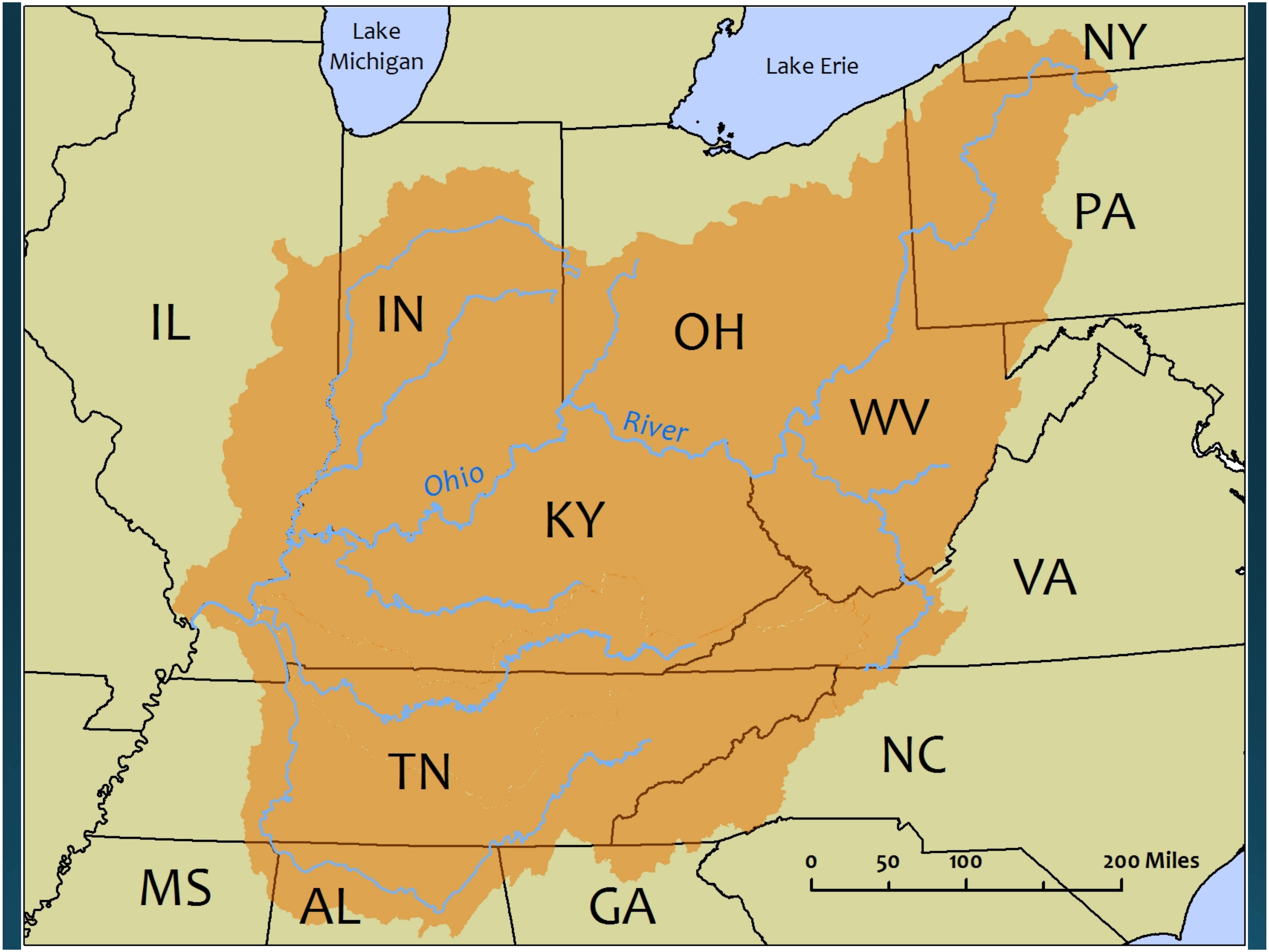
Dr. William Adams is a Chemist with the U.S. EPA, Office of Ground Water and Drinking Water, Technical Support Center in Cincinnati, OH, where he is involved with drinking water method development and support for regulated and unregulated contaminants, the Drinking Water Alternate Test Procedure (ATP) Program evaluating new and updated drinking water methods for regulatory compliance monitoring, and the UCMR program as a technical and analytical method resource. He has a research background in U.S. EPA analytical method development for drinking water contaminants using LC-MS/MS and the photolytic and photocatalytic degradation of drinking and surface water contaminants. He received a Bachelor of Science in Chemistry in 2001 and a Ph.D. in analytical chemistry in 2006 from The University of Alabama.
Email: adams.william@epa.gov; Phone: 513-569-7656

Mr. Nick Dugan is an environmental engineer with ORD's National Risk Management Research Laboratory–Water Systems Division in Cincinnati, Ohio, where he specializes in drinking water treatment. In addition to his work with cyanobacteria and cyanobacterial toxins, Nick has performed treatment studies to evaluate the control of cryptosporidium, nitrate, perchlorate, pesticides, and disinfection byproduct precursors. He has a M.S. in Environmental Engineering and a B.S. in Civil and Environmental Engineering from the University of Cincinnati, a B.A. in Economics from Carleton College, and he is a member of the technical advisory committee for the Water Research Foundation's harmful algal bloom research focus area.
Email: dugan.nicholas@epa.gov; Phone: 513-569-7239

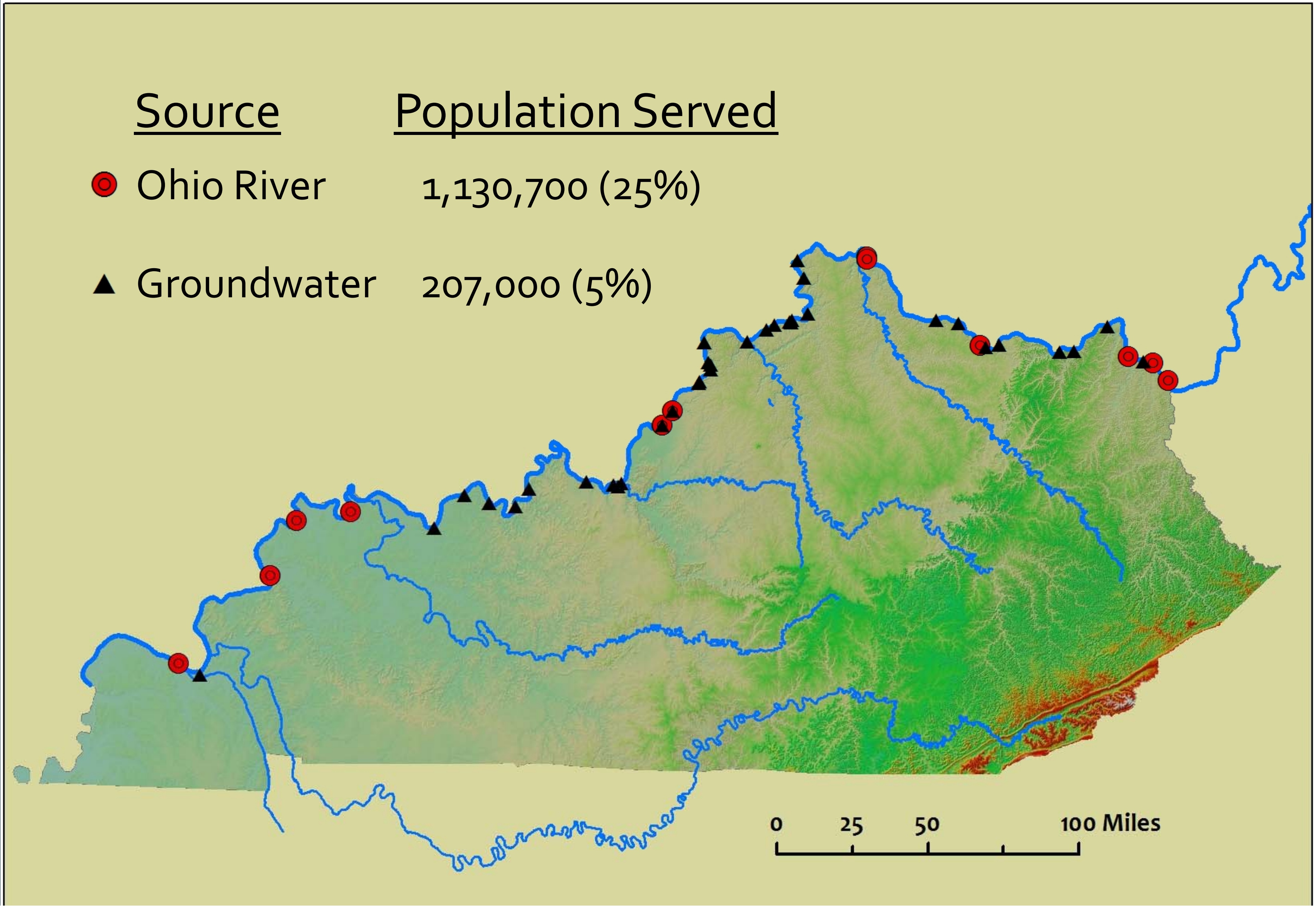
Impact of the 2015 Ohio River HABs in Kentucky's Drinking Water

Robert J. Blair, P.G.
robert.blair@ky.gov
502-782-6893

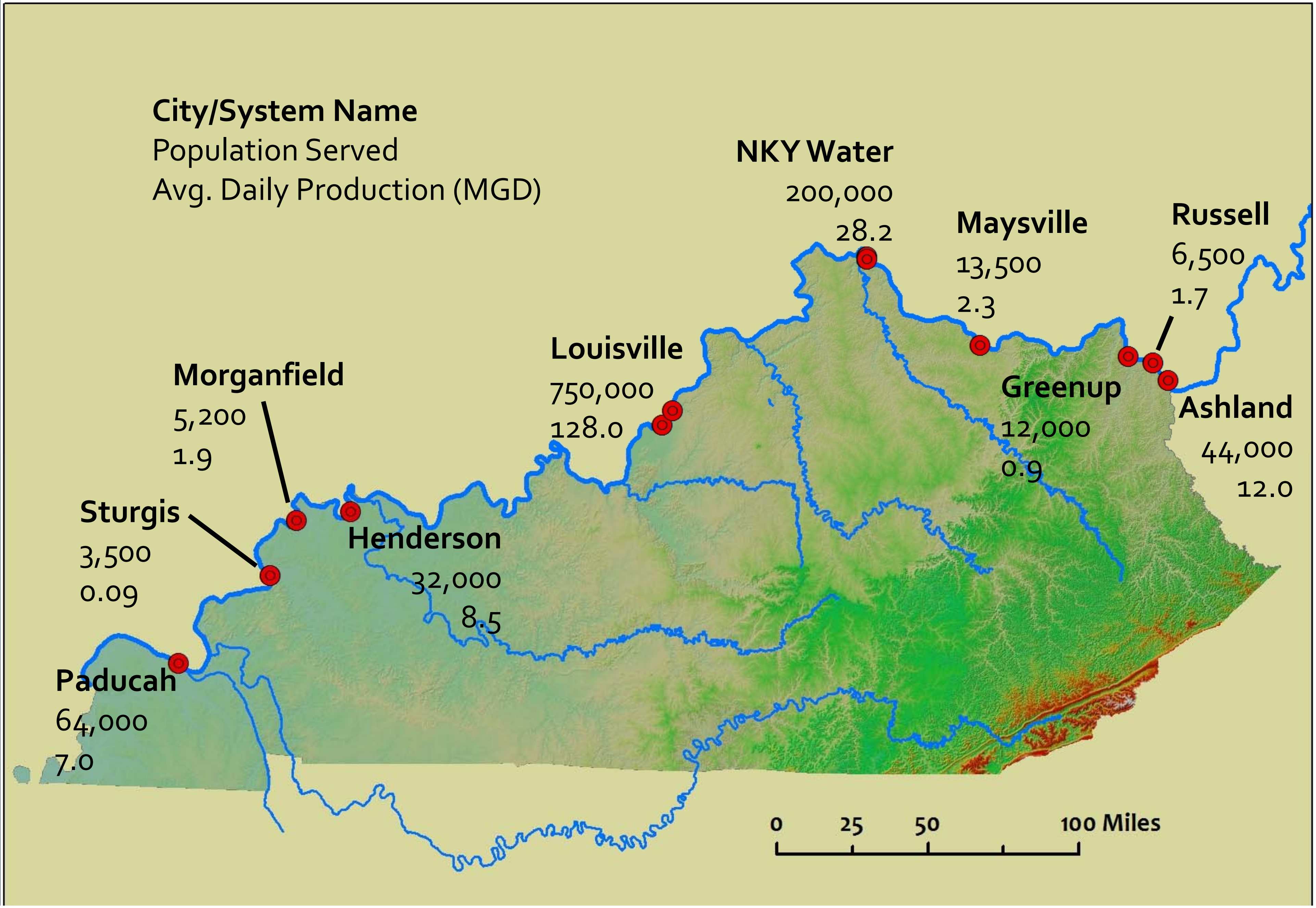
US EPA Region 4 Harmful Algal Bloom Southeastern Regional Workshop
May 14, 2018


Lake Michigan
Lake Erie
NY
PA
IL
IN
OH
WV
Ohio River
KY
VA
NC
TN
MS
AL
GA
0 50 100 200 Miles

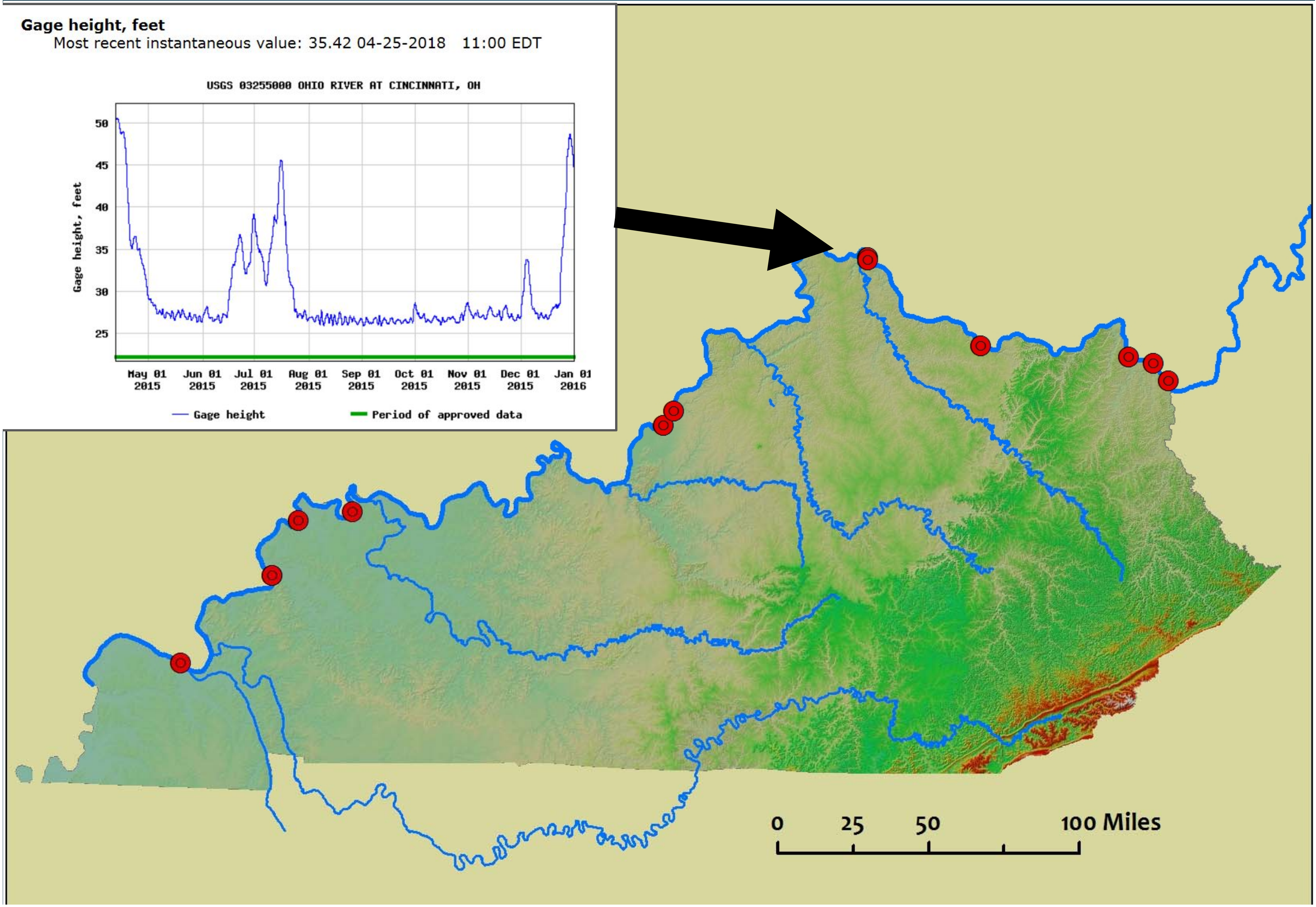
Community Water Systems on the Ohio River



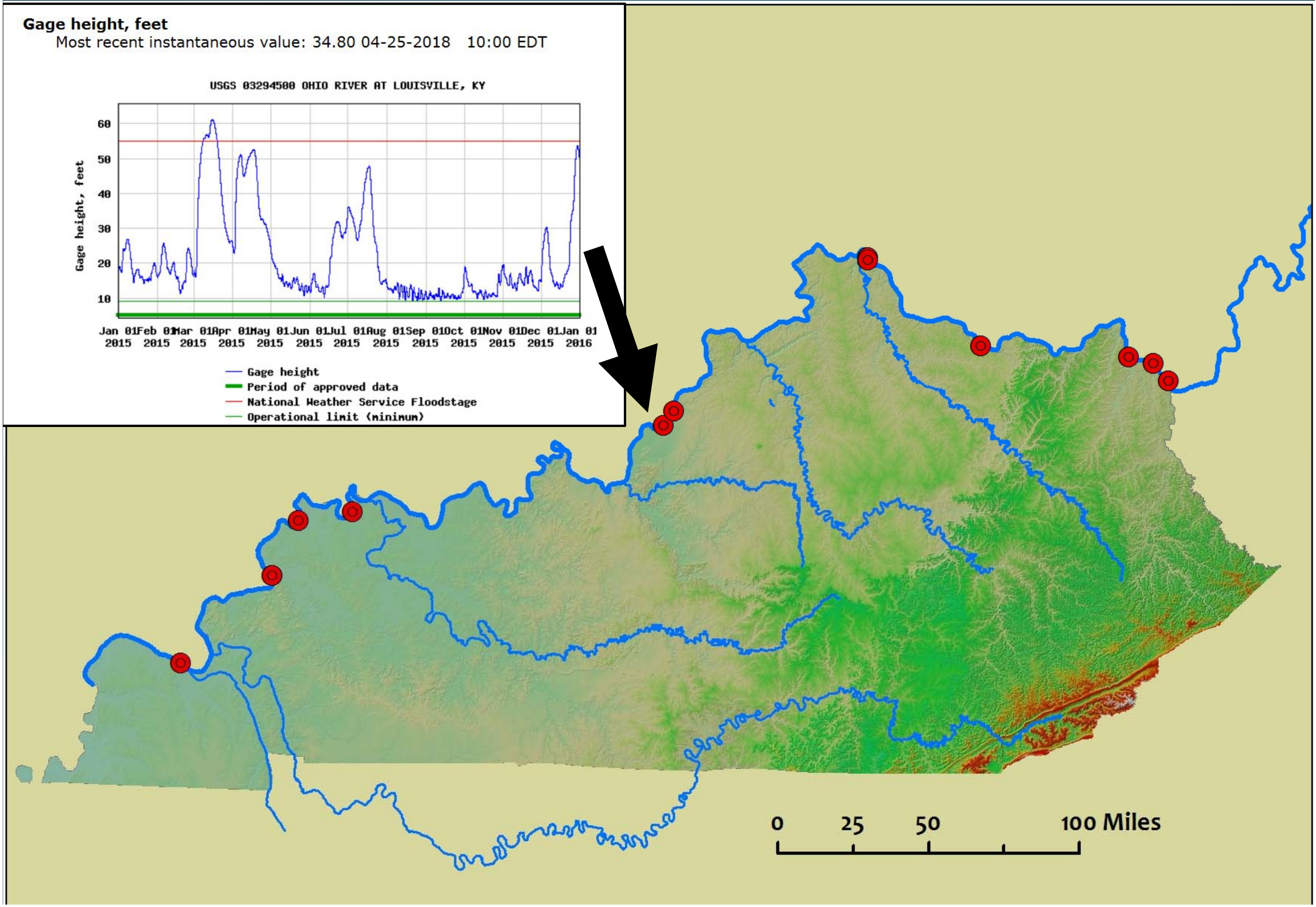
Community Water Systems using the Ohio River



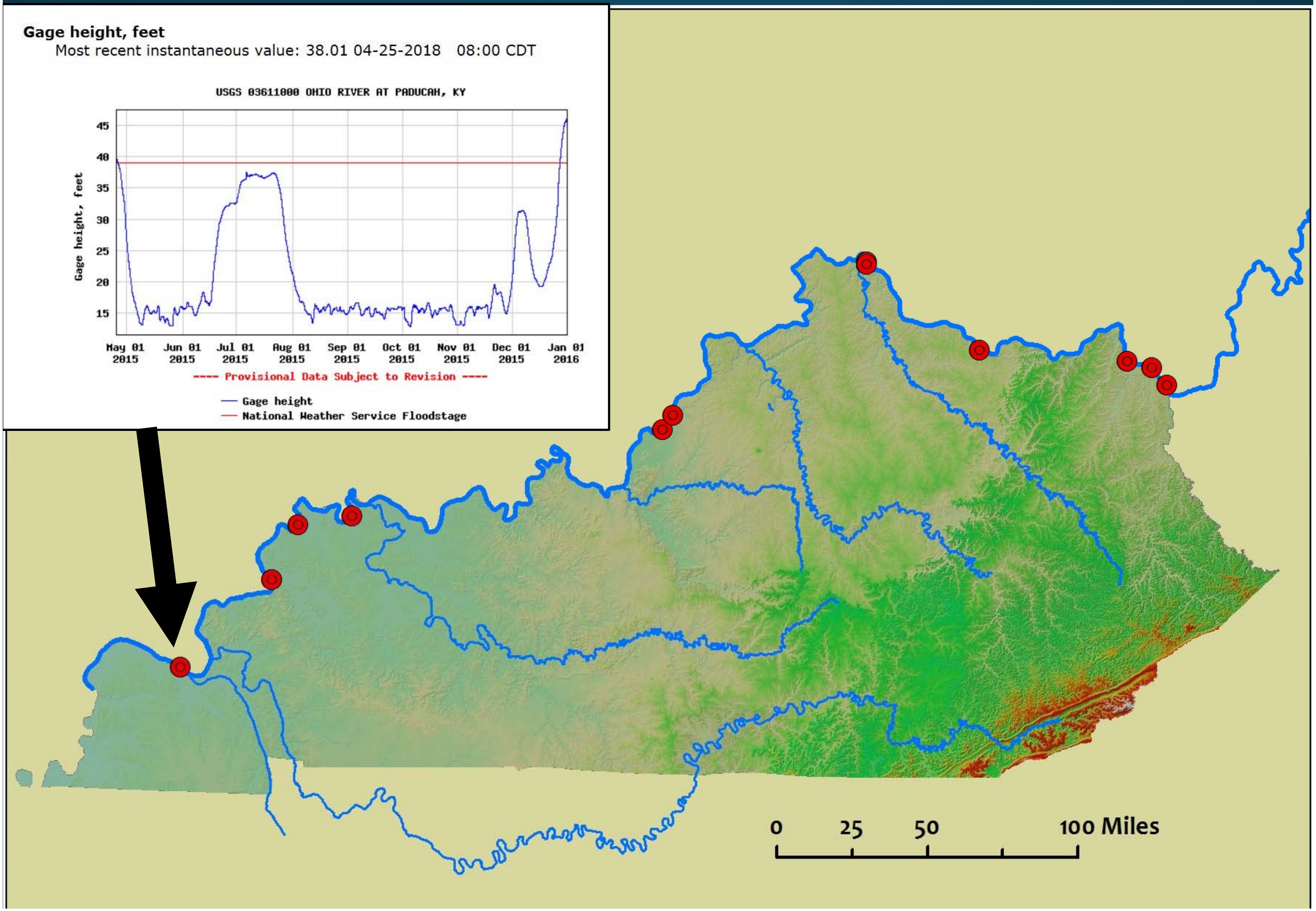
2015 USGS Gage Data for Ohio River - Cincinnati



2015 USGS Gage Data for Ohio River - Louisville



2015 USGS Gage Data for Ohio River - Paducah



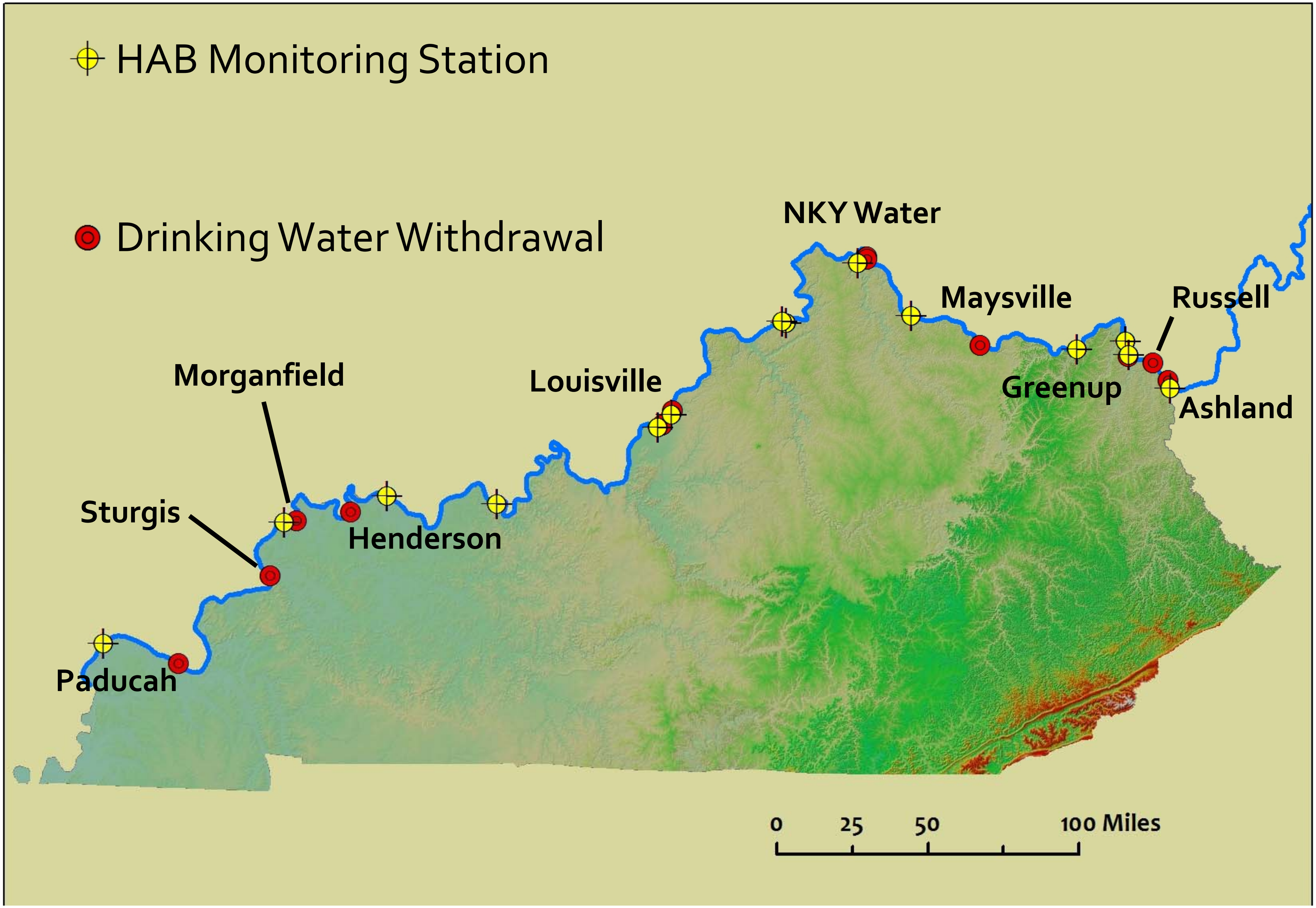
Harmful algal blooms observed on Ohio River and tributaries

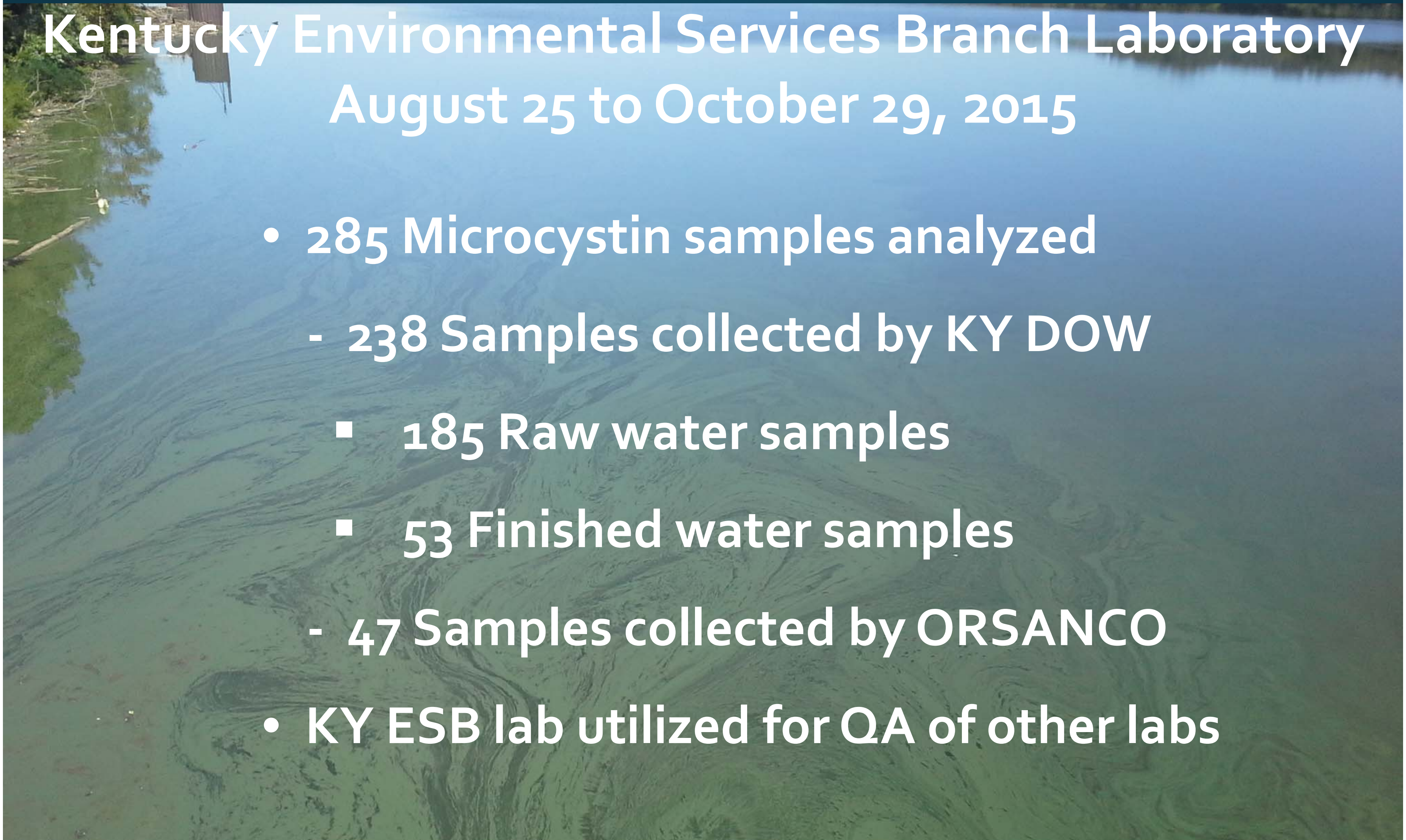
ON SEPTEMBER 2, 2015 / BY KYDEP / IN DIVISION OF WATER

- August 19 – Ohio River Valley Sanitation Commission (ORSANCO) notified of HAB near Wheeling, WV
  - KY DOW starts monitoring
- August 31 – Kentucky DOW notified of HAB near Greenup, KY
- Interstate coordination through ORSANCO

Ohio River near Ashland-Danny Fraley, DOW

Bloom Monitoring and Tracking

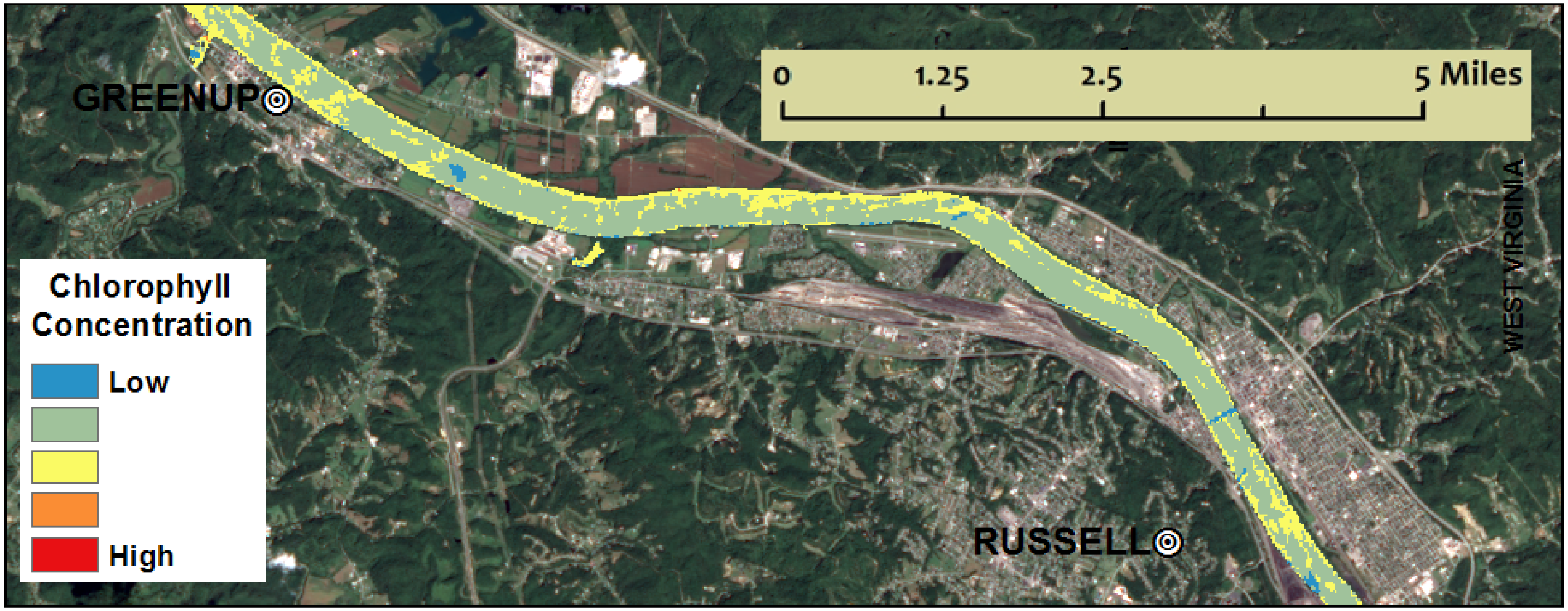




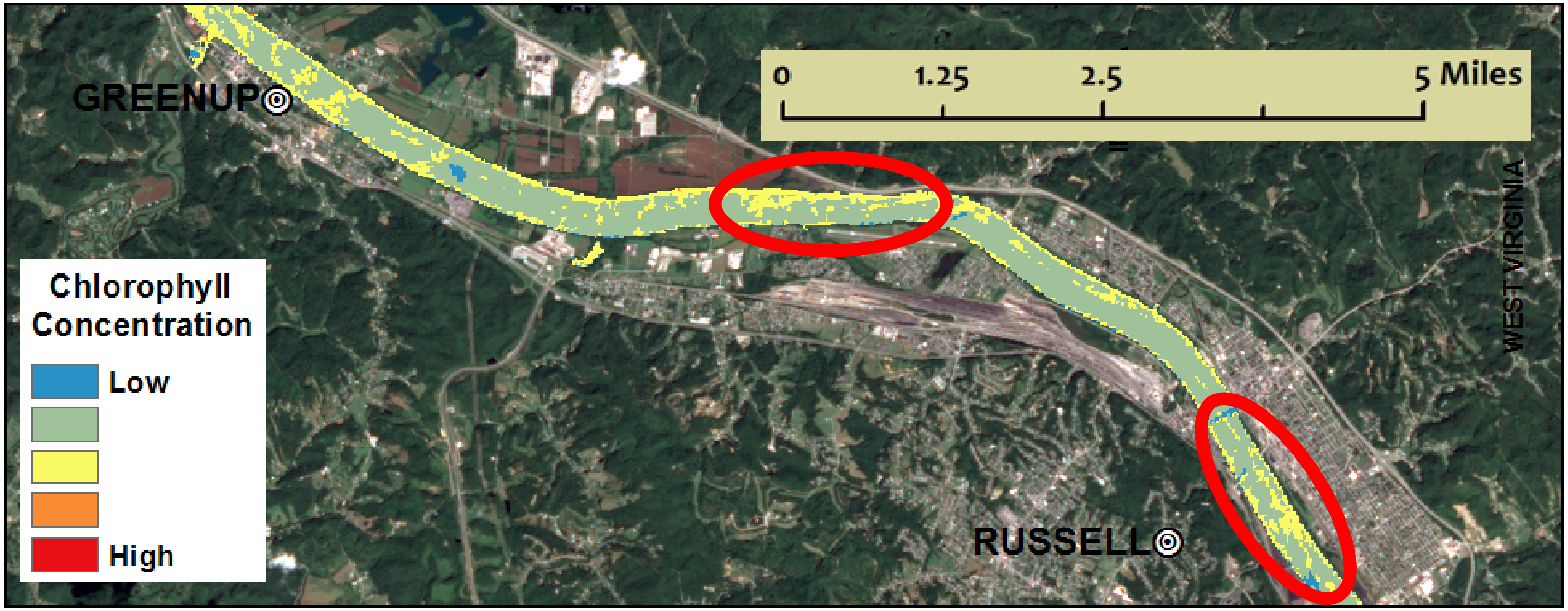
Kentucky Environmental Services Branch Laboratory
August 25 to October 29, 2015

- 285 Microcystin samples analyzed
  - 238 Samples collected by KY DOW
    - 185 Raw water samples
    - 53 Finished water samples
  - 47 Samples collected by ORSANCO
- KY ESB lab utilized for QA of other labs

Ohio River near Russell-Danny Fraley, DOW



Remote Sensing Model Output – September 14, 2015 Imagery



Remote Sensing Model Output – September 14, 2015 Imagery

Commonwealth of Kentucky
Energy and Environment Cabinet

Steve Beshear, Governor **Leonard K. Peters, Secretary**

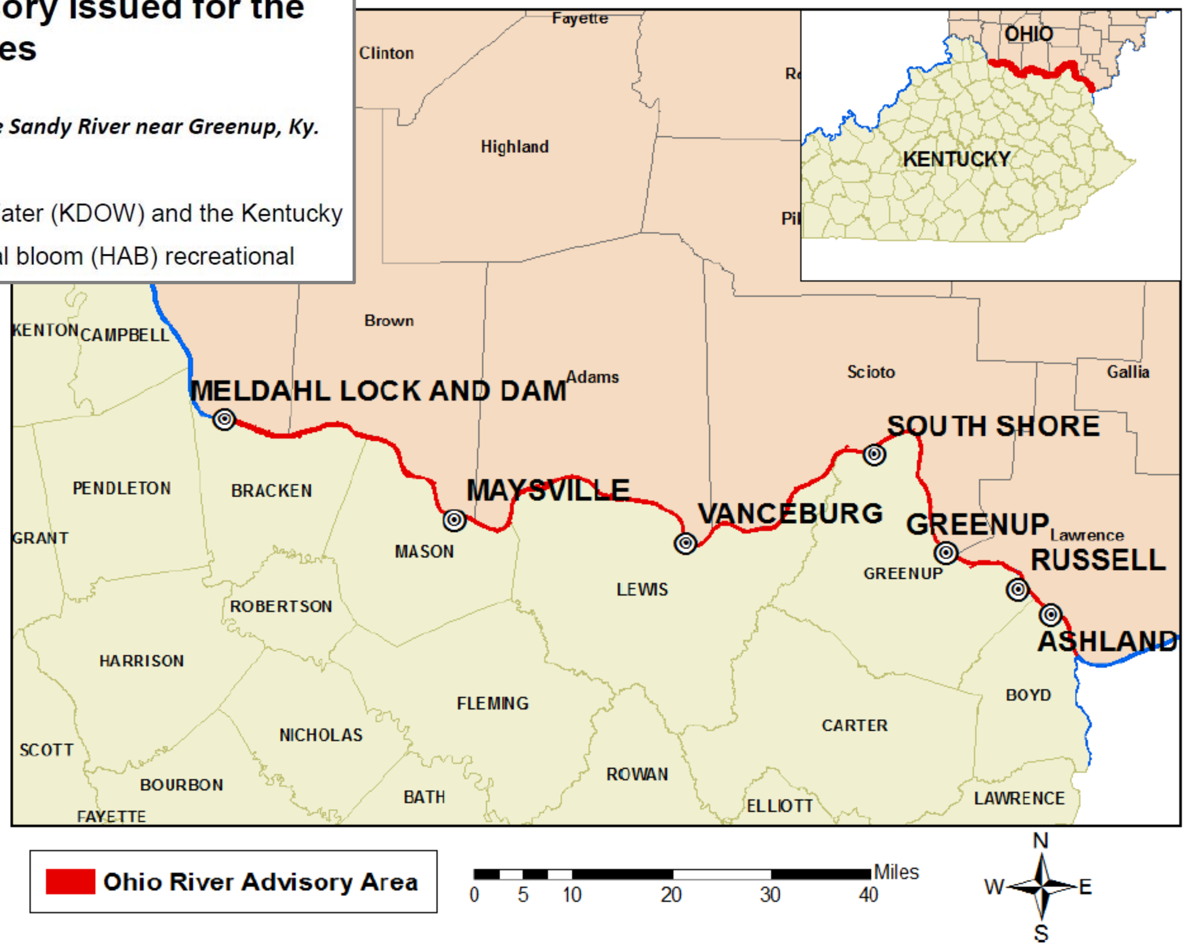
FOR IMMEDIATE RELEASE

Contact: Lanny Brannock
502-564-2150
502-229-4229

Harmful Algal Bloom recreational advisory issued for the Ohio River and tributaries

Advisory area stretches from Meldahl Dam to the W. Va. line, Little Sandy River near Greenup, Ky.

FRANKFORT, Ky. (Sept. 4, 2015) – The Kentucky Division of Water (KDOW) and the Kentucky Department for Public Health (KDPH) have issued a harmful algal bloom (HAB) recreational



ENERGY AND ENVIRONMENT CABINET

Steven L. Beshear
Governor

Department for Environmental Protection
Division of Water
200 Fair Oaks Lane, 4th Floor
Frankfort, Kentucky 40601
Phone: (502) 564-3410
Fax: (502) 564-2741
water.ky.gov

Leonard K. Peters
Secretary

R. Bruce Scott
Commissioner

September 3, 2015

To: Public Water Systems

RE: Harmful Algal Blooms

Dear Public Water System:

Cyanobacteria (also known as blue-green algae) are microscopic organisms found naturally in surface water that may sometimes multiply to form harmful algal blooms (HABs). HABs can potentially produce a variety of toxins capable of causing illness. In addition to producing toxins, cyanobacteria can pose treatment challenges for public water systems, including taste and odor and reduced filter run times. The information in this letter serves to assist public water system operators in dealing with potential algal bloom events.

Preparation Guidance Provided to Drinking Water Systems

1) Conditions are favorable for HABs

2) Monitor raw water sources and intakes closely

3) General water quality indicators:
   - increased pH
   - reduced filter run time
   - increased chlorine demand
   - taste and odor complaints

Danny Fraley, DOW

Treatment Guidance Provided to Drinking Water Systems

1) Optimize current treatment process

2) Reduce pre-oxidant feeds that may release toxins

3) Increase activated carbon feed to remove toxins

4) Maximize post chlorination and contact time

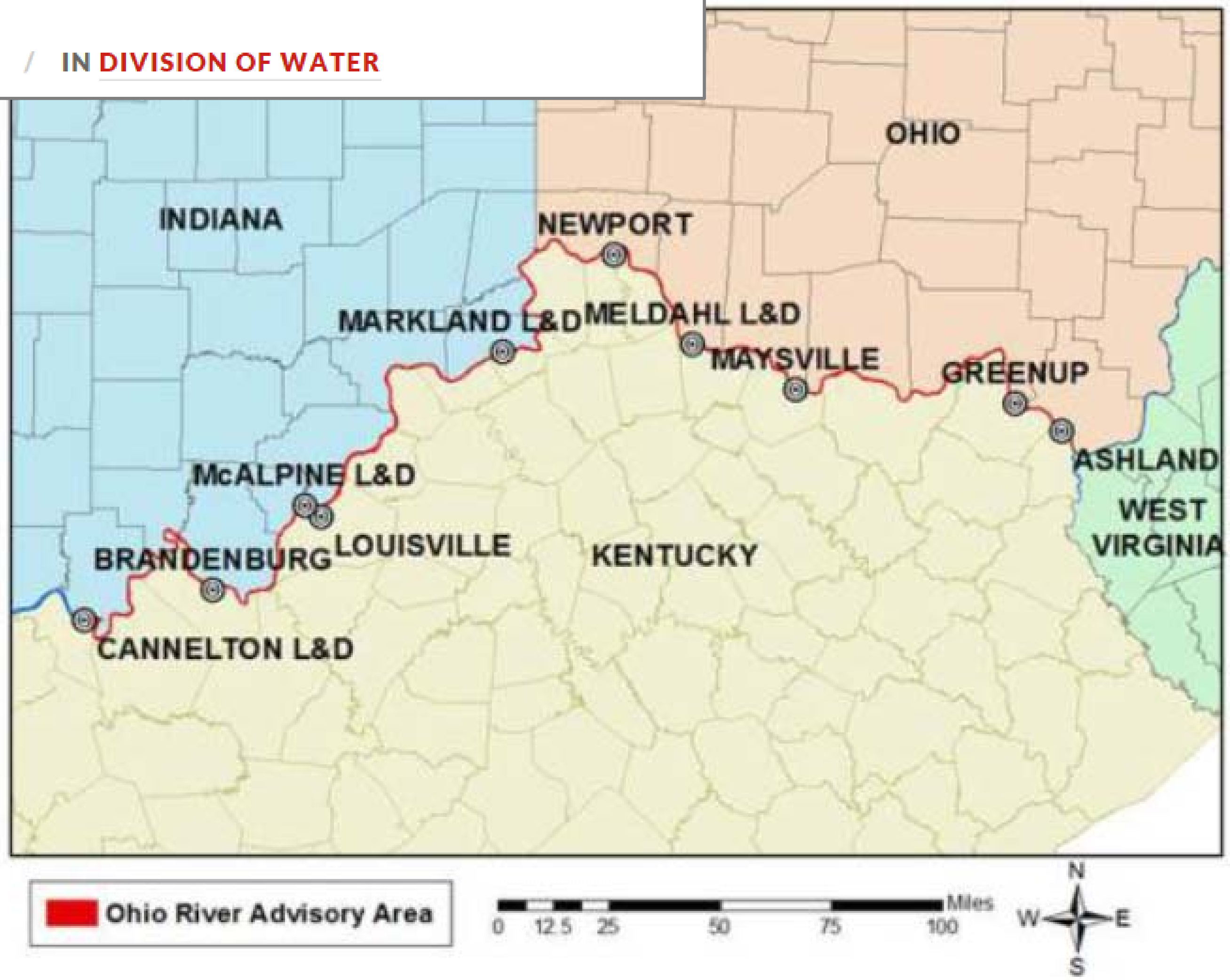
Danny Fraley, DOW

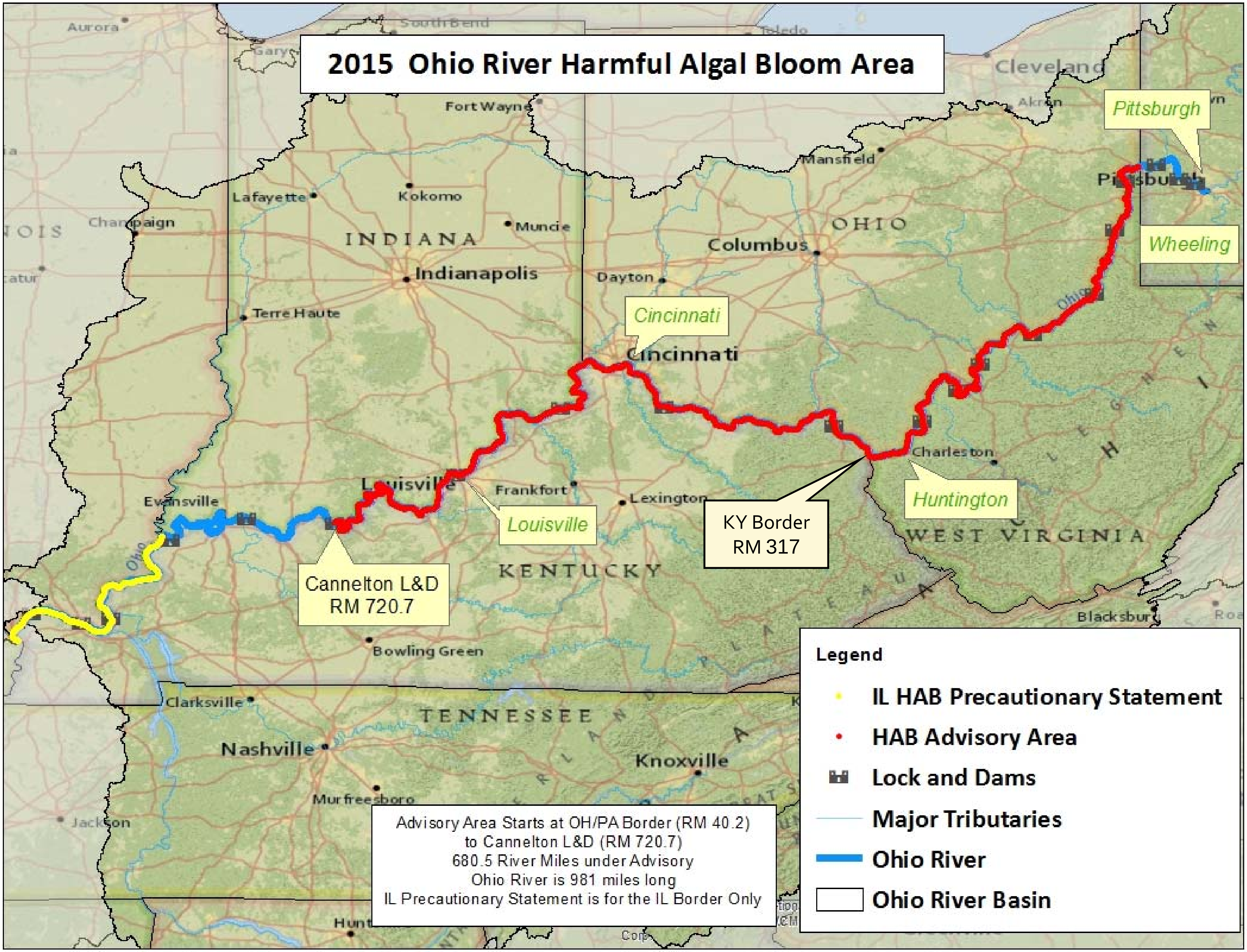
Harmful Algal Bloom recreational advisory issued for the Ohio River and tributaries

ON SEPTEMBER 11, 2015 / BY KYDEP / IN DIVISION OF WATER

Recreational advisory issued for Ohio River due to harmful algal bloom

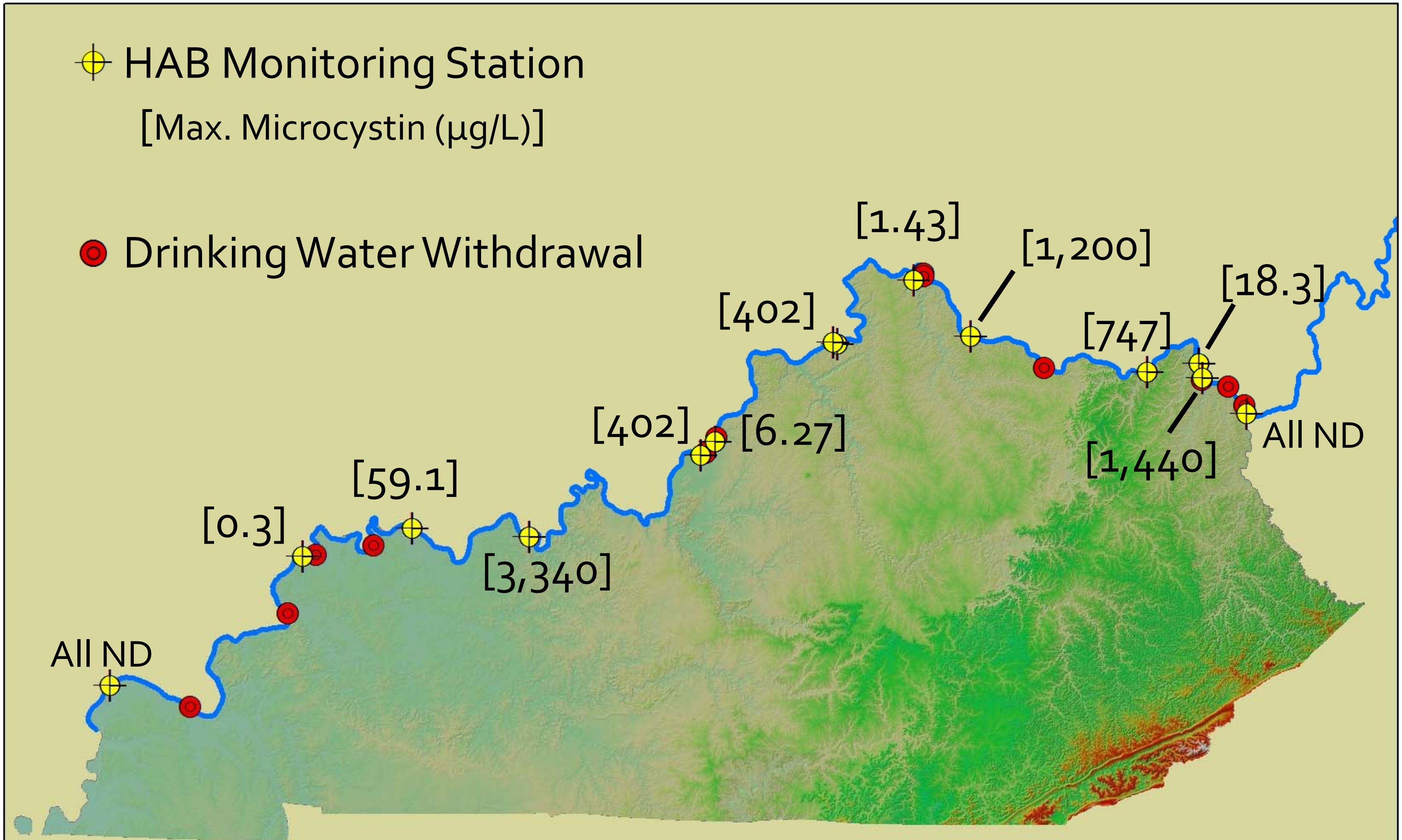
ON SEPTEMBER 18, 2015 / BY KYDEP / IN DIVISION OF WATER





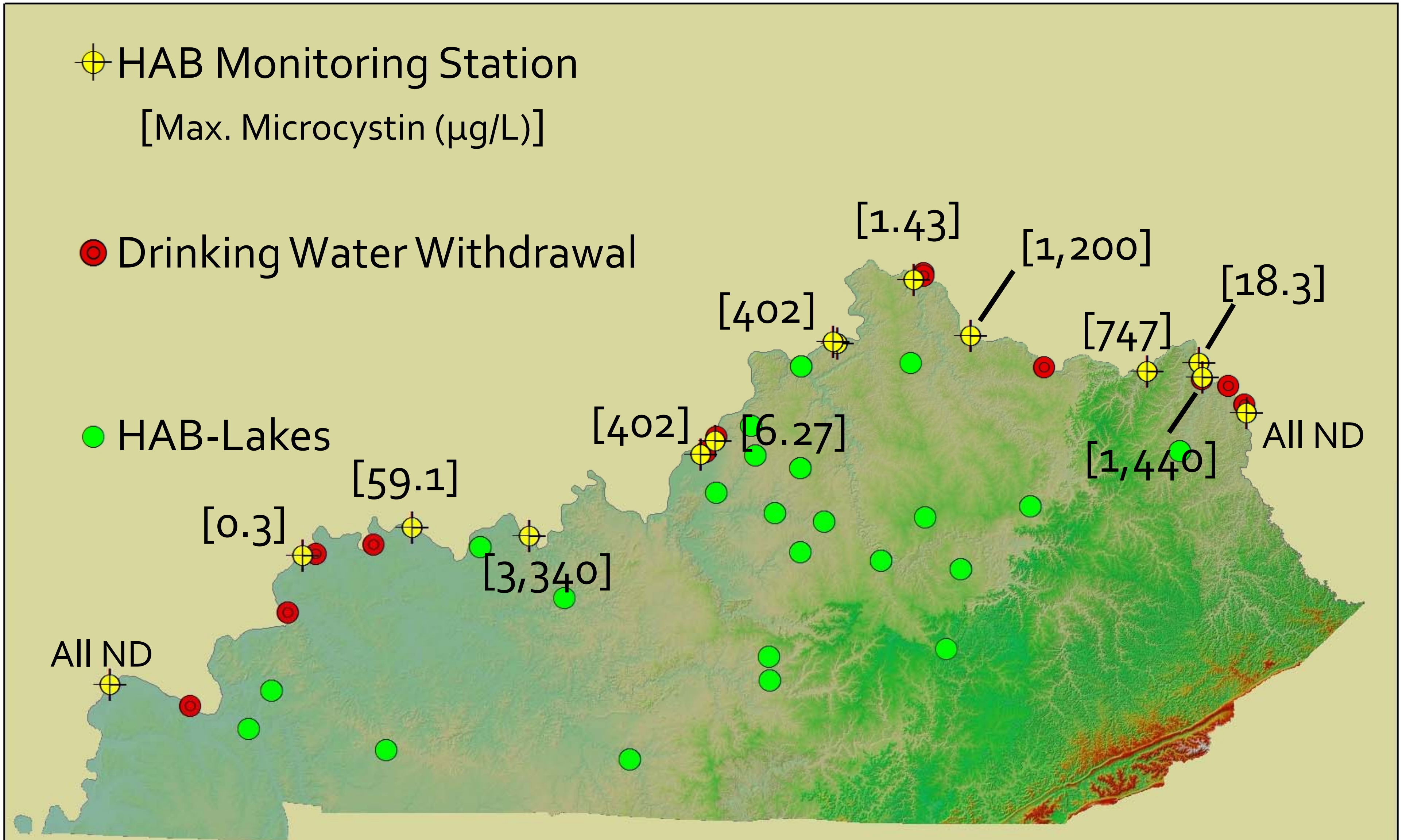
Courtesy of NKWD

Community Water System Impacts

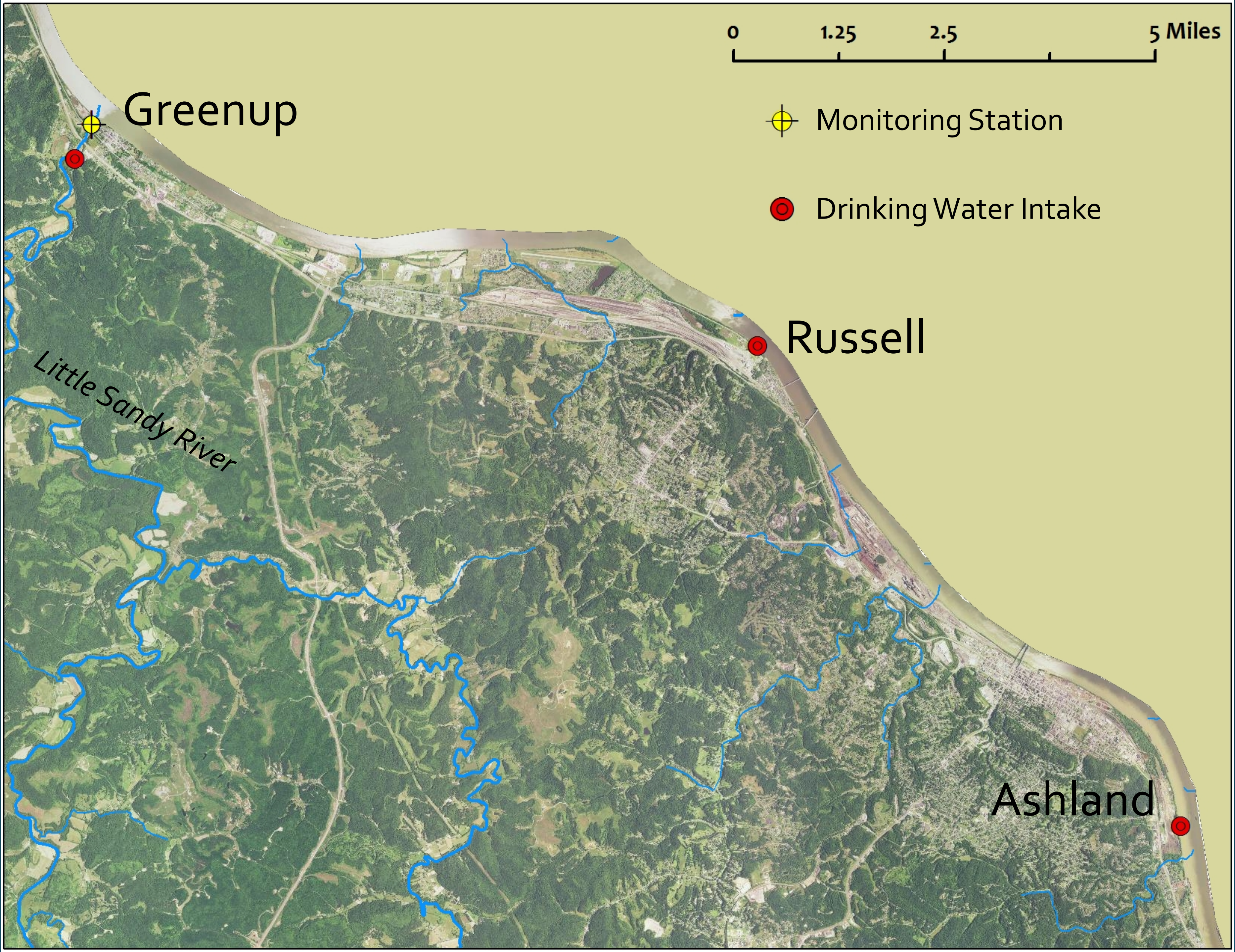


US EPA Health Advisories:
0.3 µg/L and 1.6 µg/L

Community Water System Impacts

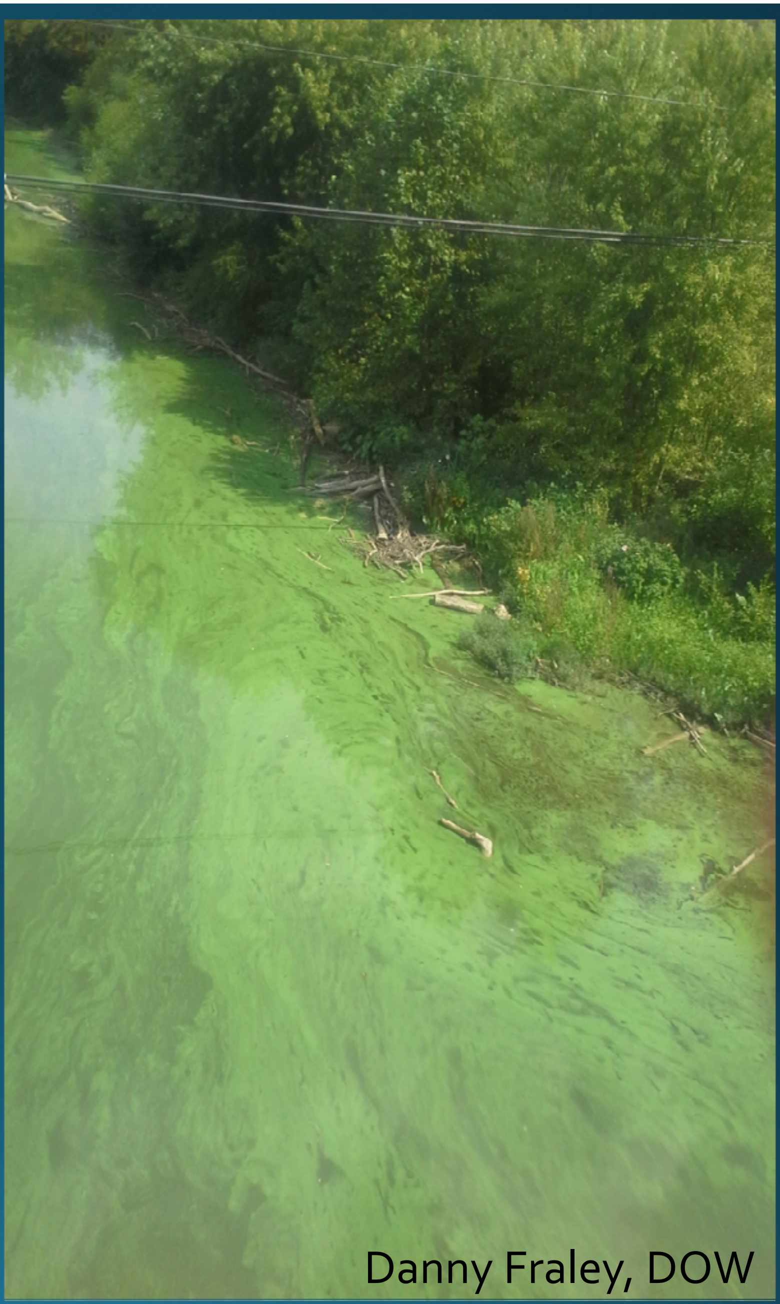


US EPA Health Advisories:
0.3 µg/L and 1.6 µg/L

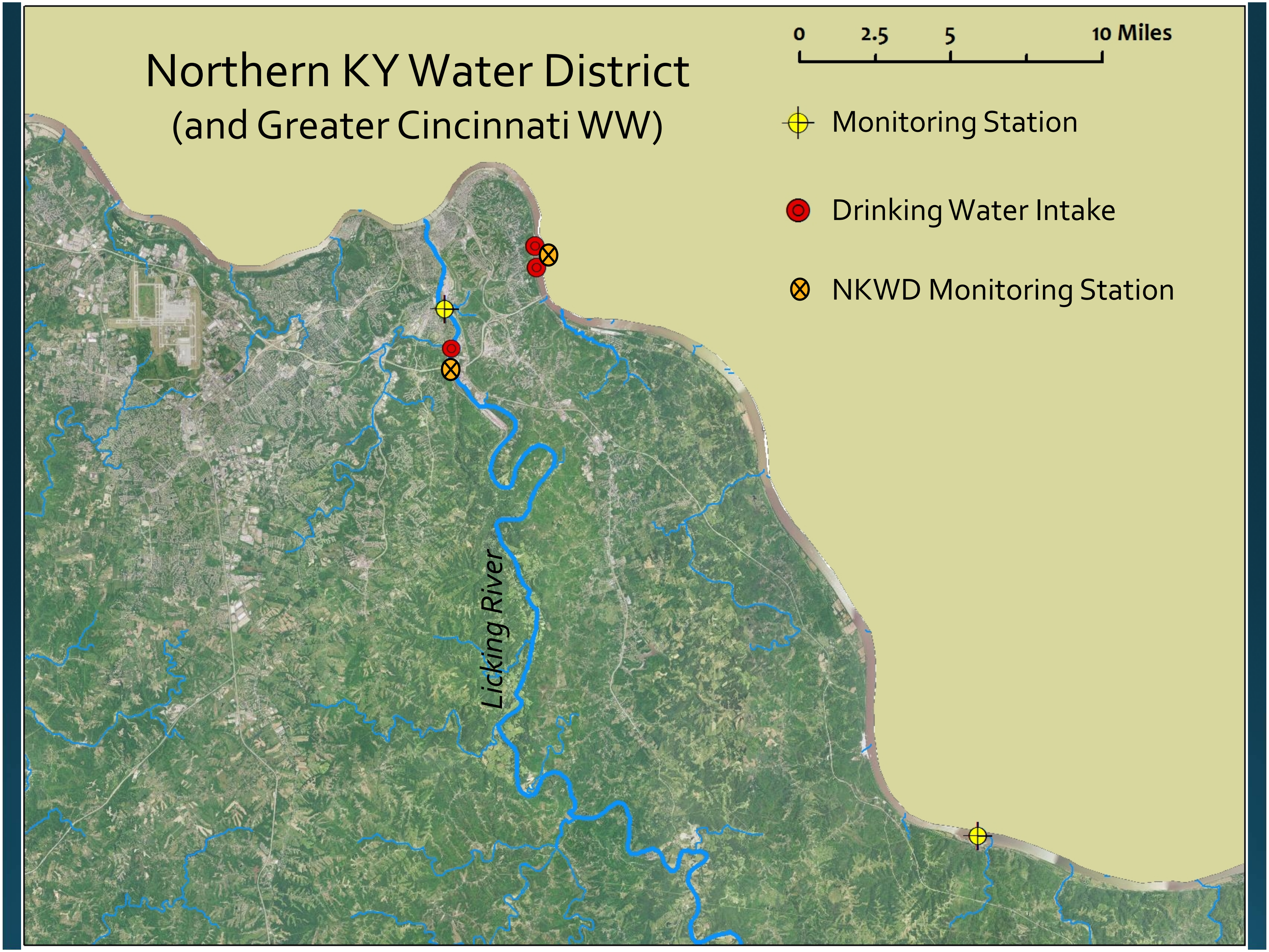


0
1.25
2.5
5 Miles
Monitoring Station
Drinking Water Intake
Greenup
Russell
Ashland
Little Sandy River

Greenup – Floating Intake



River adjacent to intake



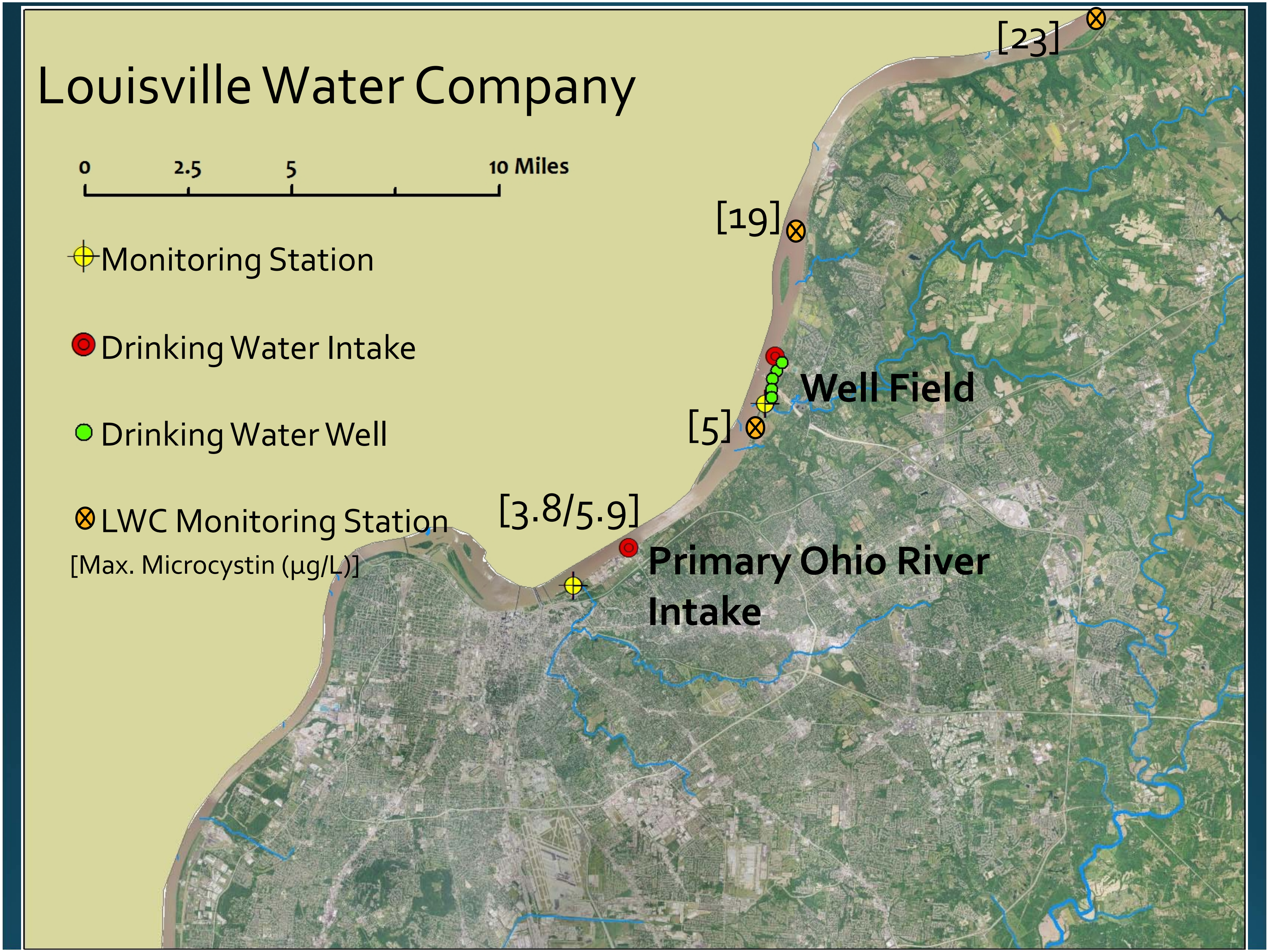
Northern KY Water District
(and Greater Cincinnati WW)
0
2.5
5
10 Miles
Monitoring Station
Drinking Water Intake
NKWD Monitoring Station
Licking River

Courtesy of Mary Carol Wagner, NKWD

Ohio River at NKWD intake, Sept 9

NKWD and GCWW Intakes on September 16, 2018

Photo courtesy of Mike Baker, Ohio EPA

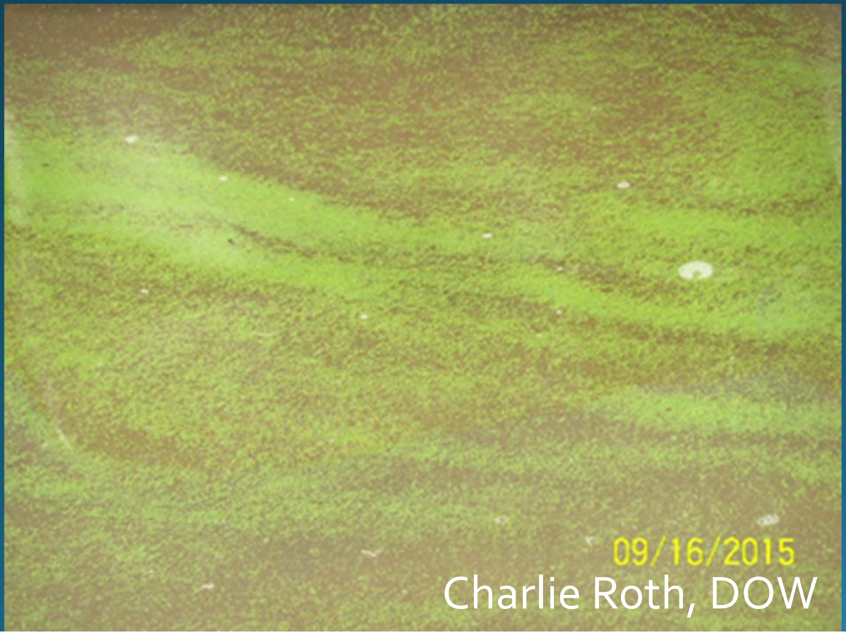


Louisville Water Company
0
2.5
5
10 Miles
Monitoring Station
Drinking Water Intake
Drinking Water Well
LWC Monitoring Station
[Max. Microcystin (µg/L)]
[23]
[19]
Well Field
[5]
[3.8/5.9]
Primary Ohio River Intake

Ohio River near Louisville's Primary Intake

Courtesy of LWC

Charlie Roth, DOW



Charlie Roth, DOW

Division of Water sampling results for IRONMAN course show improvement

ON OCTOBER 5, 2015 / BY KYDEP / IN DIVISION OF WATER

Recreational Advisory for lower McAlpine pool of Ohio River lifted after results below advisory level

ON OCTOBER 9, 2015 / BY KYDEP / IN UNCATEGORIZED

HAB Advisory on the Ohio River
October 17 – November 4

Map created by Caroline Chan
GIS & Data Analysis Section, KDOW
November 6, 2015

This map represents only generalized locations of features, objects or boundaries and should not be relied upon as being legally authoritative for the precise location of any feature, object or boundary. These data are from Kentucky Division of Water, ORSANCO and the Division of Geographic Information (DGI).

Acknowledgements

KY Division of Water
- Sarah Gaddis
- Danny Fraley
- Dan Canafax
- Charlie Roth
- Matt Gross
- Kari Johnson
- Rob Daniell
- Randy Thomas
- Mark Martin
- Garrett Stillings
- Caroline Chan

KY ESB Laboratory
- Michael Goss
- Keith Ewing
- Gerry Morford

Northern Kentucky WD
- Mary Carol Wagner

Louisville Water Co.
- Rengao Song

ORSANCO

Questions?

Robert J. Blair, P.G.
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502-782-6893

Florida Department of Environmental Protection

State of Florida Response to the 2016 and 2017 Cyanobacteria Bloom Seasons

May 15, 2018
EPA Region IV HAB Workshop





Florida's Multi-Agency Approach

- Starting in Late February or early March, FDEP staff send out a request to other state agency staff to update our Cyano HAB Contact List
- Each agency typically has a primary and one or more secondary contacts
- When a significant bloom is report, the Cyano HAB contacts coordinate agency response principally through emails, phone calls, and teleconferences

Florida's Multi-Agency Approach

- FDEP
  - Sampling, analysis, and dissemination of results
  - Water quality protection
- FDOH
  - Issues health advisories
  - Investigates reports of illness related to HAB exposure
  - Online information sharing through their CyaonoHAB tracking module in Caspio
- FWC
  - Addresses fish kills and sick wildlife
  - Principle agency for marine HABs
  - Sampling and analysis
- WMD
  - Sampling and reconnaissance
- County Governments
  - Sampling, reconnaissance, advisories

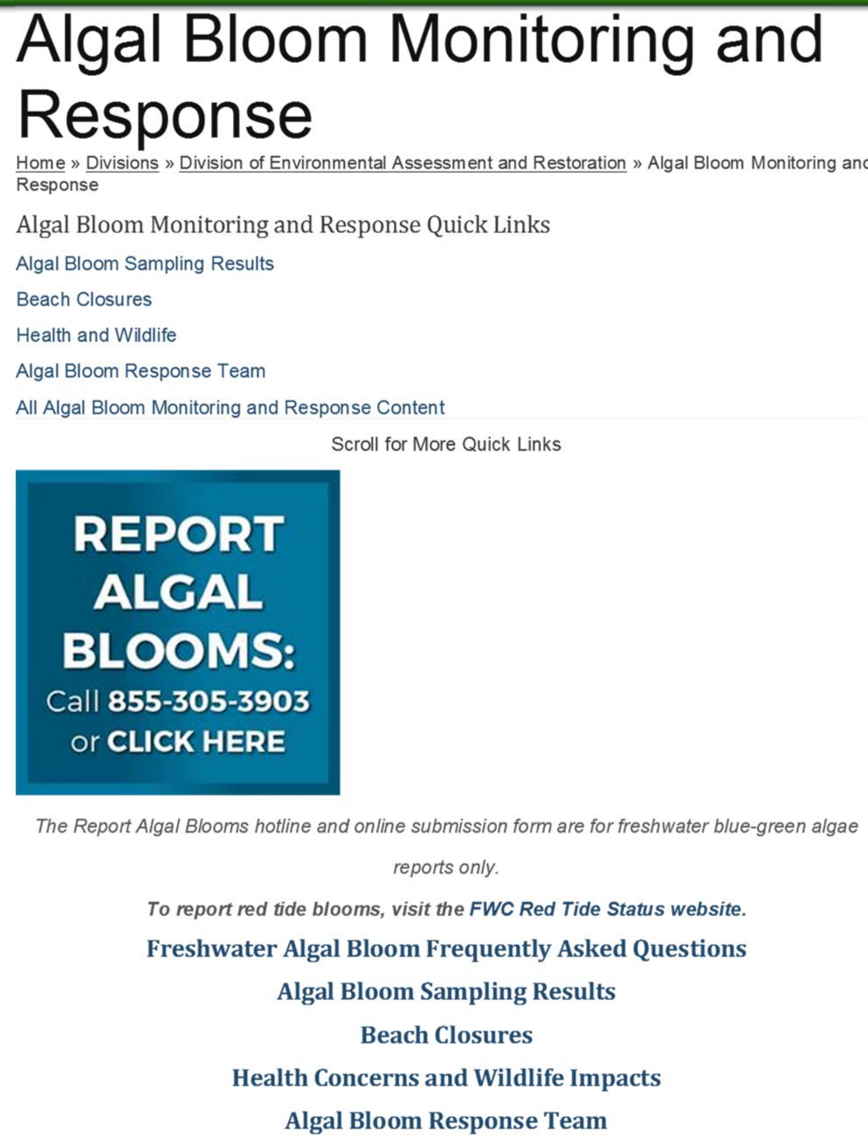
FDEP Biology Laboratory

Kalina Warren, June 23, 2016 Leighton Park

FDEP's Evolving Outreach Efforts

FDEP maintains an algal bloom information page that provides:

- An algal bloom reporting hotline and webpage where citizens could report a bloom
- CyanoHAB FAQs
- Sampling results
- Beach closure Information
- Human health and wildlife impact information
- Algal Bloom Response Team information



Algal Bloom Monitoring and Response

Home » Divisions » Division of Environmental Assessment and Restoration » Algal Bloom Monitoring and Response

Algal Bloom Monitoring and Response Quick Links

Algal Bloom Sampling Results

Beach Closures

Health and Wildlife

Algal Bloom Response Team

All Algal Bloom Monitoring and Response Content

Scroll for More Quick Links

REPORT ALGAL BLOOMS: Call 855-305-3903 or CLICK HERE

The Report Algal Blooms hotline and online submission form are for freshwater blue-green algae reports only.

To report red tide blooms, visit the FWC Red Tide Status website.

Freshwater Algal Bloom Frequently Asked Questions

Algal Bloom Sampling Results

Beach Closures

Health Concerns and Wildlife Impacts

Algal Bloom Response Team

FDEP's Evolving Outreach Efforts

- Each dot is linked to sample and analysis information
- Color denotes how recently the sample was collected
  - Blue < 30 days
  - Green < 60 days
  - Yellow < 90 days
  - Brown > 90 days
- Data also available in table view
- Microscopic analyses are performed to determine the dominant species present in the samples and whether potential toxin-producing cyanobacteria are present
- Samples are analyzed for microcystins, cylindrospermopsin, and anatoxin-a when a potential toxin-producing cyanobacteria is dominant or co-dominant in the sample.

FDEP's Evolving Outreach Efforts

- Sampling information provided in real time using Survey123 app on a smartphone
- Results added as they become available
- Field photos can be attached

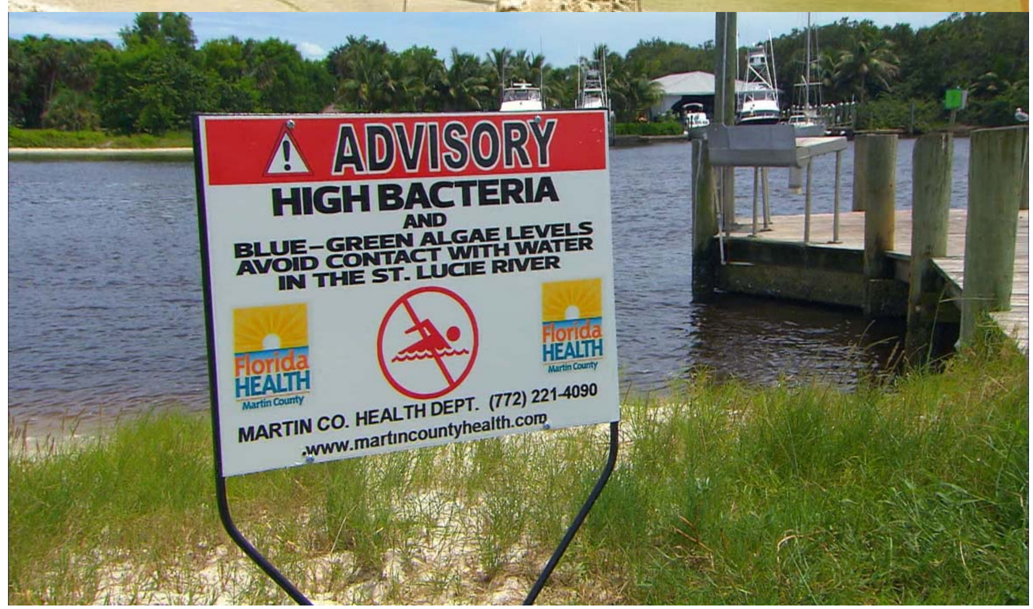
Algae Sample within 30 days
Site Visit Date and Time
4/3/2018, 8:38 AM
Sample Location
St. John's River at SR40
County
Lake
Site Visited By
SJRWMD
Sample Taken?
Yes
Sample Depth Description
Surface grab
Sample Depth (meters)
0.30
Analyzed By
DEP
Other Lab name
Greenwater Labs
Comments
Algae identified by DEP; toxin analysis performed by Greenwater
Latitude
29.1618
Longitude
-81.5234
Algal ID
Dominant taxon: Dolichospermum circinale
Total Microcystin Toxin (micrograms/L)
not detected
Other Toxin (micrograms/L)
Anatoxin-a: not detected; Cylindrospermopsin: not detected; Saxitoxin/Paralytic Shellfish Toxins: 0.08
Attachments:

- No attachments found

Edited by Cheryl.Swanson@dep.state.fl.us_FDEP on Tuesday

Sampling / Reporting / Actions

- Samples collected by multiple agencies (FDEP, FWC, SFWMD, SJRWMD, counties)
- Advisories posted by local county health departments based on visual observation of bloom conditions
- Precautionary principle – if it's green, avoid contact or use



Sampling / Reporting / Actions

- Rapidly changing bloom conditions make it difficult to collect, analyze, and disseminate toxin results to the public in a timeframe that would allow for accurate characterization of actual risk
- Better to use a precautionary approach and inform public to avoid bloom waters entirely
- Advisories are not determined based on toxin analysis thresholds
- Toxin analyses results are used to determine the magnitude of potential human health risk

Hail Storm Analogy

- Sampling a bloom doesn't change the nature of the bloom, anymore than measuring the size of hailstones changes a storm event
- Sampling does tell us something about the relative risk of a bloom, the same as knowing the size of hailstones tells us about the relative risk of the storm event

http://www.crh.noaa.gov/images/oun/spotter/training/hail.jpg

Cyanotoxin Threshold Values

- Having a cyanotoxin threshold value provides a useful comparator, like comparing a hailstone to a dime or golf ball, to explain the potential magnitude of the risk involved
- Bloom monitoring and public outreach activities increase with the level of toxin detected; however the public messaging about avoiding bloom-affected waters stays the same - *if the water is green or otherwise discolored, avoid contact and use*
- State resources are prioritized in favor of those blooms that have the highest potential to cause human health impacts

FDEP's Preferred Option

Option 1

Adopt cyanobacteria thresholds as water quality criteria

Option 2

Use cyanobacteria thresholds as the basis for swimming advisories

Option 3

Use cyanobacteria thresholds for both WQC and swimming advisories

FDEP's Preferred Option

Use cyanobacteria thresholds to explain relative risk of observed values, but rely on precautionary principle for advisories and numeric nutrient criteria for assessing waters

Numeric Nutrient Criteria

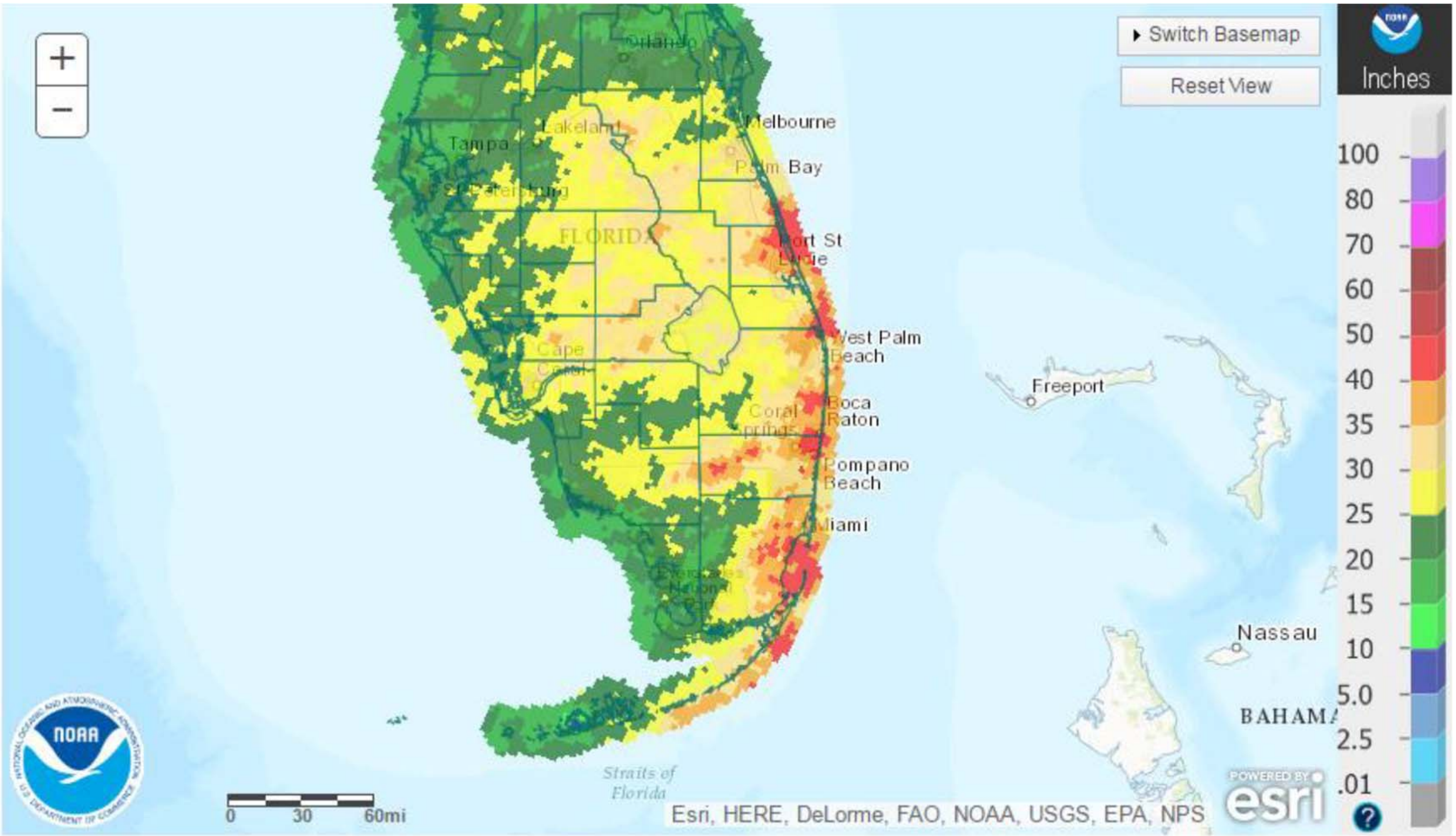
- Florida has established numeric nutrient criteria for the majority of our waters
- Many of the waters that experience significant blooms have already been determined to be impaired for nutrients

Long Term Geometric Mean Lake Color and Alkalinity	Annual Geometric Mean Chlorophyll a	Minimum calculated numeric interpretation		Maximum calculated numeric interpretation	
		Annual Geometric Mean Total Phosphorus	Annual Geometric Mean Total Nitrogen	Annual Geometric Mean Total Phosphorus	Annual Geometric Mean Total Nitrogen
≥ 40 Platinum Cobalt Units	20 µg/L	0.05 mg/L	1.27 mg/L	0.16 mg/L[1]	2.23 mg/L
≤ 40 Platinum Cobalt Units and ≥ 20 mg/L $CaCO_3$	20 µg/L	0.03 mg/L	1.05 mg/L	0.09 mg/L	1.91 mg/L
≤ 40 Platinum Cobalt Units and ≤ 20 mg/L $CaCO_3$	6 µg/L	0.01 mg/L	0.51 mg/L	0.03 mg/L	0.93 mg/L

Nutrient Watershed Region	Total Phosphorus Nutrient Threshold[1]	Total Nitrogen Nutrient Threshold[1]
Panhandle West	0.06 mg/L	0.67 mg/L
Panhandle East	0.18 mg/L	1.03 mg/L
North Central	0.30 mg/L	1.87 mg/L
Peninsular	0.12 mg/L	1.54 mg/L
West Central	0.49 mg/L	1.65 mg/L
South Florida	No numeric nutrient threshold. The narrative criterion in paragraph 62-302.530(47)(b), F.A.C., applies.	No numeric nutrient threshold. The narrative criterion in paragraph 62-302.530(47)(b), F.A.C., applies.

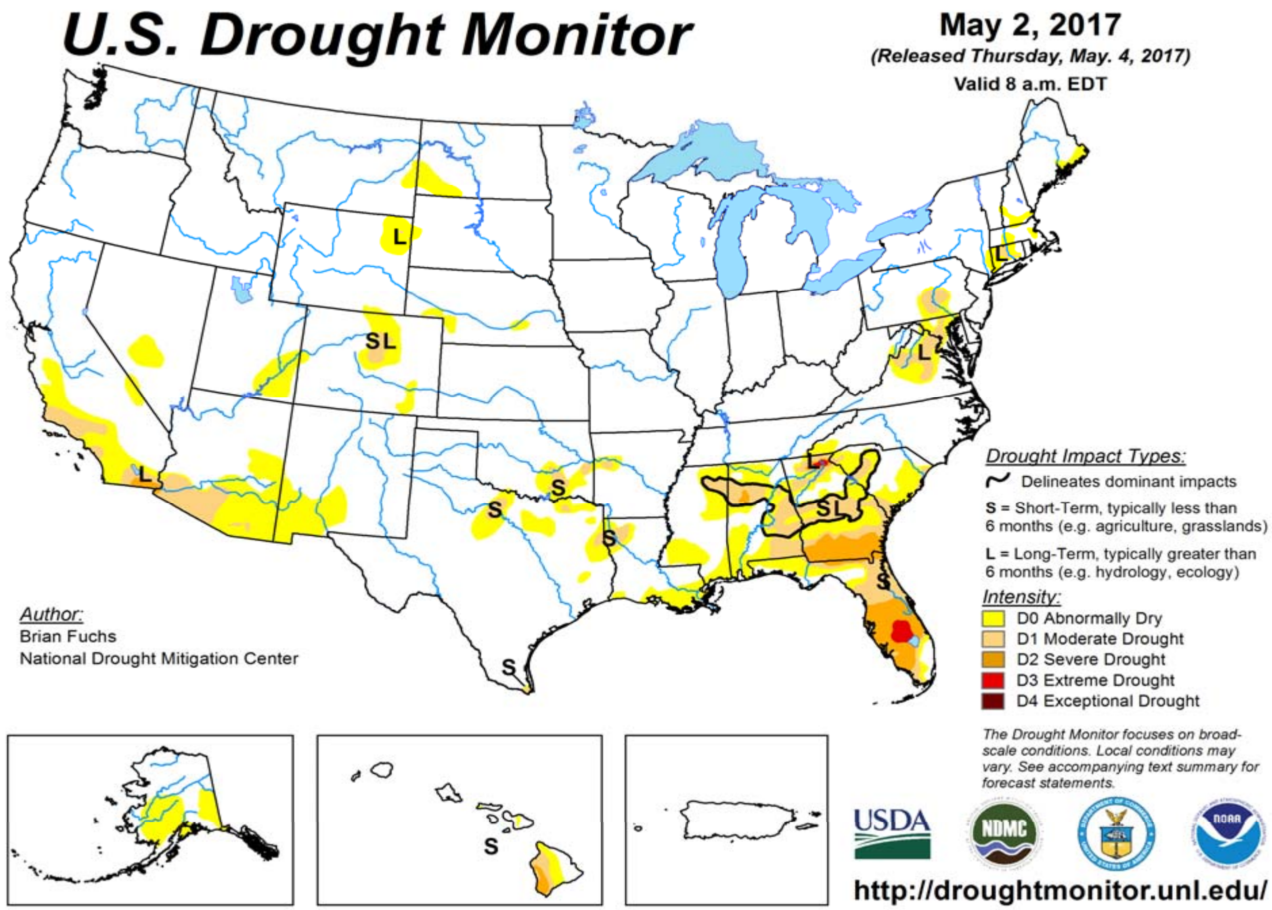
2016 Bloom Season

South Florida experienced a wetter than normal dry season (November – May) during 2015/2016, with the wettest winter on record for multiple cities



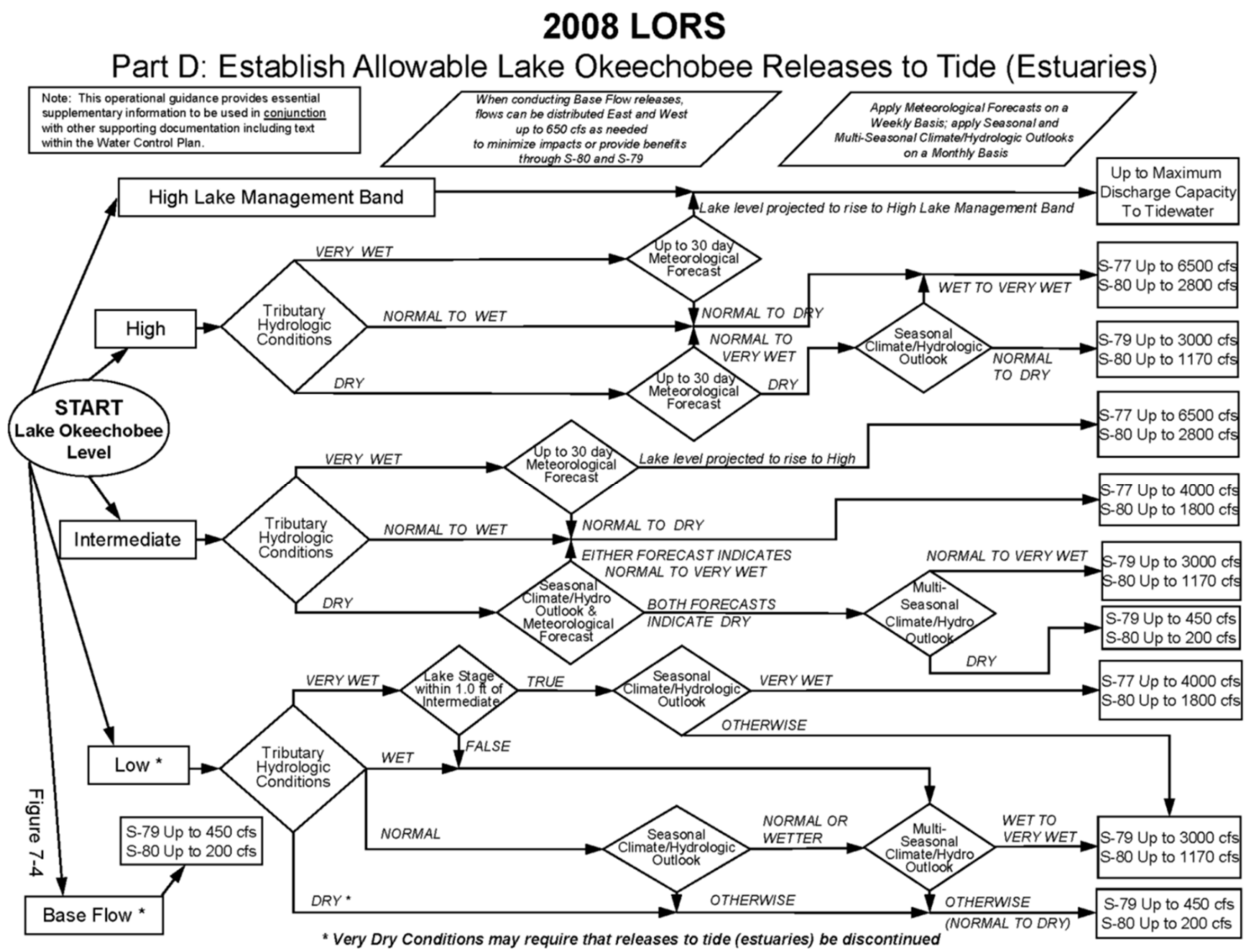
2017 Bloom Season

Unlike 2016, South Florida experienced an abnormal dry dry season (November – May) during 2016/2017



Lake Okeechobee Releases

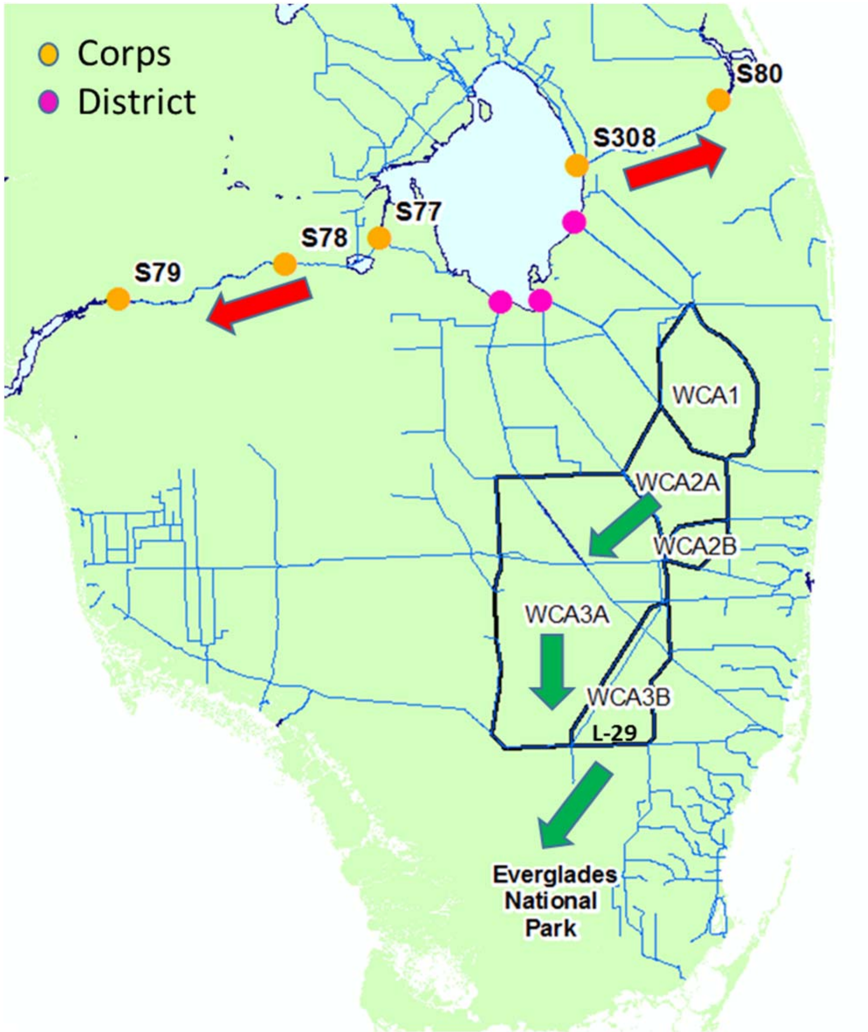
Lake level, short-term and seasonal meteorological forecasts used to determine lake releases to the St. Lucie and Caloosahatchee Rivers.



http://www.saj.usace.army.mil/Portals/44/docs/h2omgmt/LORSdocs/2008_LORS_WCP_mar2008.pdf

2016 Bloom Season

NASA Earth Observatory images by Joshua Stevens, using Landsat data from the U.S. Geological Survey.



https://content.govdelivery.com/accounts/FLDEP/bulletins/1389c24

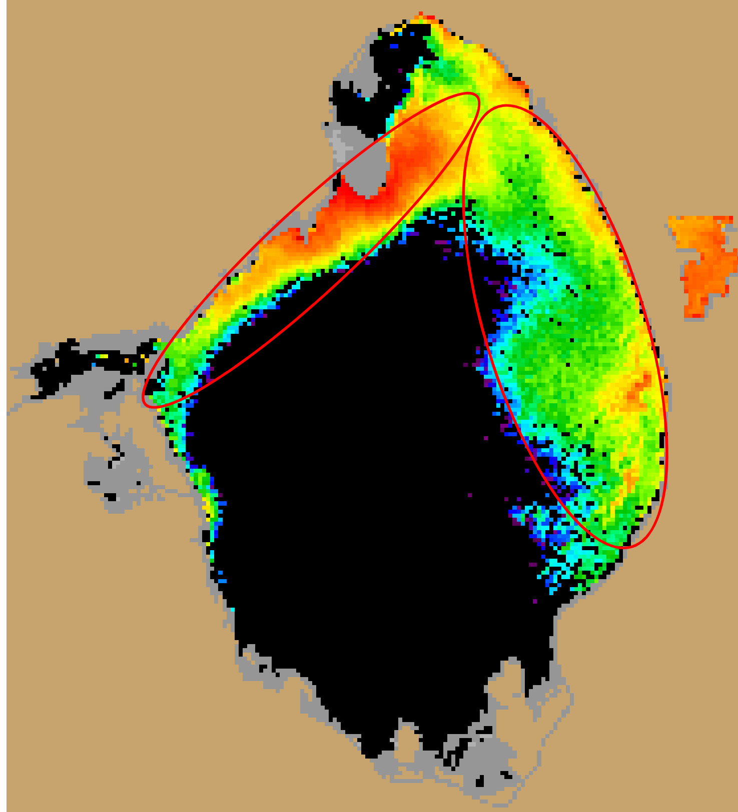
2016 Bloom Season

- High volume releases from Lake Okeechobee throughout the spring and summer
- Dense accumulation of cyanobacteria at lock structures
- Wind and current caused significant impacts to dead end canals and marinas

Eric Hasert, Treasure Coast Newspapers, St. Lucie River Estuary, June 24, 2016

2017 Lake Okeechobee Bloom

- No or low-level releases during bloom period
- Several small-scale, short-duration blooms occurred on Lake Okeechobee between Mid-March and Mid-July
- Beginning Mid-July, continuous large-scale blooms were observed on the lake
- The northwestern bloom was typically dominated by either *Dolichospermum circinale* or *Cylindrospermopsis raciborskii*
- The eastern bloom was dominated by *Microcystis aeruginosa*



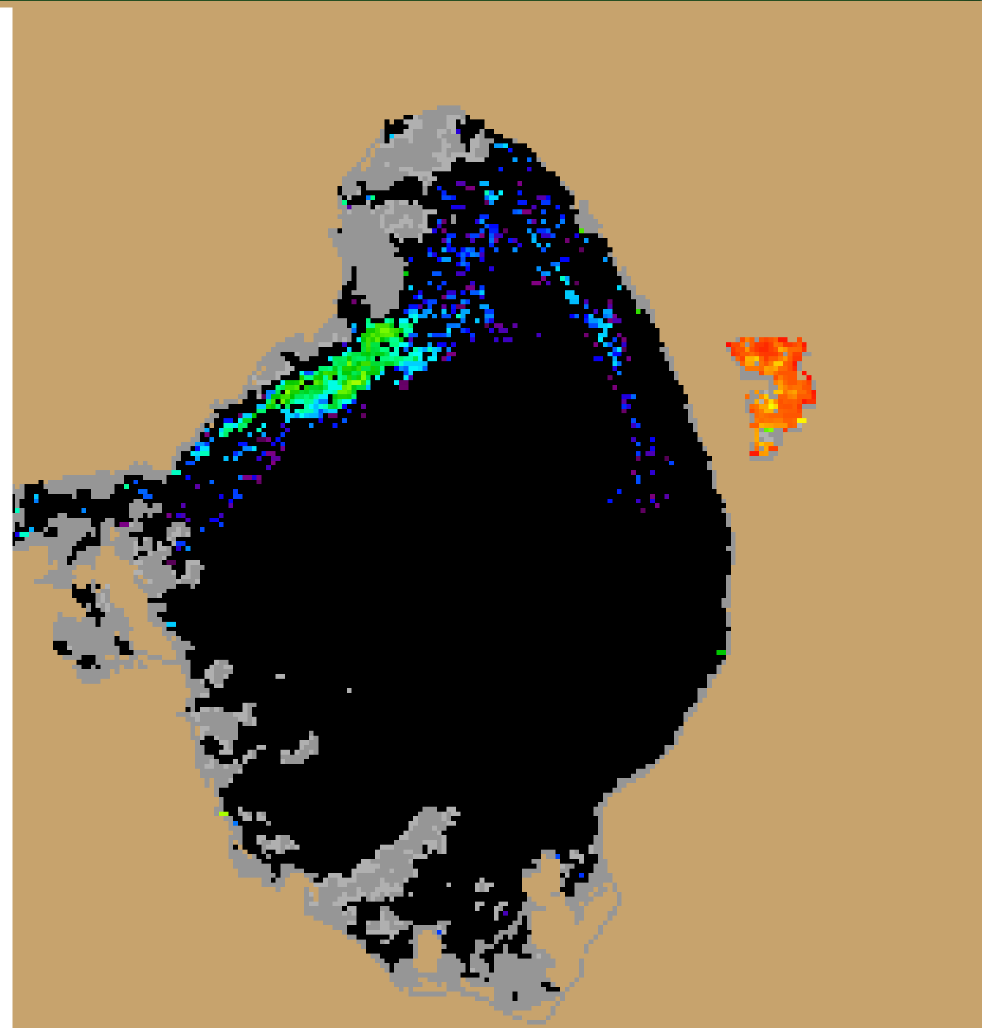
August 17, 2017 satellite imagery
https://products.coastalscience.noaa.gov/habs_explorer/index.php?path=products/olci/SouthFL300m

Drinking Water Impacts

- Lake Okeechobee is classified as a Class I potable water source
- Only about 10% of Floridians get their drinking water from surface water sources
- When blooms form near drinking water facilities, they are monitored to determine if they may impact the facility
- FDEP Drinking Water Program staff and FDEP Laboratory staff communicate with the facility operators to determine whether monitoring is needed near the facilities intakes
- Analytical results are shared with the facility to help them determine if additional treatment is needed or alternative source water should be used

2017 Lake Okeechobee Bloom

- By Mid-September, the blooms had decreased in both area and intensity
- Cyanotoxin levels were typically non-detect or single digit
- One concentrated sample collected along shore near the S-308 structure measured 815 μg/L
- Toxins were non-detect at this location a week later and no bloom was present



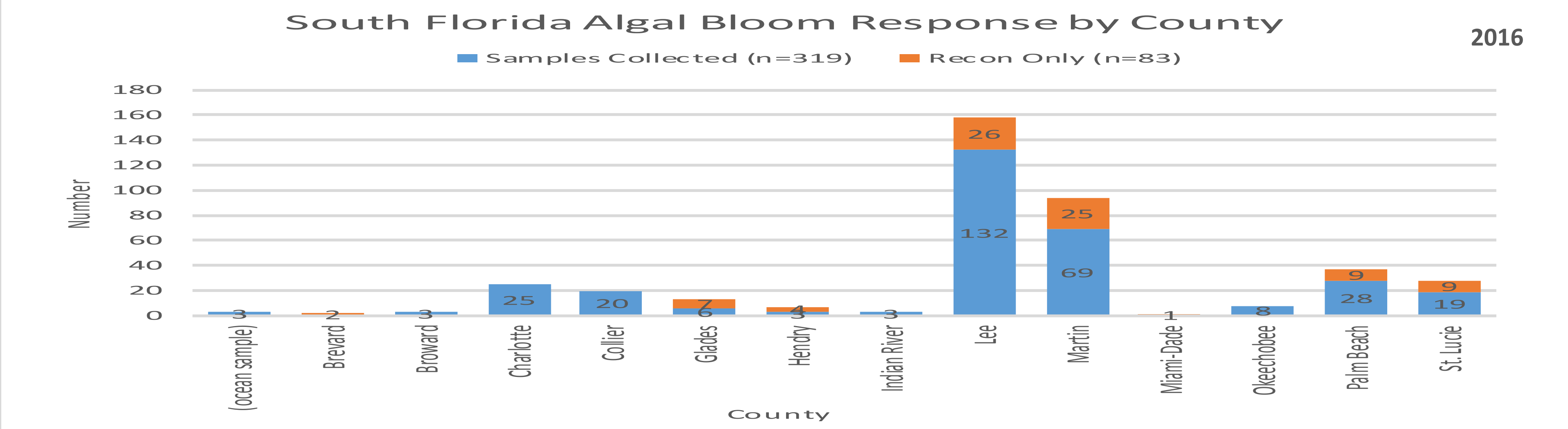
September 13, 2017
https://products.coastalscience.noaa.gov/habs_explorer/index.php?path=products/olci/SouthFL300m

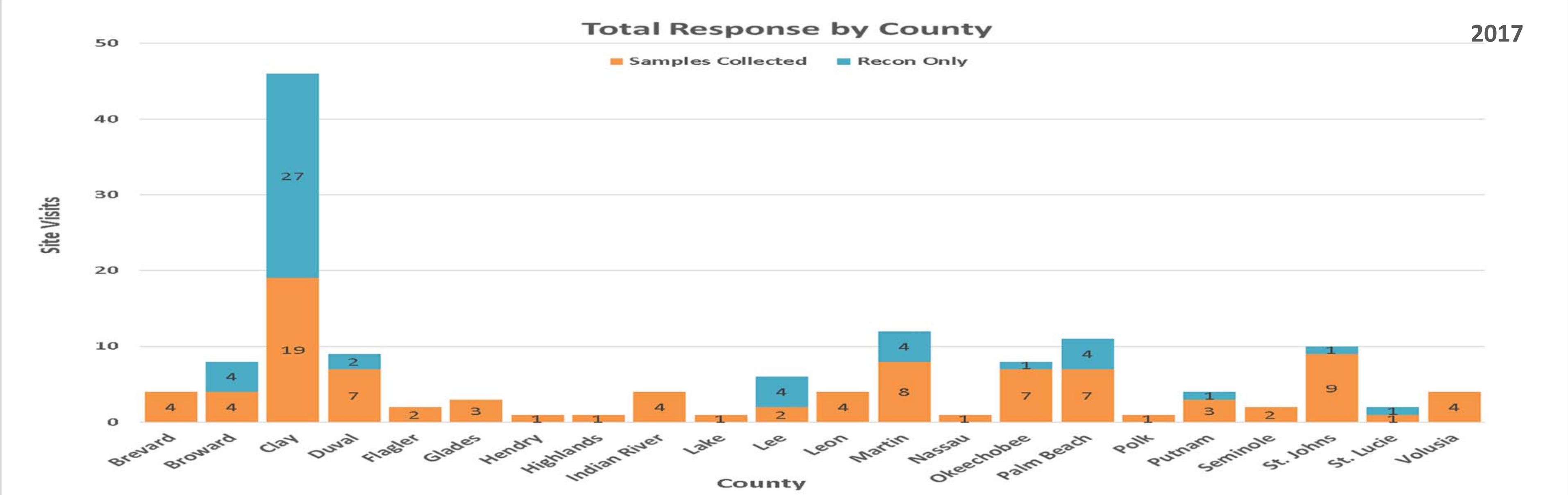
Doctor's Lake

- A cyanobacteria bloom formed on Doctor's Lake in Late May
- Boy Scout camp in vicinity of bloom
- Microcystin levels up to 10.4 µg/L were detected in July
- Bloom dissipated in Late July
- Additional minor blooms were observed on the main stem of the St. Johns River, but they did not persist and did not produce high toxin levels

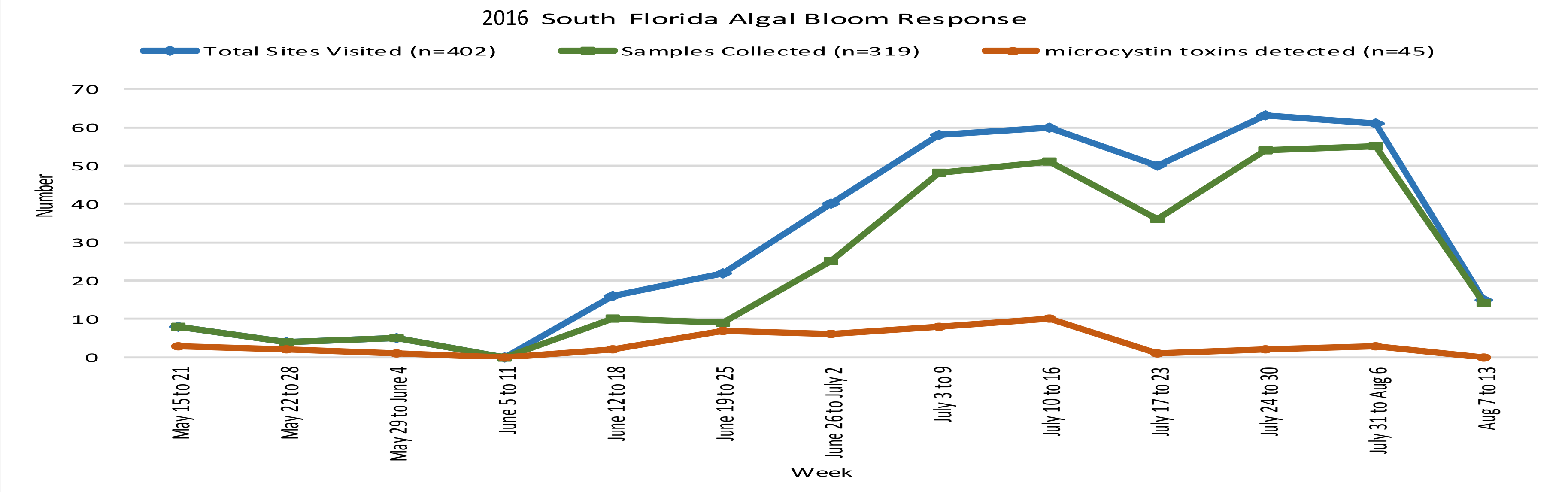
Doctor's Lake

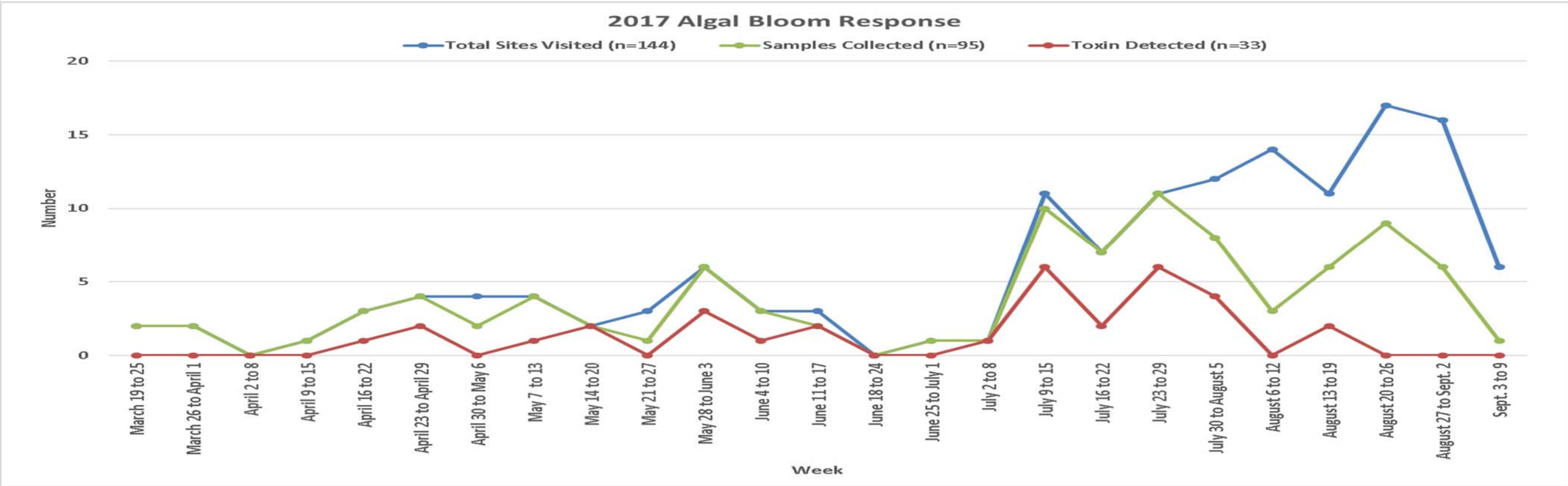
Sampling and Reporting Effort





Sampling and Reporting Effort





Innovative Algal Bloom Cleanup Request for Proposal

- In 2016, a committee with representatives from FDEP, DOH, FWC, SFWMD, U. S. EPA, U. S. ACE, U. S. Geological Survey, and Martin County reviewed a wide range of technologies submitted to the department's HAB Cleanup Technology Portal
- Committee reviewed submitted technologies with an eye towards applicability, human and environmental health concerns, scalability, mobility, and deployment time requirements

Innovative Algal Bloom Cleanup Technology Portal

- Committee members expressed a strong preference for technologies that did not require chemical or biological agents to be added directly to surface waters
- Technologies that removed algal biomass from the surface water would need a disposal plan if the algal biomass was not being used as feedstock for the production of a product (e.g., bioplastic products, paraffin, syngas)
- Potential worker and resident exposure to cyanotoxins needs to be addressed if aerosols could be created by technology

Innovative Algal Bloom Cleanup Request for Proposal

- FDEP identified a list of technologies that met these criteria and is attempting to establish contract services that state agencies and local governments could use to procure cleanup services for small-scale bloom events that pose a potential hazard to human health
- The FDEP Laboratory will analyze samples from the treatment area once cleanup is complete to ensure adequate contractor performance

Lessons Learned

Scale of the Event

- Coordination and communication tools that worked fine for past smaller scale bloom events were inadequate for more recent South Florida blooms

Location of Event

- Level of public exposure to the bloom is an important factor in level of media attention and concern

- In order to expedite the reporting of reconnaissance and sampling results, new tools had to be deployed
  - New FDEP HAB Response webpage
  - Survey123
  - Geoforms
  - Surveygismo.com
  - webinars

Lessons Learned

The public is very interested in a "one-stop shop" for information about HABs and local conditions

- CyanoHAB response is handled by multiple agencies in Florida; however, FDEP included links and contact information for all of the responding state agencies and affected counties

Educating the public and the media about HABs is an ongoing process

- Just because you provide information on a webpage doesn't mean the everyone has found it, looked at it, or understood it

Lessons Learned

Bloom conditions can be highly variable

- Beach conditions near St. Lucie Inlet were highly depended on the tide, with toxin concentrations ranged from non-detect to hundreds of micrograms per liter within hours
- Dead end canals and marinas can be severely impacted for a much longer timeframe than more open water areas
- These confined areas may be more amenable to cleanup efforts than larger unconfined blooms

Lessons Learned

Have an algal clean up technology review and approval plan before the bloom season starts

Clean up technologies span all size ranges and timelines

- Some technologies were developed for pools or ponds, while others were geared towards large open water applications
- Some technologies would require weeks to months to see an effect, while others would be more immediate

Lessons Learned

Algal clean up technologies need to be selected and implemented in a manner that minimizes their potential for adverse health or environmental impacts while still being effective

Contracting for algal cleanup work can be tricky

- unique nature of each bloom
- need for rapid deployment
- site access
- measurable results

Contact

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Guidelines and Advisories for Cyanotoxins in Drinking Water

Lesley V. D'Anglada, Dr.PH. - - - EPA Region 4 HABs Workshop - - - May 15th, 2018

Presentation Overview

- Overview of current regulations and guidelines for cyanotoxins in drinking water
- Discussion of the toxicity assessments
- Discussion of the development of the Health Advisories
- Opportunity for Questions

Current Regulations and Guidelines for Cyanotoxins in Drinking Water

Drinking Water Regulations for Cyanotoxins

No Federal regulations for cyanobacteria or cyanotoxins in drinking water in the U.S.

Safe Drinking Water Act Requirements (SDWA Section 1412(b)(1))

- Contaminant Candidate List (CCL) - includes cyanobacteria and their toxins
  - List of unregulated contaminants that are known or anticipated to occur in public water systems and may require a drinking water regulation.
- Unregulated Contaminant Monitoring Rule (UCMR) - 10 cyanotoxins
  - Collect data from selected public water systems.
- Regulatory Determination (RD)
  - Determine whether or not to regulate; EPA publishes determinations every on a five year cycle.

Drinking Water Protection Act *(H.R. 212)* – (SDWA Section 1459)

- To develop and submit a strategic plan (*Algal Toxin Risk Assessment and Management Strategic Plan for Drinking Water*) for assessing and managing risks associated with algal toxins in drinking water provided by public water systems.

Drinking Water Guidelines for Cyanotoxins

EPA published Health Advisories for Microcystins and Cylindrospermopsin in 2015.

- The Health Advisory (HA) Program (1978) provides information for public health officials on pollutants associated with short-term contamination incidents or spills for contaminants that can affect drinking water quality, but are not regulated under the Safe Drinking Water Act (SDWA).
- HAs are **Non-Regulatory** guideline values.

Toxins	Bottle-fed infants and pre-school children	School-age children and adults
Microcystins	**0.3 µg/L**	**1.6 µg/L**
Cylindrospermopsin	**0.7 µg/L**	**3 µg/L**

International and US Drinking Water Guidelines for Cyanotoxions

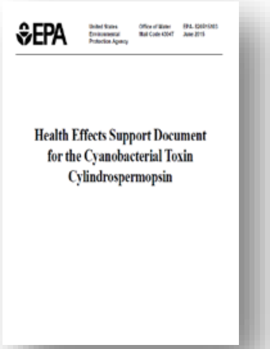
Authority/Country/State	Microcystins	CYL	Anatoxin-a	Saxitoxin
World Health Organization, 2003	1 µg/L MC-LR	-	-	-
Health Canada, 2002	1.5 µg/L MCs (proposed)	-	-	-
Brazil, 2005	1 µg/L MC-LR	15 µg/L	-	3 µg/L
Australia, 2009	1.3 µg/L MC-LR TE	1 µg/L	3 µg/L	3 µg/L
Ohio, 2015	0.3 µg/L bottle-fed infants and pre-school age children 1.6 µg/L school-age children and adults	0.7 µg/L bottle-fed infants and pre-school age children 3 µg/L school-age children and adults	20 µg/L	0.3 µg/L age 5 and younger 1.6 µg/L age 6 and older
Oregon	0.3 µg/L age 5 and younger 1.6 µg/L age 6 and older	0.7 µg/L age 5 and younger 3 µg/L age 6 and older	0.7 µg/L age 5 and younger 3 µg/L age 6 and older	0.3 µg/L age 5 and younger 1.6 µg/L age 6 and older
Minnesota	0.1 µg/L MC-LR	-	-	-

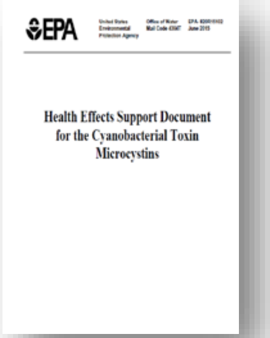
Toxicity Assessment for the Cyanotoxins Microcystins, Cylindrospermopsin and Anatoxin –a

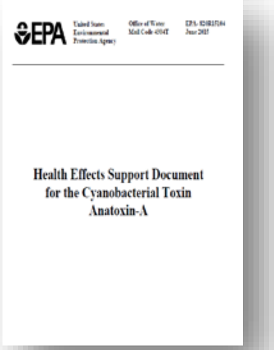
Health Effects Support Documents (HESD)

- Comprehensive review of the health effects information for microcystin, cylindrospermopsin and anatoxin-a.
- Provides the health effects basis for the development of HAs.
- Externally Peer Reviewed
  - External peer reviewers concurred that current data is inadequate to develop an HA for anatoxin-a.
    - No acute oral studies using purified anatoxin, and no chronic oral studies.
    - No studies on mutagenicity or genotoxicity of anatoxin-a on possible carcinogenic processes.

https://www.epa.gov/nutrient-policy-data/health-effects-support-documents


EPA
Health Effects Support Document for the Cyanobacterial Toxin Cylindrospermopsin

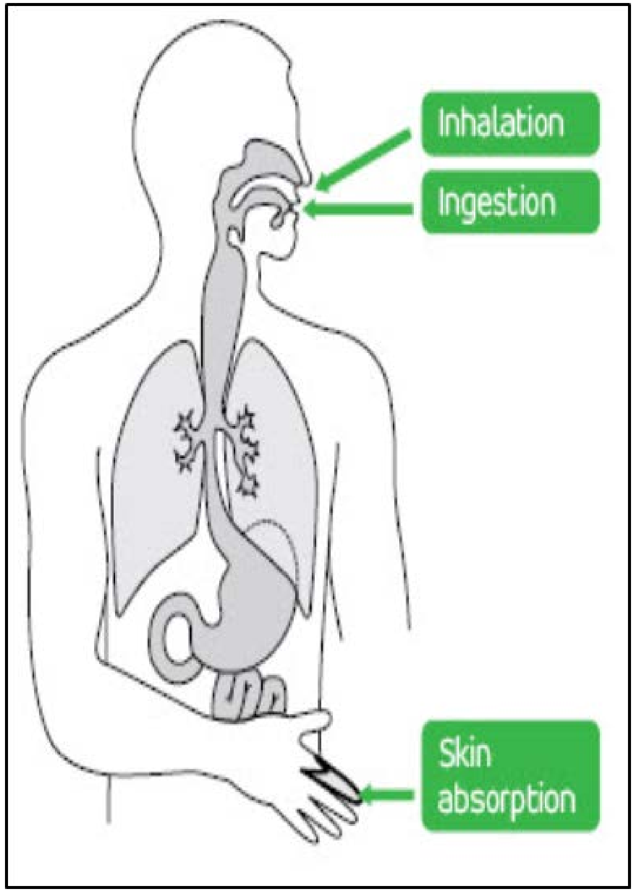

EPA
Health Effects Support Document for the Cyanobacterial Toxin Microcystins


EPA
Health Effects Support Document for the Cyanobacterial Toxin Anatoxin-A

Potential Routes of Exposure and Health Effects

- Potential routes of exposure:
  - Consumption in drinking water and food
  - Ingestion during recreational activities
  - Dermal contact
  - Inhalation of aerosolized toxins

- Human health outcomes differ by concentration and toxin, and type and duration of exposure.
  - Mild skin rash, acute dermatitis, blisters
  - Eyes, ears and throat irritation
  - Gastroenteritis
  - Nervous system, liver and kidney damage
  - Death (rare)



Summary of HESD Findings for MCs, CYL and Ana-a

Microcystins (MC)

- Group of at least 100 toxin variants (congeners), MC-LR the most studied.
- Primarily affect the liver, but also kidney, and reproductive system.
- Evaluation of chronic effects is limited and data does not report significant effects.
- Can bioaccumulate in common aquatic vertebrates and invertebrates such as fish, mussels, and zooplankton.
- The evidence of carcinogenicity in humans and experimental animals is inadequate to access carcinogenicity potential. Classified as possibly carcinogenic to humans (Group 2B) by IARC.

Cylindrospermopsin (CYL)

- Affects the liver and kidneys.
- No chronic studies are available to determine long term effects.
- The evidence of carcinogenicity in humans and experimental animals is inadequate to access carcinogenicity potential.

Anatoxin-a

- Affect the central nervous system.
- There are multiple variants, including anatoxin-a, homoanatoxin-a, and anatoxin-a(s)
- Limited toxicity data.

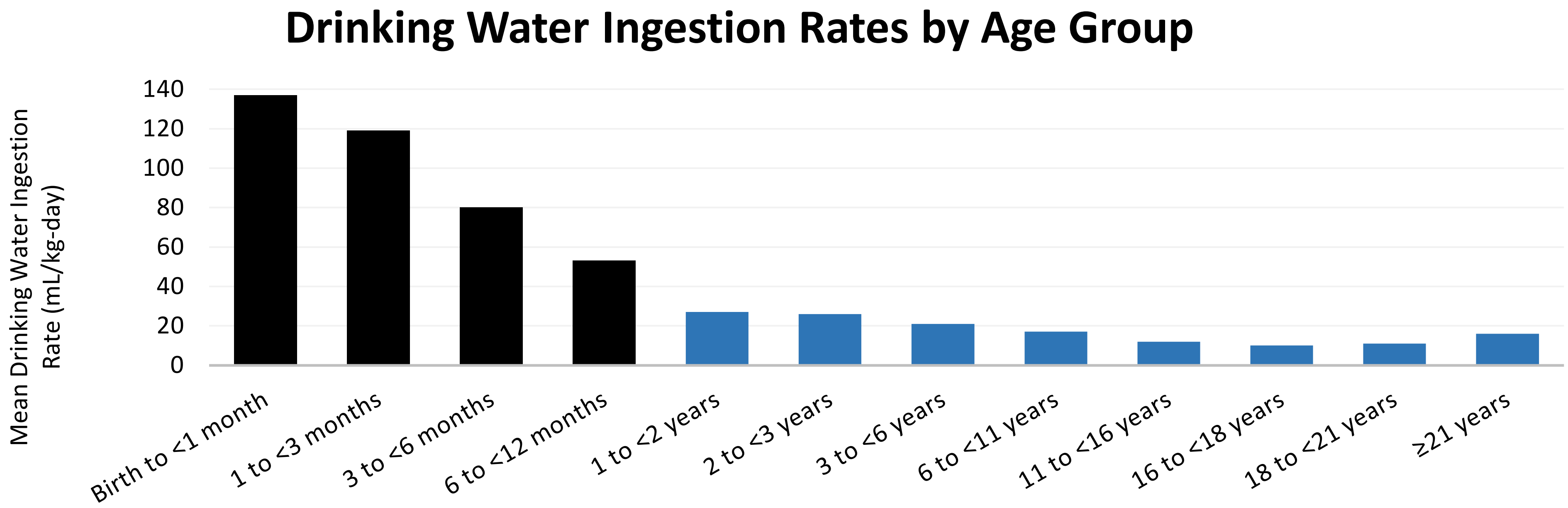
Overview of USEPA's Drinking Water Health Advisories for Cyanotoxins

EPA Drinking Water Health Advisories (HA)

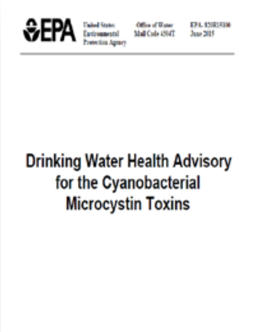
- **<u>HA Represents:</u> Concentration in drinking water at or below that is not expected to cause any adverse non carcinogenic effects for a specific exposure duration:**
  - One-day HA assumes a single acute exposure (children);
  - Ten-day HA assumes a period of one to two weeks exposure (children);
  - Chronic HA assumes a lifetime exposure (adults only).

Children’s Exposure to Cyanotoxins

- Bottle-fed infants consume large amounts of drinking water compared to their body weight.
- At 6 years and older, exposure on a body-weight basis is similar to that of an adult.
- Infant-specific exposure factors are available from U.S. EPA’s Exposure Factors Handbook (2011).



Ten-day HAs for Microcystins



Drinking Water Health Advisory for the Cyanobacterial Microcystin Toxins

- Microcystin-LR, considered a surrogate for all microcystins
  - LR is the same or more toxic than other congeners, based on available data.
- Key Study Selected: Heinze, 1999; 28 day drinking water study in rats
- Most sensitive endpoint: liver toxicity
- Short term exposure is more consistent with expected exposure pattern
- No lifetime or carcinogenic value derived

Ten-day HA for Bottle-fed Infants

$$HA_{10\,day} = \frac{50\ \mu g/kg/d}{1000 \times 0.15\ L/kg/day} = \mathbf{0.3\ \mu g/L}$$

Ten-day HA for Adults

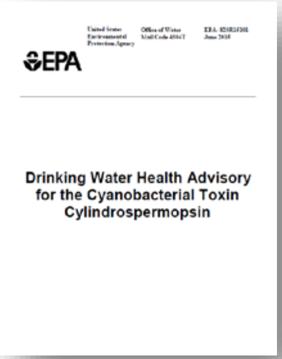
$$HA_{10\,day} = \frac{50\ \mu g/kg/d}{1000 \times 0.03\ L/kg/day} = \mathbf{1.6\ \mu g/L}$$

LOAEL = 50 µg/kg/day

UF = 1000: 10 intraspecies; 10 interspecies; $10^{0.5}$ LOAEL to NOAEL; $10^{0.5}$ database

DWI/BW = 0.15L/kg/day normalized DW intakes per unit body weight over the first year of life
0.03 L/kg/day based on adult defaults of 2.5 L/day and 80 kg

Ten-day HAs for Cylindrospermopsin



EPA

Drinking Water Health Advisory for the Cyanobacterial Toxin Cylindrospermopsin

- Key Study Selected: Humpage and Falconer (2002, 2003); 11 weeks study in mice
- Most sensitive endpoint: kidney damage
- Short term exposure is more consistent with expected exposure pattern.
- No lifetime or carcinogenic value derived.

Ten-day HA for Bottle-fed Infants

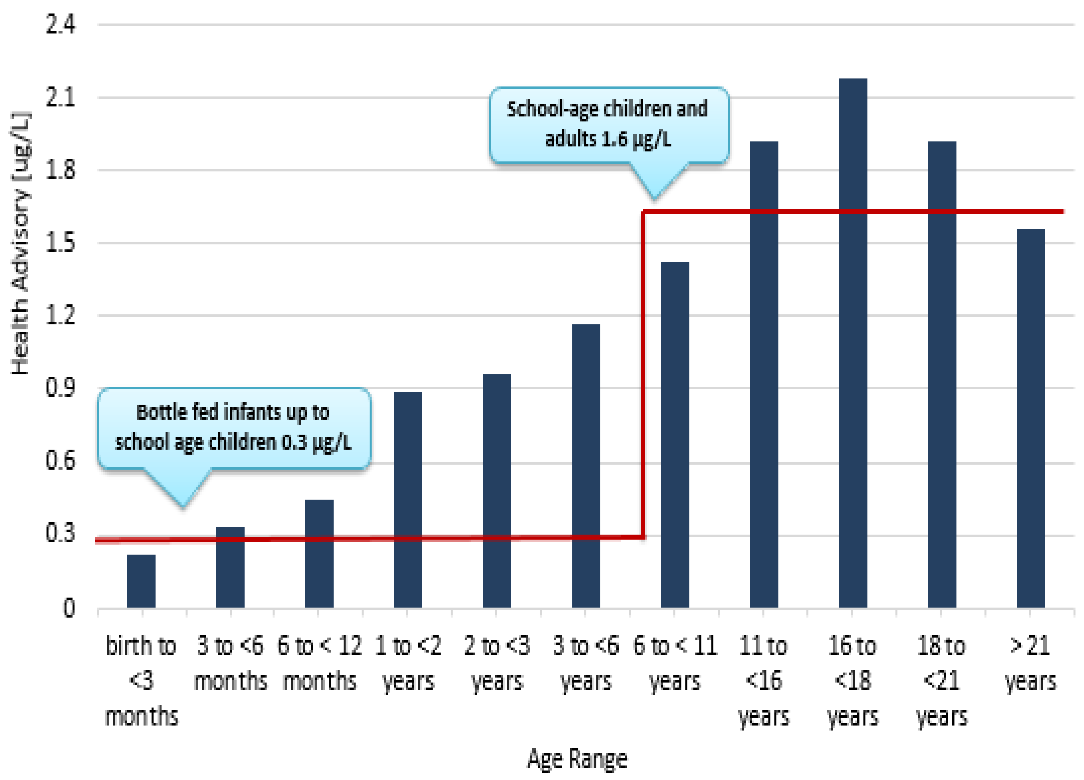
$$HA_{10\,day} = \frac{30\ \mu g/kg/d}{300\ \times\ 0.03\,L/kg/day} = \mathbf{0.7\ \mu g/L}$$

Ten-day HA for Adults

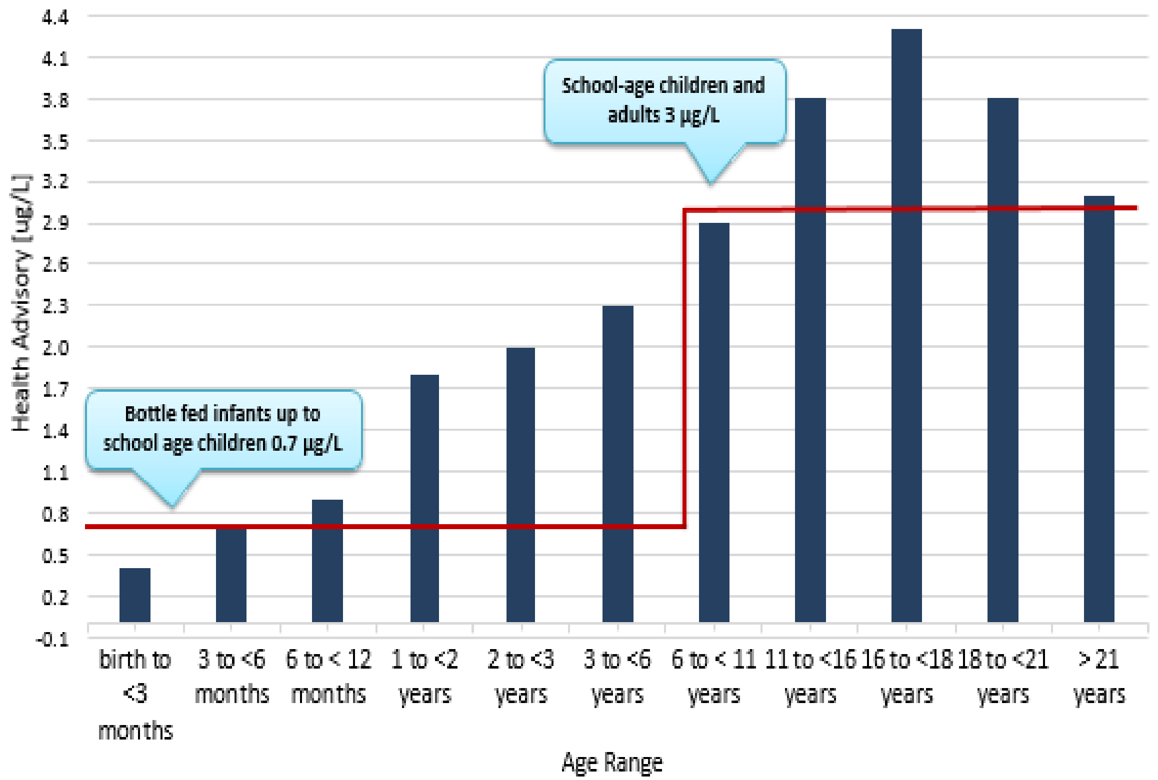
$$HA_{10\,day} = \frac{30\ \mu g/kg/d}{300\ \times\ 0.15 L/kg/day} = \mathbf{3\ \mu g/L}$$

LOAEL	=	30 µg/kg/day
UF	=	300: 10 intraspecies; 10 interspecies; $10^{0.5}$ database
DWI/BW	=	0.15L/kg/day normalized DW intakes per unit body weight over the first year of life
		0.03 L/kg/day based on adult defaults of 2.5 L/day and 80 kg

HAs for Microcystins



HAs for Cylindrospermopsin



Mean Drinking Water Ingestion Rates by Age Groups

https://www.epa.gov/nutrient-policy-data/drinking-water-health-advisory-documents-cyanobacterial-toxins

Difference among EPA and WHO GVs for Microcystins

	Principal Study	Duration /Route	Dose (µg/kg-d)	Endpoint	Point of Departure (µg/kg-d)	Uncertainty Factors	Guideline Value
WHO Provisional GV for MC-LR	Fawell et al. 1994	13 weeks; gavage; MC-LR	0 40 200 1000	Minimal/ light chronic inflammation; increased serum enzymes	NOAEL= 40	10-interspecies 10-intraspecies 10-database Total = 1000	1 µg/L Applies to a Lifetime Exposure
U.S.EPA GV for MCs	Heinze 1999	28 day; drinking water; purified extract MC-LR	0 50 150	Increased liver weight, increased serum enzymes; degenerative and necrotic hepatocytes with hemorrhage	LOAEL = 50	10-interspecies 10-intraspecies 3-LOAEL to NOAEL 3-database Total = 1000	0.3 µg/L for infants 1.6 µg/L for adults Applies to Short-term (10-day) Exposures

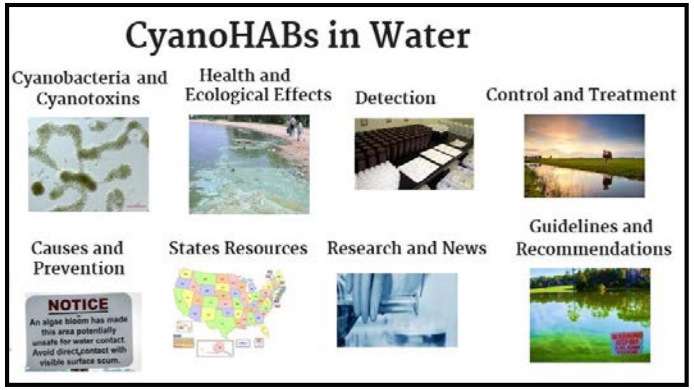
NOAEL: No-observed-adverse-effect level

LOAEL: lowest-observed-adverse-effect-level

Research Needs Identified

- The potencies of other microcystin congeners relative to microcystin-LR.
- Reproductive and developmental effects
  - Male reproductive system toxicity following sub-acute to chronic oral exposure.
  - Toxicity of microcystin during pregnancy and effects on offspring following oral exposure.
- Effects of inhalation and/or dermal exposures.
- Acute and chronic toxicity of anatoxin-a.
- Chronic toxicity of cylindrospermopsin.
- Carcinogenic potential.
- Health risks from exposure to mixtures of cyanotoxins.
- Bioaccumulation of cyanotoxins in aquatic food webs.

Outreach and Communications



- EPA's Cyanobacteria HABs Webpage
- Monthly Freshwater HABs Newsletter
- Fact Sheets
  - Cyanobacteria and Cyanotoxins: Information for Drinking Water Systems
  - Climate Change and Harmful Algal Blooms
- Stakeholder Engagement through webinar
  - Inland HABs Discussion Group
  - OST's sponsored webinars
- EPA Regional Workshops on HABs (2015-2017)
- Region 8 (2015), Regions 5 and 10 (2016) and Region 7 and 9 (2017), Region 4 (2018)
- EPA's HABs Listserv:epacyanohabs@epa.gov

Contact Information

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EPA's CyanoHABs Website
www.epa.gov/cyanohabs

U.S. EPA's Support Tools for Managing Cyanotoxins in Drinking Water

Katie Foreman

May 14, 2018

EPA Region 4

Harmful Algal Bloom Workshop

EPA
OFFICE OF GROUND WATER AND DRINKING WATER

Presentation Overview

OFFICE OF GROUND WATER AND DRINKING WATER

- Overview of harmful algal blooms (HABs) and drinking water impacts
- EPA's recent and ongoing HAB-related activities in drinking water
- Discussion of key support tools for managing cyanotoxin risks in drinking water

Harmful Algal Blooms

- Naturally occurring cyanobacteria in surface water can rapidly form HABs
- Leading factors causing HABs:
  - Excess nutrient loadings and concentrations
  - Slow moving surface water
  - Elevated water temperature
- Some species of cyanobacteria produce toxic compounds, called algal toxins or cyanotoxins
- Significant impacts of HABs include:
  - Adverse human health effects
  - Adverse ecosystem impacts from toxins and hypoxia
  - Drinking and recreational water quality concerns
  - Economic losses

HAB-Related Drinking Water Challenges

- Drinking water quality
  - Taste and odor problems
  - Human health effects from ingesting toxins: gastroenteritis, liver and kidney damage
  - Potential development of disinfection byproducts
- Public water systems
  - Increasing operational costs
  - Additional research needed on how to prevent, predict, analyze, monitor and treat toxins
  - Developing and implementing cost effective methods to reduce HABs in source waters
  - Determining how to communicate risk to the public

Highlights from Recent Bloom Seasons

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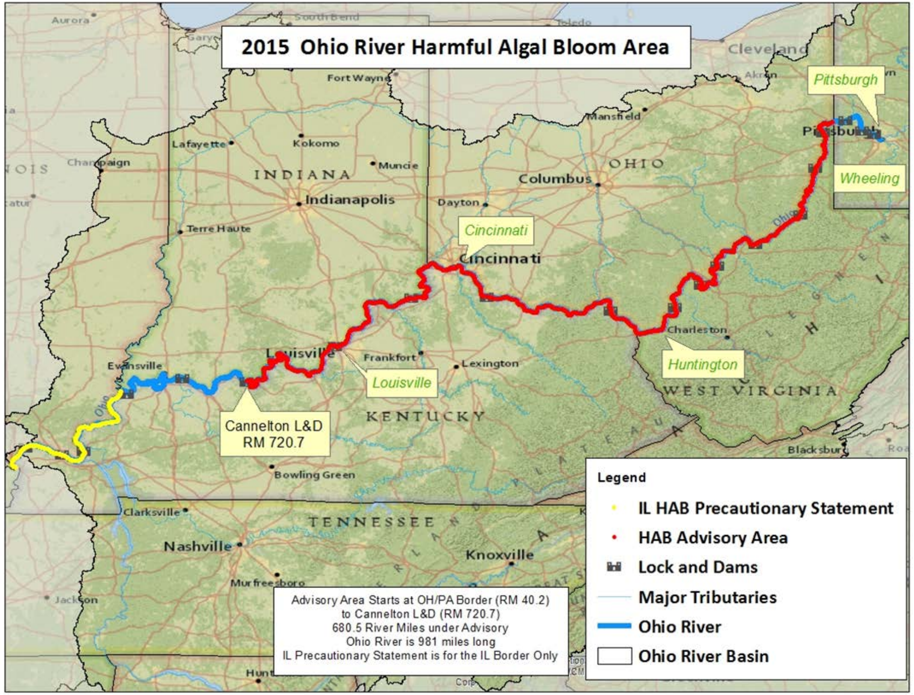
Ohio River 2015

- Approximately 700 mile bloom
- Source of drinking water for over 5 million people



Florida 2016

- Severe bloom impacted Lake Okeechobee, rivers, and estuaries

Utah 2016

- Severe bloom impacted Utah Lake and nearby waterbodies
- Recreational waters and secondary water systems impacted (i.e. irrigation, gardening, livestock)

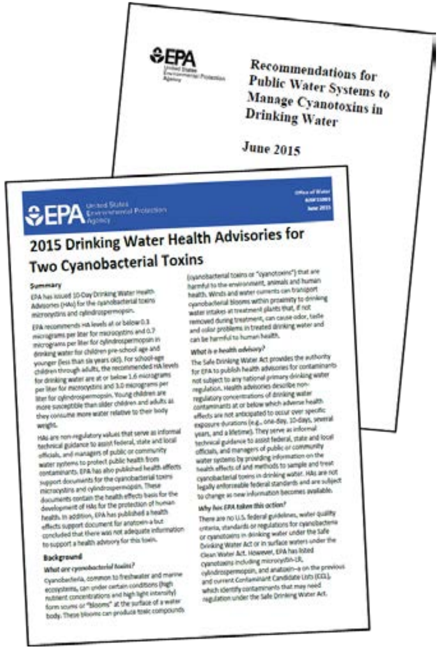
Drinking Water Detects 2016-17

- Ingleside, Texas (Jan./Feb. 2016)
  - Resulted in advisory
- *Des Moines, Iowa (Aug. 2016)
- *Cayuga County, New York (Sept./Oct. 2016); *Syracuse, NY (Sept./Oct. 2017)

* Below U.S. EPA Health Advisory levels

Recent Key OW Cyanotoxin Drinking Water Activities

- Drinking water Health Advisories for two cyanotoxins – 2015
- Recommendations documents released for public water systems to manage cyanotoxins in drinking water – 2015
- “Algal Toxin Risk Assessment and Management Strategic Plan for Drinking Water”, submitted to Congress – 2015
- Algal toxins placed on the Safe Drinking Water Act’s Contaminant Candidate Lists (CCLs) including CCL 4 – 2016
- Cyanotoxins monitoring for the fourth Unregulated Contaminant Monitoring Rule (UCMR 4) – 2018-2020
- Cyanotoxin drinking water tools – 2016
- Regional HABs Workshops



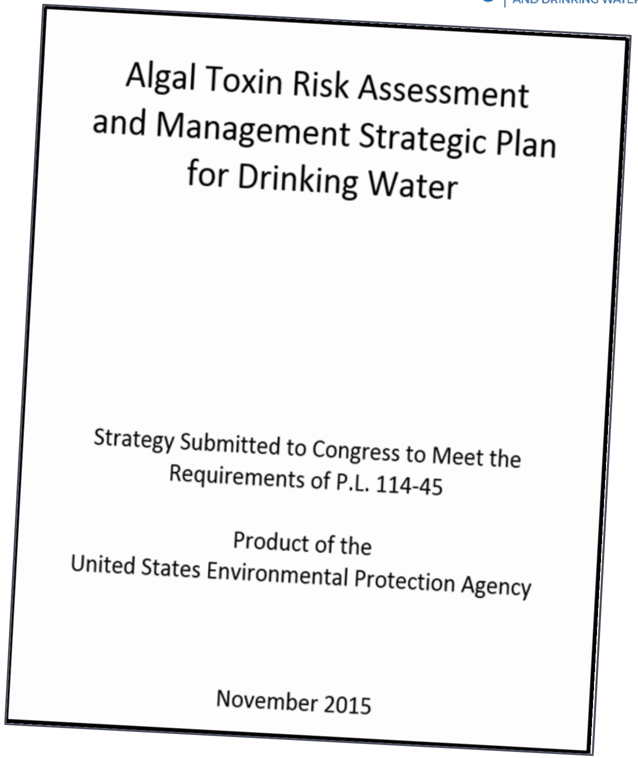
H.R. 212: The Drinking Water Protection Act

- The 2015 Drinking Water Protection Act amended the SDWA, adding Section 1459
- Directed EPA to develop and submit a strategic plan for assessing and managing risks associated with algal toxins in drinking water provided by public water systems
- Strategic Plan delivered to Congress November 2015

Algal Toxin Risk Assessment and Management Strategic Plan for Drinking Water

OFFICE OF GROUND WATER AND DRINKING WATER

- Includes steps and timelines for:
  - Assessing human health effects
  - Developing list of algal toxins of concern
  - Publishing Health Advisories
  - Assessing treatment options
  - Developing analytical and monitoring approaches
  - Summarizing the causes of HABs
  - Recommending source water protection actions
  - Strengthening collaboration and outreach


Algal Toxin Risk Assessment and Management Strategic Plan for Drinking Water

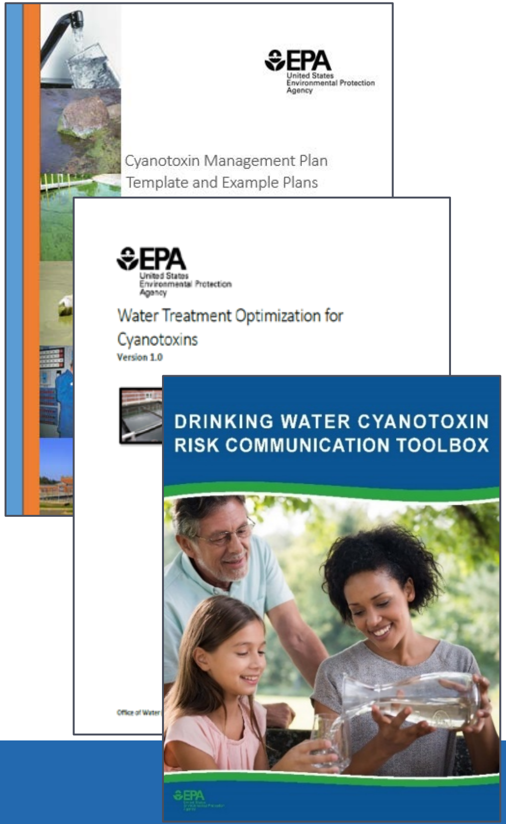
Strategy Submitted to Congress to Meet the Requirements of P.L. 114-45

Product of the United States Environmental Protection Agency

November 2015

Recent EPA OW HAB-Related Drinking Water Activities

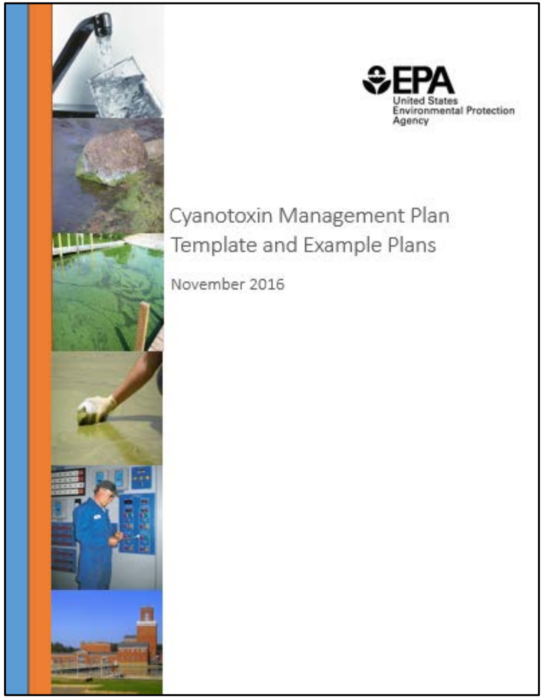
- Cyanotoxin Management Plan Template and Example Plans
- Water Treatment Optimization for Cyanotoxins
- Cyanotoxin Risk Communication Toolbox
- HABs Funding Fact Sheet
- Analytical Method Development
- Promoting CWA/SDWA Integration and Source Water Protection
- Source Water Collaborative and Partnerships



Cyanotoxin Management Plans

Two parts:

1. Template
   - Framework for public water systems (PWSs) to inform the development of their own cyanotoxin management plans as they deem appropriate
2. Five example cyanotoxin management plans
   - Examples from five partner PWSs representing diversity in system characteristics and geography



Risk Communication Toolbox

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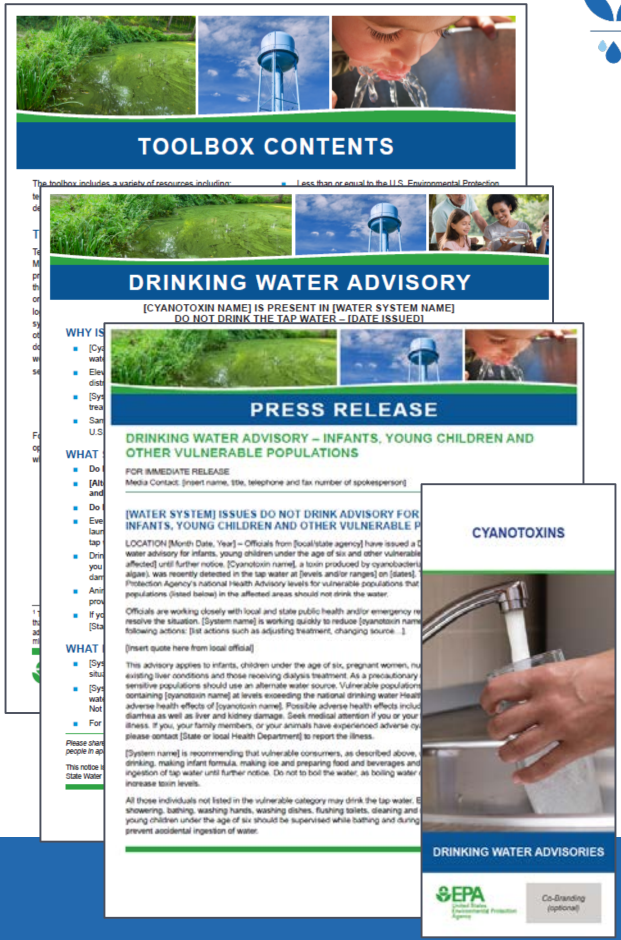
- Ready-to-use, “one-stop shop” for communicating risks of cyanotoxins in drinking water
- Tools developed for use by local and state governments and PWSs
- The public is the target audience
- Available in English and Spanish



EPA's Health Advisories for Cyanotoxins Used as Example

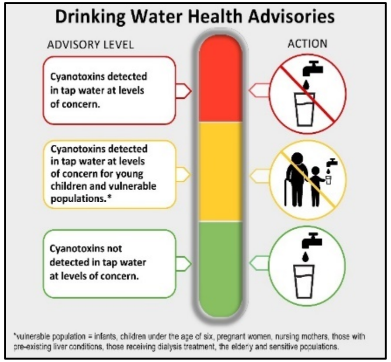
- U.S. EPA's national drinking water Health Advisory levels are used as example cyanotoxin levels that inform public communication decisions in the toolbox.
- Templates are editable to include state and local action levels.

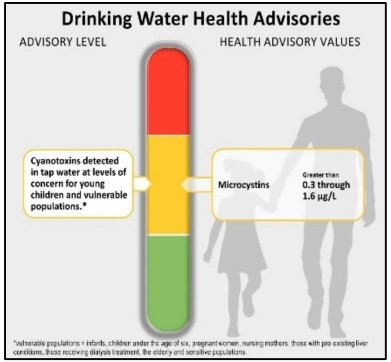
chemical	10-day advisory	
	Bottle-fed infants and pre-school children	School-age children and adults
microcystins	0.3 µg/L	1.6 µg/L
cylindrospermopsin	0.7 µg/L	3 µg/L

Risk Communication Toolbox Contents

EPA
OFFICE OF GROUND WATER
AND DRINKING WATER

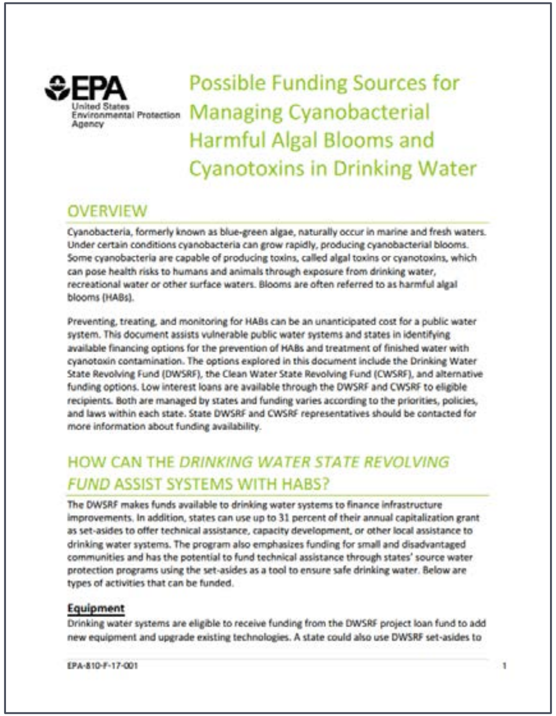
- Templates
  - Press releases
  - Drinking Water Advisories
  - Social Media and Text Alerts
- General Information
  - Public Messaging
  - Frequently Asked Questions
  - Factsheets
- Graphics
  - Menu of multiple downloadable options





HABs Funding Fact Sheet for Drinking Water Systems

- Provides overview of funding mechanisms:
  - Drinking Water State Revolving Fund
  - Clean Water State Revolving Fund
  - Additional funding sources
  - State examples


EPA United States Environmental Protection Agency

Possible Funding Sources for Managing Cyanobacterial Harmful Algal Blooms and Cyanotoxins in Drinking Water

OVERVIEW

Cyanobacteria, formerly known as blue-green algae, naturally occur in marine and fresh waters. Under certain conditions cyanobacteria can grow rapidly, producing cyanobacterial blooms. Some cyanobacteria are capable of producing toxins, called algal toxins or cyanotoxins, which can pose health risks to humans and animals through exposure from drinking water, recreational water or other surface waters. Blooms are often referred to as harmful algal blooms (HABs).

Preventing, treating, and monitoring for HABs can be an unanticipated cost for a public water system. This document assists vulnerable public water systems and states in identifying available financing options for the prevention of HABs and treatment of finished water with cyanotoxin contamination. The options explored in this document include the Drinking Water State Revolving Fund (DWSRF), the Clean Water State Revolving Fund (CWSRF), and alternative funding options. Low interest loans are available through the DWSRF and CWSRF to eligible recipients. Both are managed by states and funding varies according to the priorities, policies, and laws within each state. State DWSRF and CWSRF representatives should be contacted for more information about funding availability.

HOW CAN THE *DRINKING WATER STATE REVOLVING FUND* ASSIST SYSTEMS WITH HABS?

The DWSRF makes funds available to drinking water systems to finance infrastructure improvements. In addition, states can use up to 31 percent of their annual capitalization grant as set-asides to offer technical assistance, capacity development, or other local assistance to drinking water systems. The program also emphasizes funding for small and disadvantaged communities and has the potential to fund technical assistance through states' source water protection programs using the set-asides as a tool to ensure safe drinking water. Below are types of activities that can be funded.

Equipment

Drinking water systems are eligible to receive funding from the DWSRF project loan fund to add new equipment and upgrade existing technologies. A state could also use DWSRF set-asides to

EPA-810-F-17-001 1

Ongoing EPA HAB Research Activities

- Developing innovative cyanotoxin treatment optimization, analytical methods and monitoring designs
- Correlating HABs with changes in the formation potential of regulated disinfection byproducts
- Comparing toxicity of bloom extracts with toxicity of mixtures of pure toxins
- Characterizing microcystin health effects through epidemiology studies
- Developing predictive models/satellite imaging
    - Cyanobacteria Assessment Network (CyAN)
    - EPA, USGS, NOAA, NASA collaboration
- Investigating interactive effects of temperature and nutrient loadings on HAB formation
- Evaluating the effectiveness of cost-effective source water protection measures for reducing nutrient pollution and other drivers of HAB formation

EPA's Goals for Managing Risks of HABs Impacting Drinking Water

OFFICE OF GROUND WATER AND DRINKING WATER

- **Improving scientific understanding** of HABs and cyanotoxin production to better predict their occurrence;
- **Protecting human health** by identifying human health effects of current and emerging cyanotoxins;
- **Providing necessary technical assistance** to utilities so they can provide safe drinking water through effective HABs and cyanotoxin treatment in finished water;
- **Preventing HAB formation** with effective source water protection efforts and nutrient reduction strategies at the watershed scale.

Contact Information

Katie Foreman

Foreman.katherine@epa.gov

CyanoHABs website:

https://www.epa.gov/cyanohabs

Cyanotoxins in Drinking Water website:

https://www.epa.gov/ground-water-and-drinking-water/cyanotoxins-drinking-water

QUESTIONS

Cyanotoxins: EPA Analytical Methods and UCMR 4

William A. Adams, Ph.D.

Office of Ground Water and Drinking Water
Standards and Risk Management Division
Technical Support Center
Cincinnati, OH

Overview

- Method development
- EPA methods used for cyanotoxin analysis
- UCMR 4 Program

General Method Development

Target analyte selection

Instrument Optimization

- Based on scientific literature and preliminary experiments
- Instrument: Analytical column, eluent, temperature programs, flow, injection volume, assays
- Detectors: Target analyte MS tuning, detector settings, probes

System Background – Laboratory Reagent Blank (LRB)

LCMRL Calculation – Lowest Concentration Minimum Reporting Level

- The lowest true concentration for which the future recovery is predicted to fall between 50% to 150% with 99% confidence

Precision and Accuracy Measurements

- Accuracy: Low: 50–150%; Mid/High: 70–130%
- Precision: Low: ≤30%; Mid/High: ≤20%
- Analyzed in three matrixes

Storage Stability Study

- Tracks target analyte concentrations in preserved tap water for 5 weeks

Multi-Laboratory Demonstration

- At least two outside laboratories

Submitted for EPA clearance

Microcystins DW Methods Overview

Summary Options	ELISA-Field (Tube/Strips)	ELISA-Lab	LC-MS/MS
Scope	"Total Microcystins and Nodularins"	"Total Microcystins and Nodularins" (EPA Method 546)	6 Specific Microcystin Congeners and Nodularin-R (EPA Method 544)
Approx. Limit of Quantification (LOQ)	~0.5 – 1 ug/L	~ 0.3 µg/L	~ 0.02 µg/L
Time to Result	10 – 60 minutes	1 – 4 hours	< one day

Cylindrospermopsin and Anatoxin-a DW Methods Overview

Summary Options	ELISA-Lab	LC-MS/MS
Scope	Cylindrospermopsin and Anatoxin-a	Cylindrospermopsin and Anatoxin-a
Approx. Limit of Quantification (LOQ)	~ 0.3 and 1.0 µg/L	~ 0.06 and 0.02 µg/L
Time to Result	1 – 4 hours	< one day

LC-MS/MS

- EPA finished water methods
  - EPA Method 544 – six selected microcystins and nodularin-R
  - EPA Method 545 – cylindrospermopsin and anatoxin-a
  - These methods were developed primarily for potential UCMR application

LC-MS/MS

- EPA ambient water methods
  - Single Laboratory Validated Method for Determination of Cylindrospermopsin and Anatoxin-a in Ambient Water by Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS) (Nov 2017, EPA 600-R-17-130)
  - Single Laboratory Validated Method Determination of Microcystins and Nodularin in Ambient Freshwaters by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS) (Nov 2017, EPA 600-R-17-344)
    - thirteen selected microcystins and nodularin-R

LC-MS/MS EPA Method 544 (Selected Microcystins and Nodularin-R)[1]

Parameter	Method Description	Parameter	Method Description
Reporting Limit	0.0029–0.022 µg/L (LCMRL)	Sample Preparation	Cell lysing, SPE, concentration
Sample Collection	500 mL in glass	Quality Control	LRB, precision and accuracy demonstrations, MRL confirmation, QCS, calibration checks, surrogate standard, laboratory fortified blank, laboratory fortified sample matrix and duplicate, field duplicate
Preservation	Refrigerated samples, frozen extracts, Trizma buffer, ascorbic acid dechlorination, 2-chloroacetamide microbial inhibition, EDTA, 28-day extract and sample hold time		

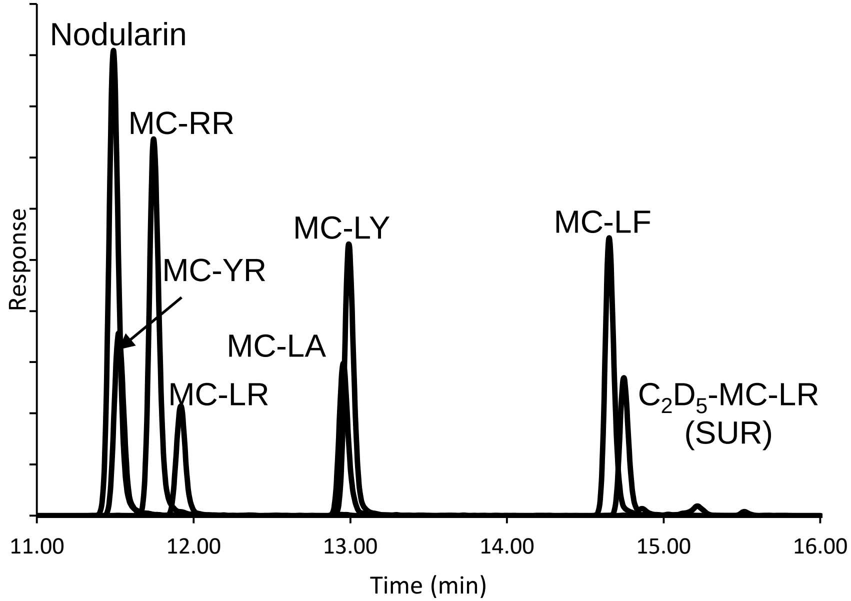
[1]*EPA Method 544: Determination of microcystins and nodularin in drinking water by solid phase extraction and liquid chromatography/tandem mass spectrometry (LC/MS/MS)*; EPA Document No. 600-R-14-474; U.S. Environmental Protection Agency, ORD/NERL: Cincinnati, OH, 2015.

LC-MS/MS EPA Method 545 (Cylindrospermopsin and Anatoxin-a)[1]

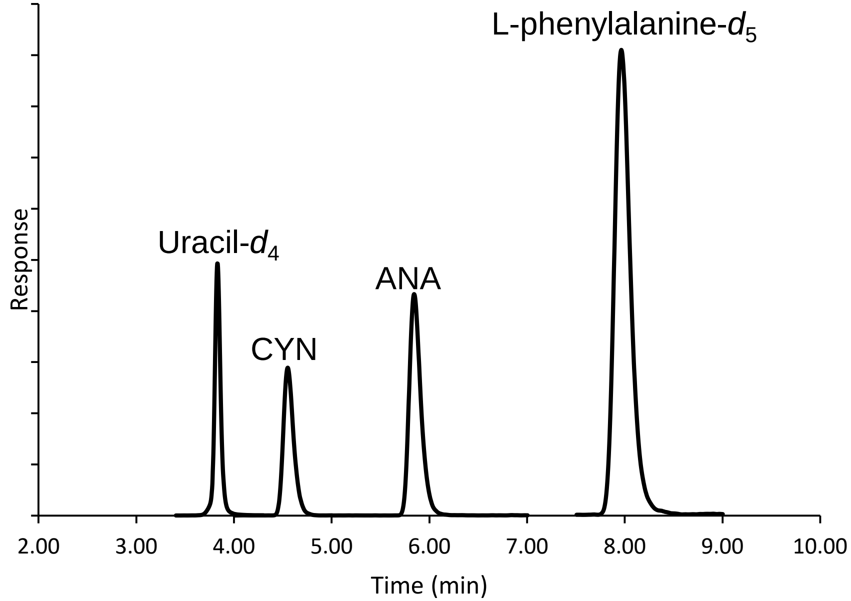
Parameter	Method Description	Parameter	Method Description
Reporting Limit	0.063 and 0.018 µg/L (LCMRL)	Sample Preparation	Cell lysing, filtration
Sample Collection	At least 10 mL in glass	Quality Control	LRB, precision and accuracy demonstrations, MRL confirmation, QCS, calibration checks, internal standards, laboratory fortified sample matrix and duplicate, field duplicate
Preservation	Refrigerated, ascorbic acid dechlorination, sodium bisulfate microbial inhibition, 28-day hold time		

[1]*EPA Method 545: Determination of cylindrospermopsin and anatoxin-a in drinking water by liquid chromatography electrospray ionization tandem mass spectrometry (LC/ESI-MS/MS)*; EPA Document No. 815-R-15-009; U.S. Environmental Protection Agency, OW/OGWDW/SRMD/TSC: Cincinnati, OH, 2015.

LC-MS/MS Chromatograms



EPA Method 544



EPA Method 545

Enzyme-Linked Immunosorbent Assay (ELISA)

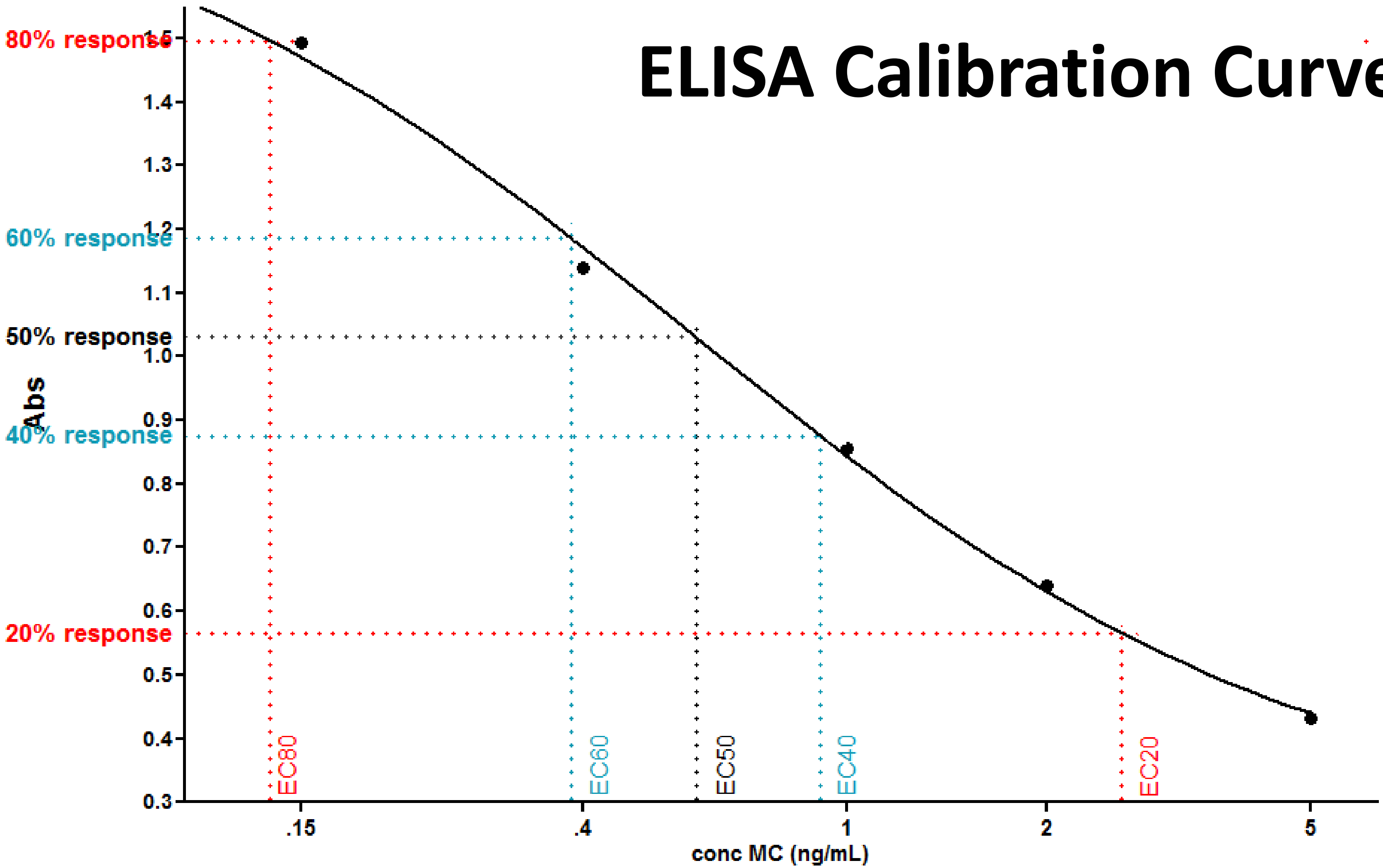
- ELISA is commonly used to detect cyanotoxins
  - Separate assays are used to detect individual or groups of cyanotoxins
- Adda-ELISA results quantify “total microcystins and nodularins”
  - Based on the Adda portion of the molecules
- Calibration curve based on four-parameter logistic function (sigmoidal curve)

Adda-ELISA EPA Method 546 (Total Microcystins and Nodularins)[1]

<table>
<tr><th>Parameter</th><th>Method Description</th><th>Parameter</th><th>Method Description</th></tr>
<tr><td>Reporting Limit</td><td>0.26 µg/L (MC-LR, LCMRL)</td><td>Sample Preparation</td><td>Cell lysing, filtration</td></tr>
<tr><td>Sample Collection</td><td><100 mL in glass or PTEG</td><td rowspan="2">Quality Control</td><td rowspan="2">LRB, precision and accuracy demonstrations, MRL confirmation, QCS, calibration verification, laboratory fortified sample matrix and duplicate</td></tr>
<tr><td>Preservation</td><td>Refrigerated then frozen, sodium thiosulfate dechlorination, 14-day hold time</td></tr>
</table>

[1]*EPA Method 546: Determination of Total Microcystins and Nodularins in Drinking Water and Source Water by Adda Enzyme-Linked Immunosorbent Assay*; EPA Document No. 815-B-16-011; U.S. Environmental Protection Agency, OW/OGWDW/SRMD/TSC: Cincinnati, OH, 2016.

ELISA Calibration Curve



Microcystin Analytical Comparisons

Analysis	Advantages	Limitations
EPA Method 544 -or- Other Microcystin LC-MS/MS Analyses	• Sensitive • Speciates microcystins	• Standards not available for all microcystin congeners (limited target analyte list) • Instrument limitations considering number of congeners
EPA Method 546 ADDA-ELISA	• Cost effective • Provides “total” concentration (single number)	• Does not speciate microcystins • Non-typical calibration • Technique is important

UCMR Objective

- Collect national occurrence data for suspected drinking water contaminants that do not have health-based standards set under the SDWA
  - Drinking water occurrence information to support future regulatory determinations and actions to protect public health
  - Public benefit from information about whether or not unregulated contaminants are present in their drinking water

UCMR 4

- UCMR 4 proposal published on December 11, 2015
- Public comment period closed February 9, 2016
- UCMR 4 final rule published December 20, 2016
- UCMR 4 monitoring 2018-2020
- UCMR 4 NCOD initial posting expected by Fall 2018

Timeline of UCMR 4 Implementation

2017	2018	2019	2020	2021
Pre-monitoring Implementation • Continuation of Lab Approval • PWS SDWARS registration/notification/Inventory • PAs, SMPs, SSIs, LSIs • Design kits, STFs and sampling instructions (small) • GWRMP submittal • Outreach/trainings	**Assessment Monitoring List 1 Contaminants** ← → **Implementation Activities** • Assist PWSs with compliance • Implement small system monitoring • Post data quarterly to NCOD **Reporting and analysis of data** • All large systems serving more than 10,000 people; • 800 SW and GWUDI small systems serving 10,000 or fewer people for cyanotoxins; • 800 small systems serving 10,000 or fewer people for the 20 additional contaminants.			**Post-monitoring Phase** • Complete resampling • Conclude data reporting • Finalize NCOD • Continued enforcement

UCMR 4 Analytes

EPA Method 546 (Adda ELISA)
“total microcystins”

EPA Method 544 (LC/MS/MS)	
microcystin-LA	microcystin-RR
microcystin-LF	microcystin-YR
microcystin-LR	nodularin
microcystin-LY	

EPA Method 545 (LC/MS/MS)	
anatoxin-a	cylindrospermopsin

EPA Method 200.8 (ICP-MS) or alternate SM or ASTM	
germanium	manganese

EPA Method 530 (GC/MS)	
butylated hydroxyanisole	quinolone
o-toluidine	

EPA Method 525.3 (GC/MS)	
alpha-hexachlorocyclohexane	profenofos
chlorpyrifos	tebuconazole
dimethipin	total permethrin (cis- & trans-)
ethoprop	tribufos
oxyfluorfen	

EPA Method 552.3 (GC/ECD) or 557 (IC/MS/MS)	
HAA5 (regulated)	HAA9
HAA6Br	

EPA Method 541 (GC/MS)	
1-butanol	2-propen-1-ol
2-methoxyethanol	

UCMR 4 Sampling Design

Assessment Monitoring (List 1 Contaminants)	10 Cyanotoxins	20 Additional Chemicals
Applicable Systems	All large + 800 randomly selected small SW and GWUDI systems	All large + 800 randomly selected small SW, GWUDI, and GW systems
Time Frame	March – November	January – December
Frequency	Twice a month for four consecutive months (total of eight sampling events).	SW/GWUDI: Monitor four times during your 12-month monitoring period. Sample events must occur quarterly. GW: Monitor two times during your 12-month monitoring period. Sample events must occur 6 months apart.

UCMR Program Highlights: Laboratory Approval

- Laboratory Approval
  - Administered by EPA
  - Ensures that laboratories participating in the UCMR program provide quality data through:
    - QC requirements
    - Proficiency testing
    - Demonstrations of capability to meet reporting level, precision, and accuracy criteria

UCMR Program Highlights: Reporting Data

- SDWARS (for UCMR 4)
  - Used for reporting both small and large public water systems (PWS) data
  - QC data are included, which indicate and allow for a single complete data set
  - Allows for more timely availability of all results for PWS, States, and Regions
  - Provides for more effective data management

UCMR Program Highlights: Data Availability

- National Drinking Water Contaminant Occurrence Database (NCOD)
  - Quarterly posting of results to NCOD
- Data summary
  - Also updated quarterly
  - Summarizes NCOD results (e.g., the number and % of PWS with results above the reference concentration)
  - Critical reference to interpret NCOD electronic data format

For More Information…

- UCMR 4: https://www.epa.gov/dwucmr/fourth-unregulated-contaminant-monitoring-rule
  - Lab Approval Program https://www.epa.gov/dwucmr/laboratory-approval-program-fourth-unregulated-contaminant-monitoring-rule-ucmr-4
  - EPA Drinking Water Methods https://www.epa.gov/dwanalyticalmethods/approved-drinking-water-analytical-methods
  - Go to UCMR 4 Docket (EPA-HQ-OW-2015-0218) at http://www.regulations.gov for federal register notice and supporting documents

Questions?

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Disclaimer: Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

U.S. Environmental Projection Agency, Office of Research and Development

SAFE AND SUSTAINABLE WATER RESOURCES RESEARCH PROGRAM

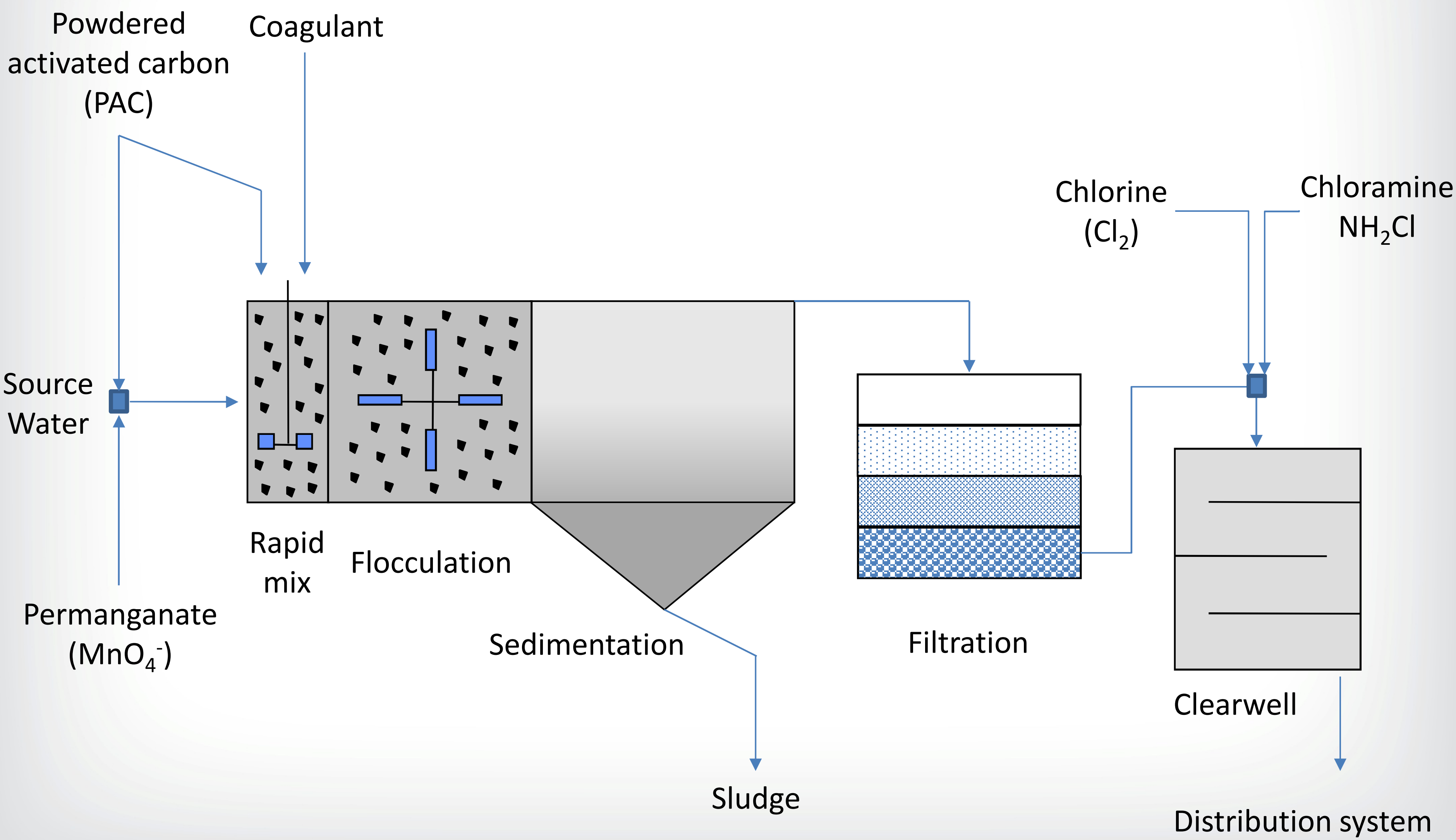
Conventional Treatment Options For HABs Impacted Waters

Nicholas Dugan, PE
Thomas Waters, PE

US Environmental Protection Agency Region 4 HABs Workshop, Atlanta, GA

May 14, 2018

Conventional surface water treatment process



Definitions

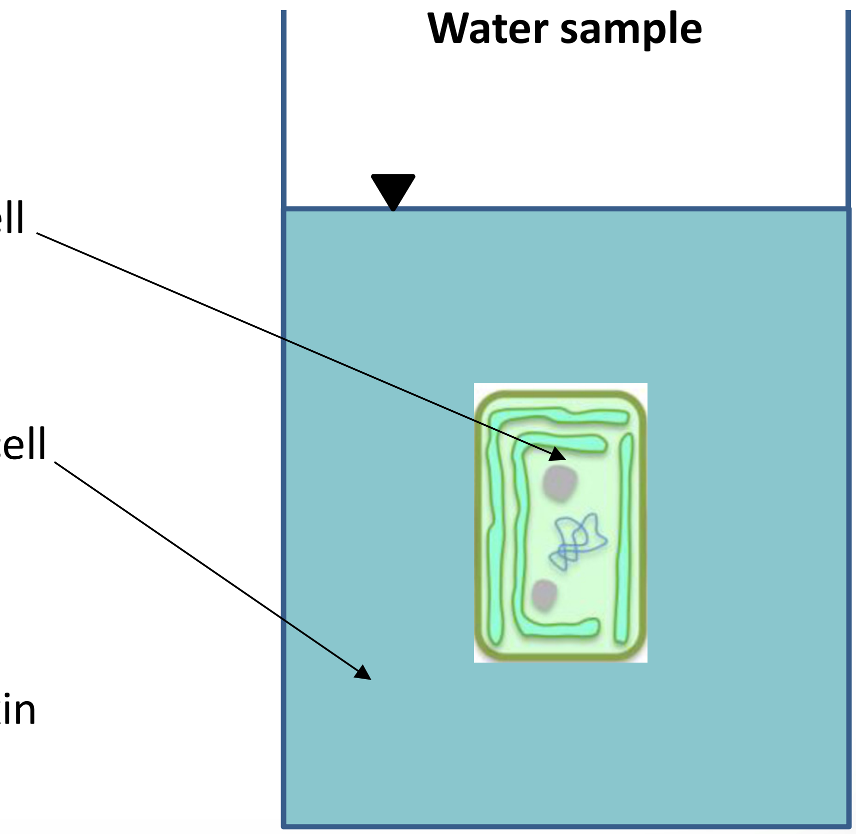
- Cell counts: direct counting of cells under a microscope
- Chlorophyll: pigment molecules in algae and cyanobacteria that play a role in photosynthesis
- Phycocyanin: pigment molecules in cyanobacteria that play a role in photosynthesis
- Microcystin: A type of toxin produced by cyanobacteria, most commonly detected, affects the liver

Combined, intracellular and extracellular toxins

Intracellular
Toxins contained inside the cell

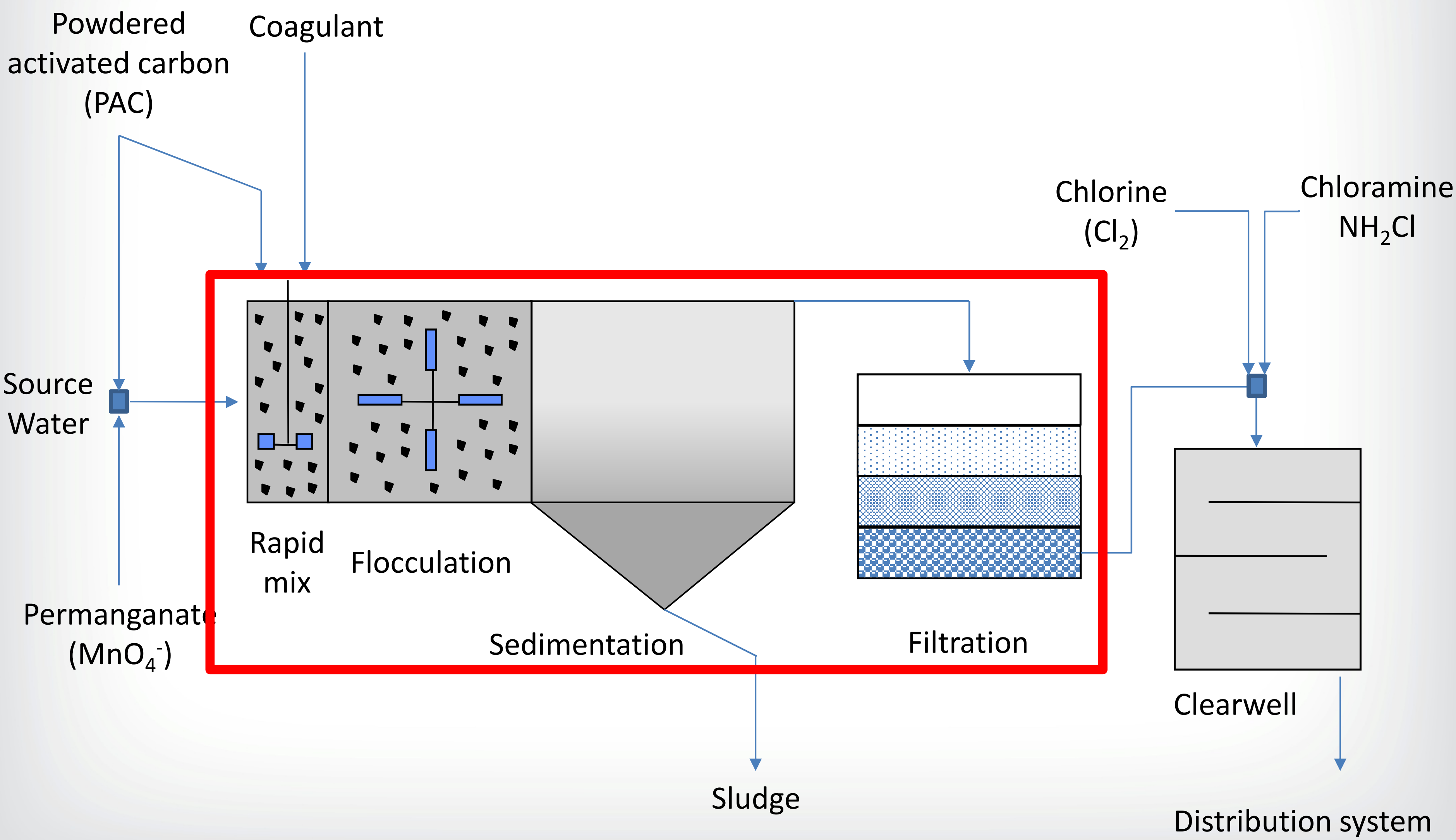
Extracellular
Toxins in solution outside the cell

Combined
Extracellular + intracellular toxin

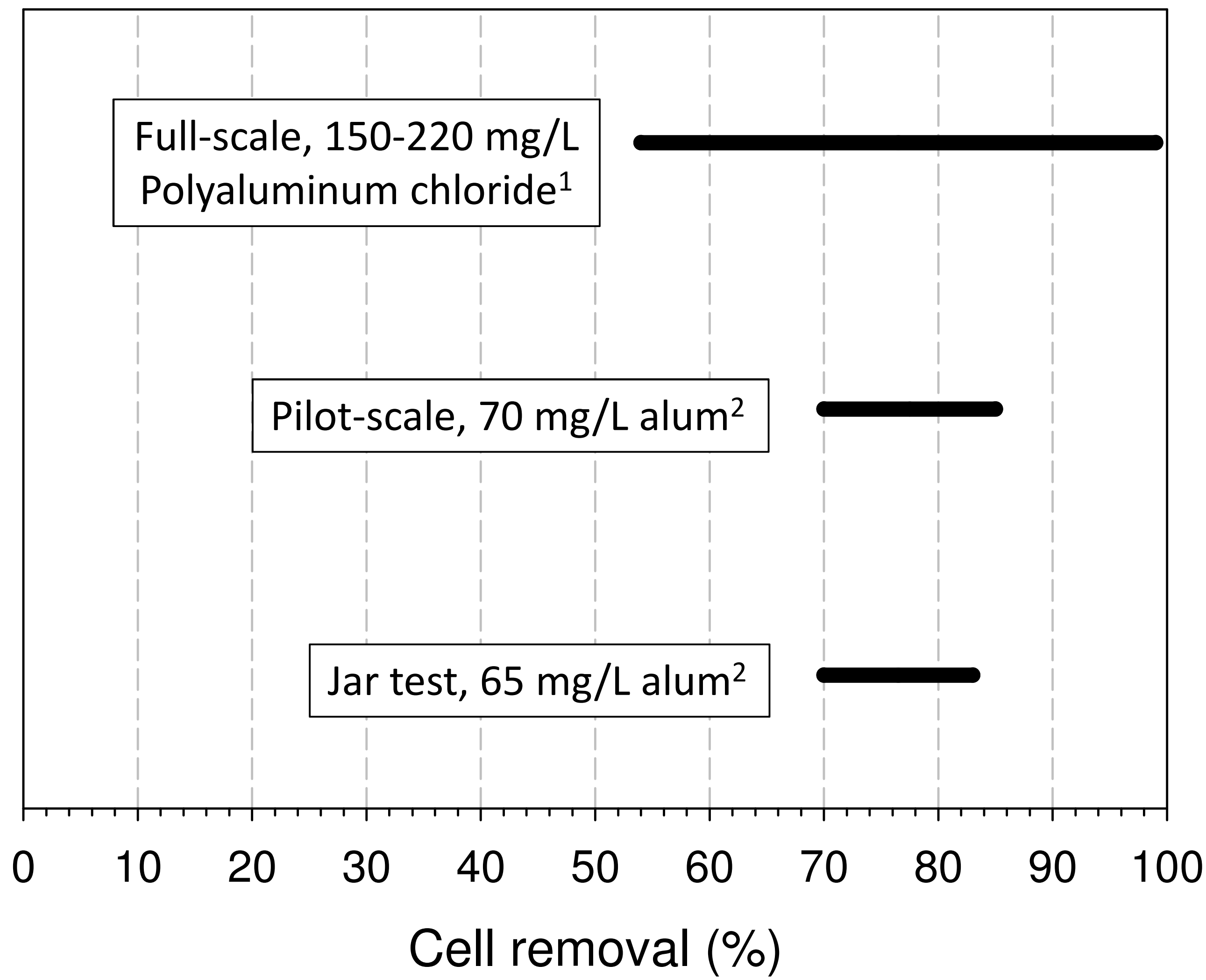


Jar testing

Conventional surface water treatment process



Cell removals through coagulation and sedimentation



[1]Zamyadi et al; *Species Dependence of Cyanobacteria Removal Efficiency by Different Drinking Water Treatment Processes*; Water Research; 2013:47:2689-2700
[2]Drikas et al; *Using Coagulation, Flocculation and Settling to Remove Toxic Cyanobacteria*; Journal AWWA; 2001:93:2:100-111

Toxin removals through pilot-scale coagulation, sedimentation and filtration

Sample point	Toxin type	Microcystin-LR concentration (µg/L) Trial 1	Trial 2
Influent	Combined	119	60
	Extracellular	3	2
Effluent	Combined	3	2
	Extracellular	3	2

Source: Drikas et al; *Using Coagulation, Flocculation and Settling to Remove Toxic Cyanobacteria*; Journal AWWA; 2001:93:2:100-111

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Source: Drikas et al; *Using Coagulation, Flocculation and Settling to Remove Toxic Cyanobacteria*; Journal AWWA; 2001:93:2:100-111

EPA

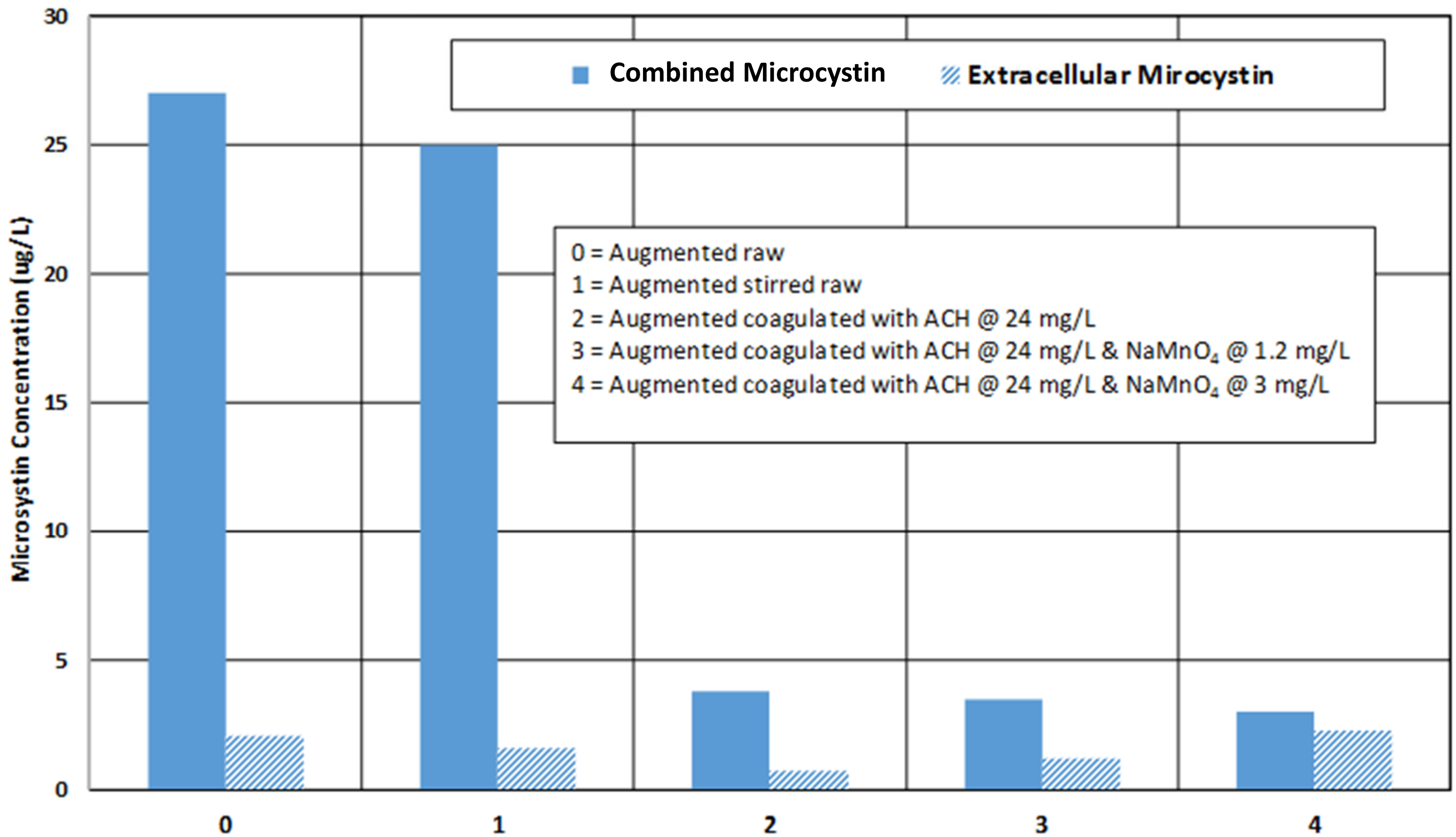
Bench-scale coagulation experiments with *M. aeruginosa*

Water source/pH	Dose necessary to achieve 80% removal of cells (mg/L)		
	Aluminum chlorohydrate	Ferric chloride	Aluminum sulfate
Myponga Reservoir			
pH 7.5 – 7.8	40	40	60
pH 6.3	20	40	60
River Murray			
pH 7.2 – 7.6	20	40	80
pH 6.3	20	20	60

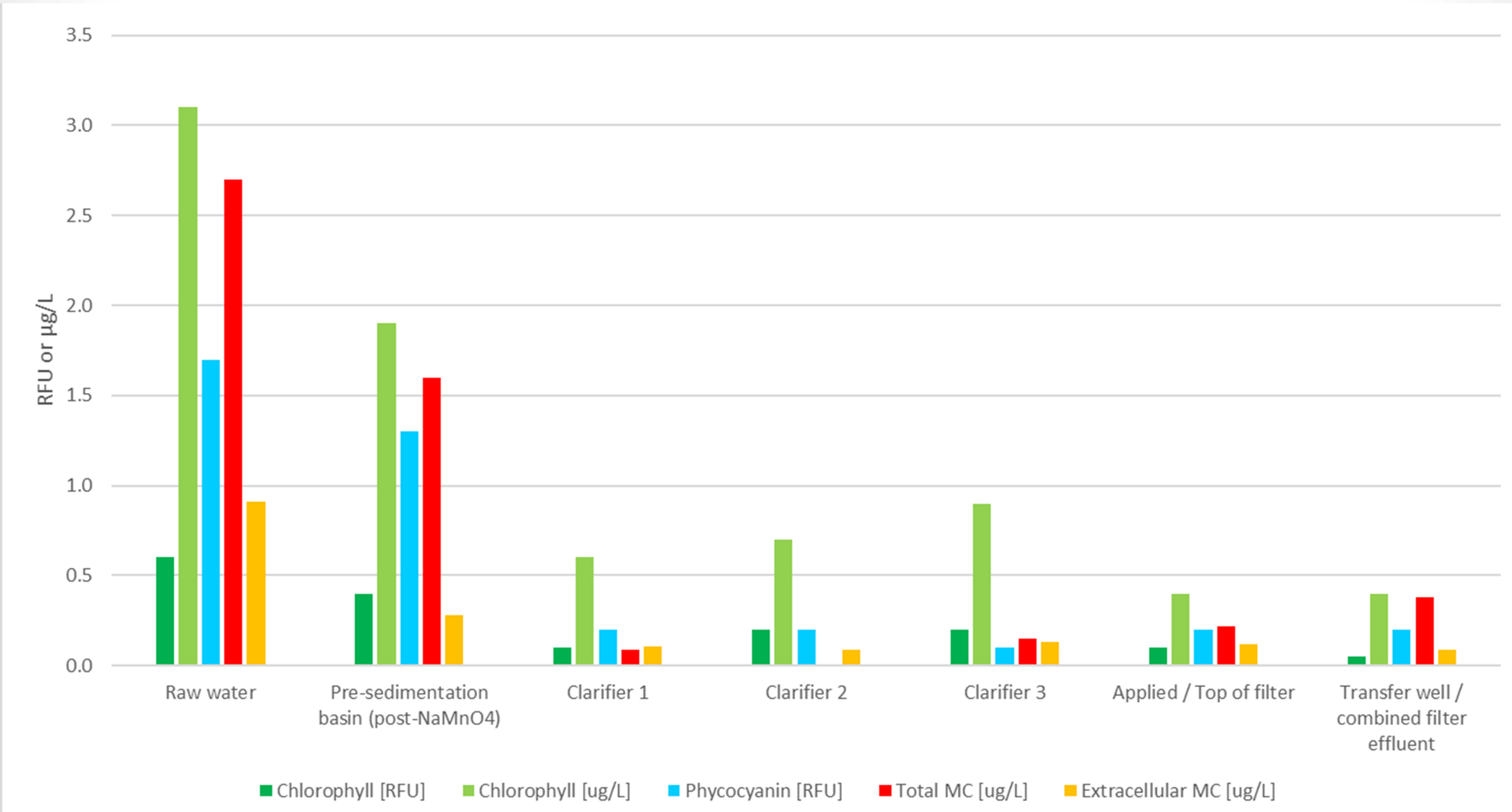
Myponga turbidity = 1.2 – 8.7 NTU, DOC = 10 – 12 mg/L
Murray turbidity = 23 – 101 NTU, DOC = 5.3 - 17

Source: Newcombe, G. et al; *Optimizing Conventional Treatment for the Removal of Cyanobacteria and Toxins*; Water Research Foundation, Denver CO; 2015

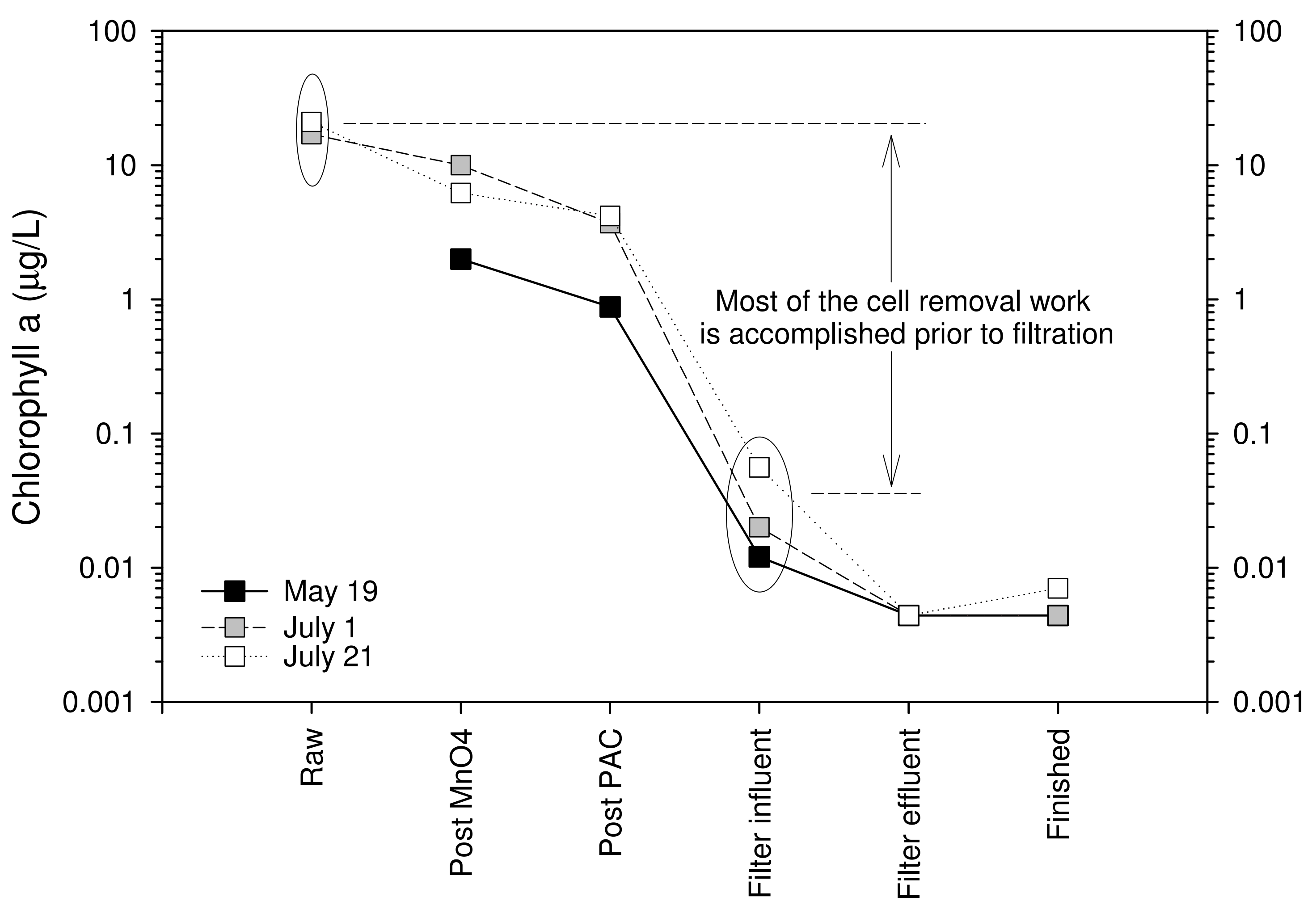
Bench-scale coagulation experiments with Lake Erie water and cyanobacteria



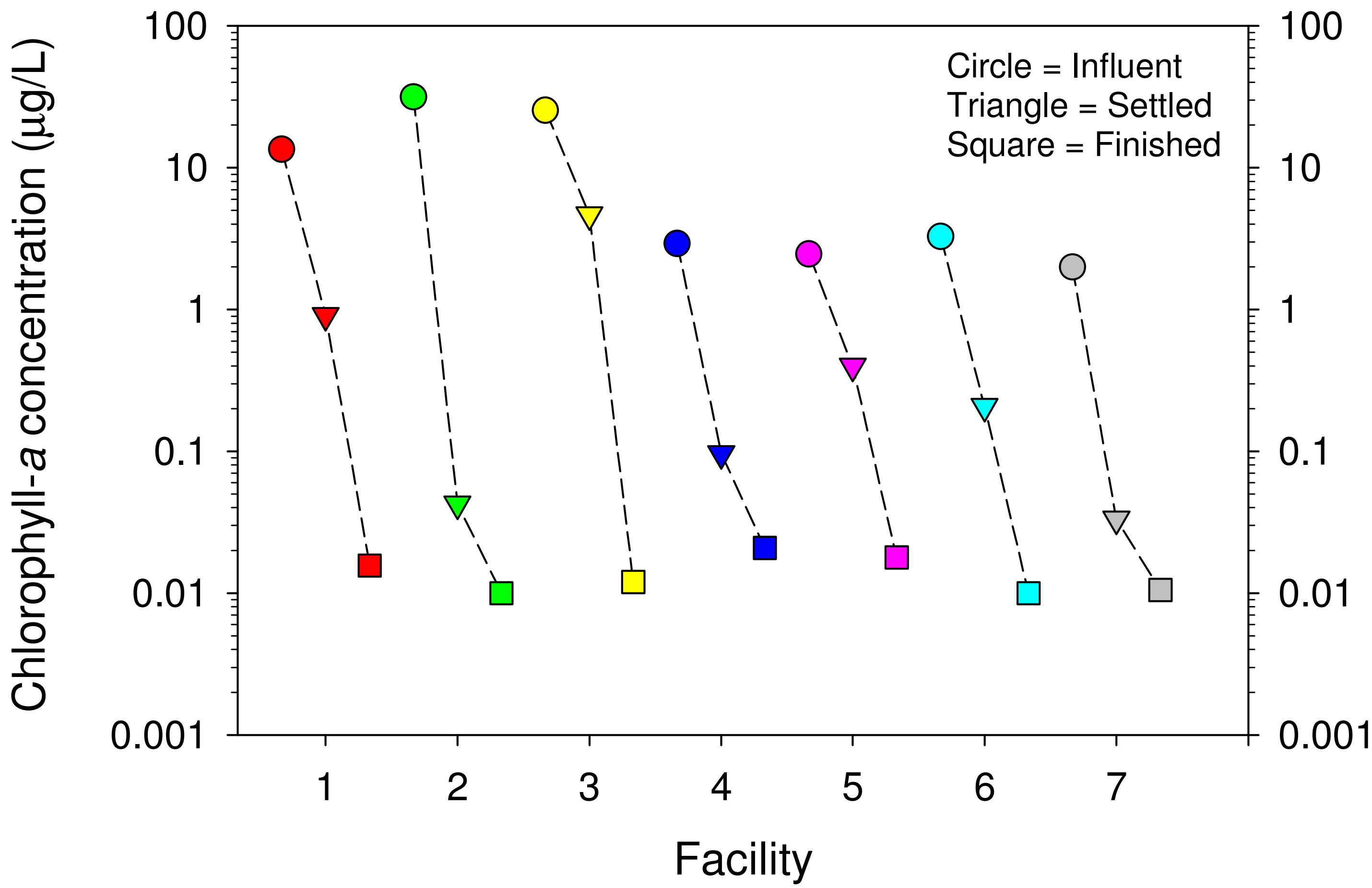
Through-plant sampling – Lake Erie water treatment plant



Cell propagation through a full-scale Lake Erie treatment facility



Physical removal of cells through seven full-scale Lake Erie facilities



Each data point represents the average of 5 – 7 samples collected between May and October

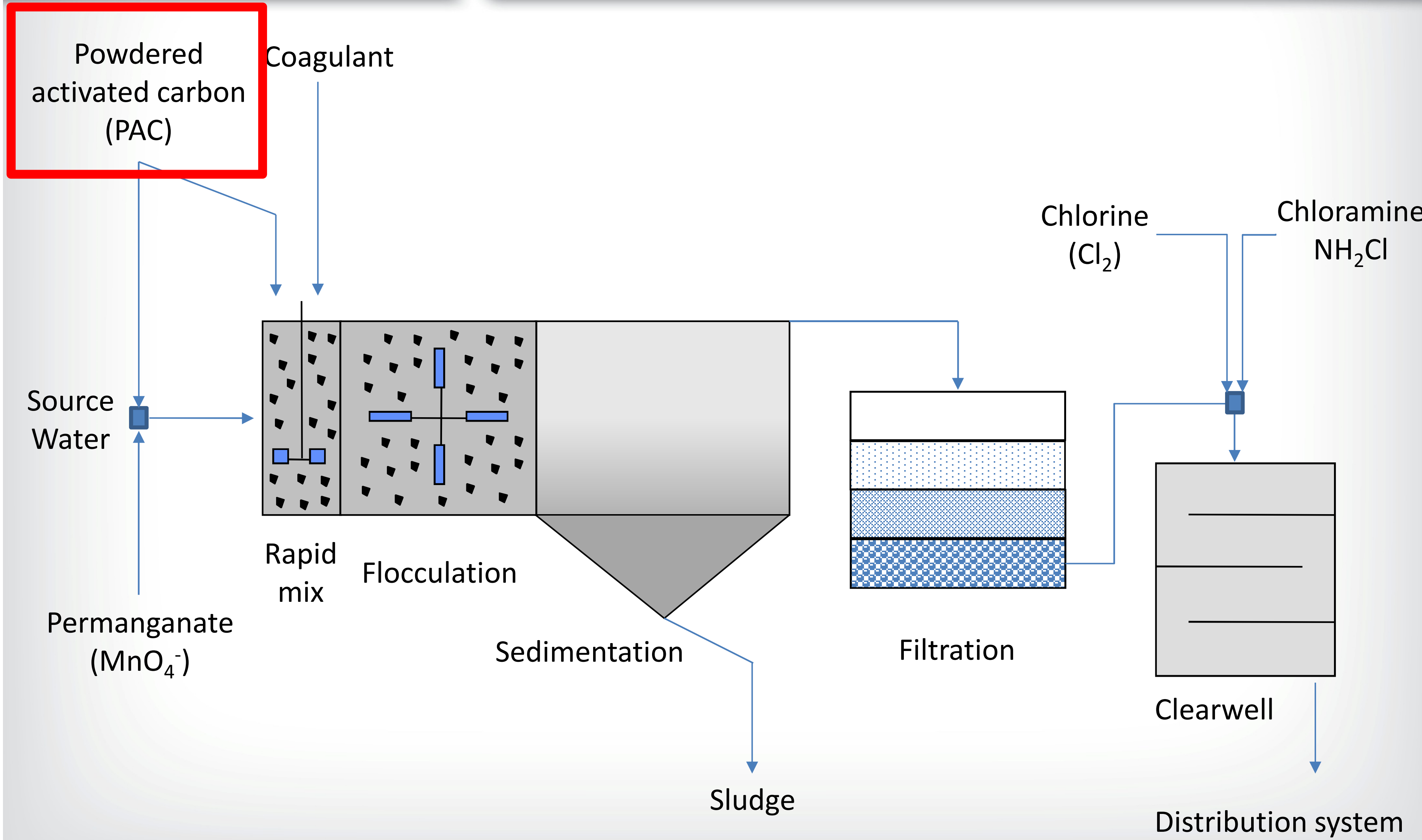
West → 150 miles → East

Filtration of *M. aeruginosa*
Pilot-scale seeding trial results

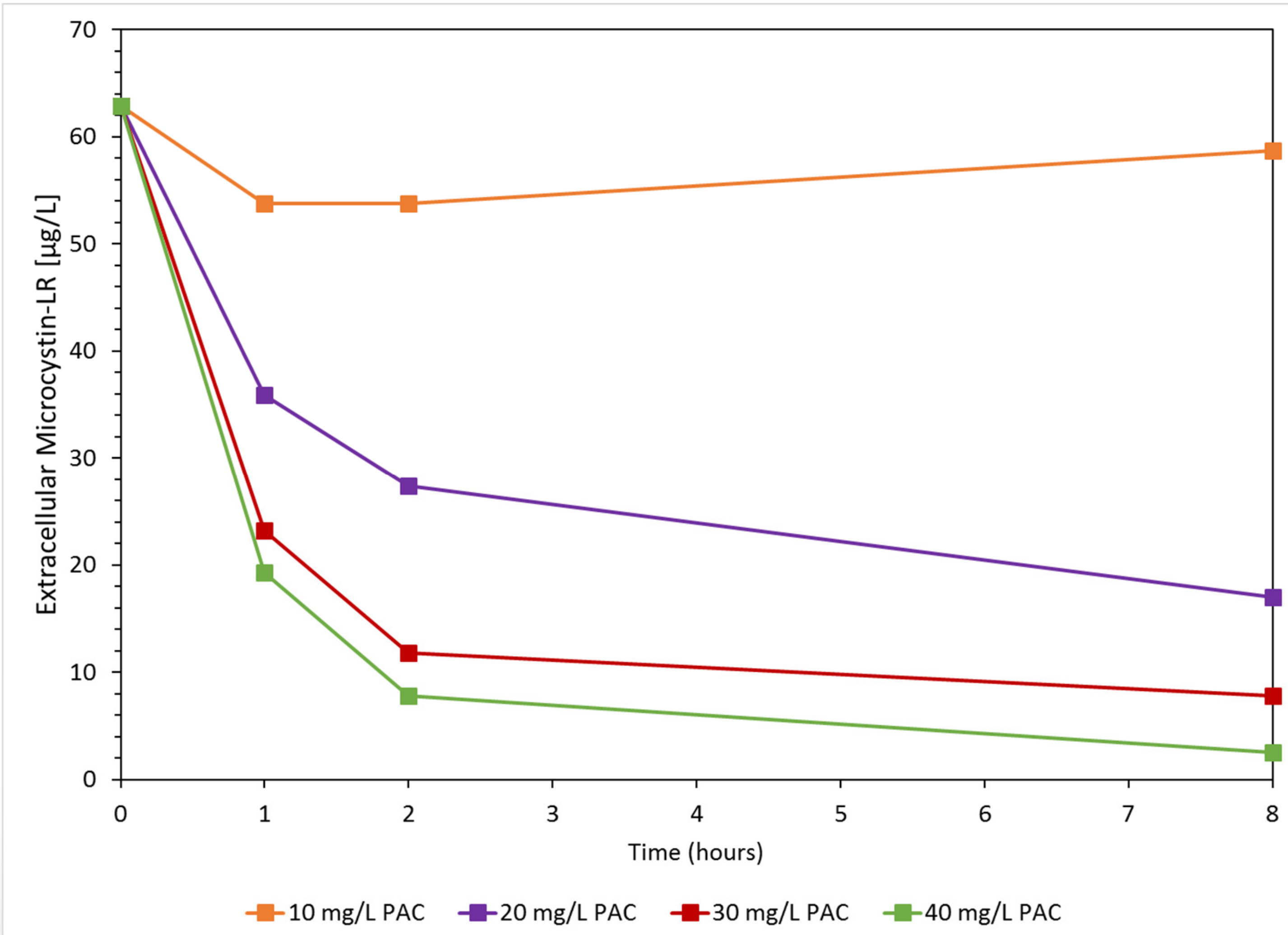
Coagulant	Baseline filter loading rate (m/hr)	Steady-state removal of chlorophyll-*a* (Δ log)
Alum + cationic polymer	7	2.8
	10	2.5
Ferric chloride + cationic polymer	7	2.9
	10	3.8

- Average influent chlorophyll-*a* concentration = 26 µg/L (SD = 12 µg/L)
- 1 m/hr = 0.41 gal/min•ft^2

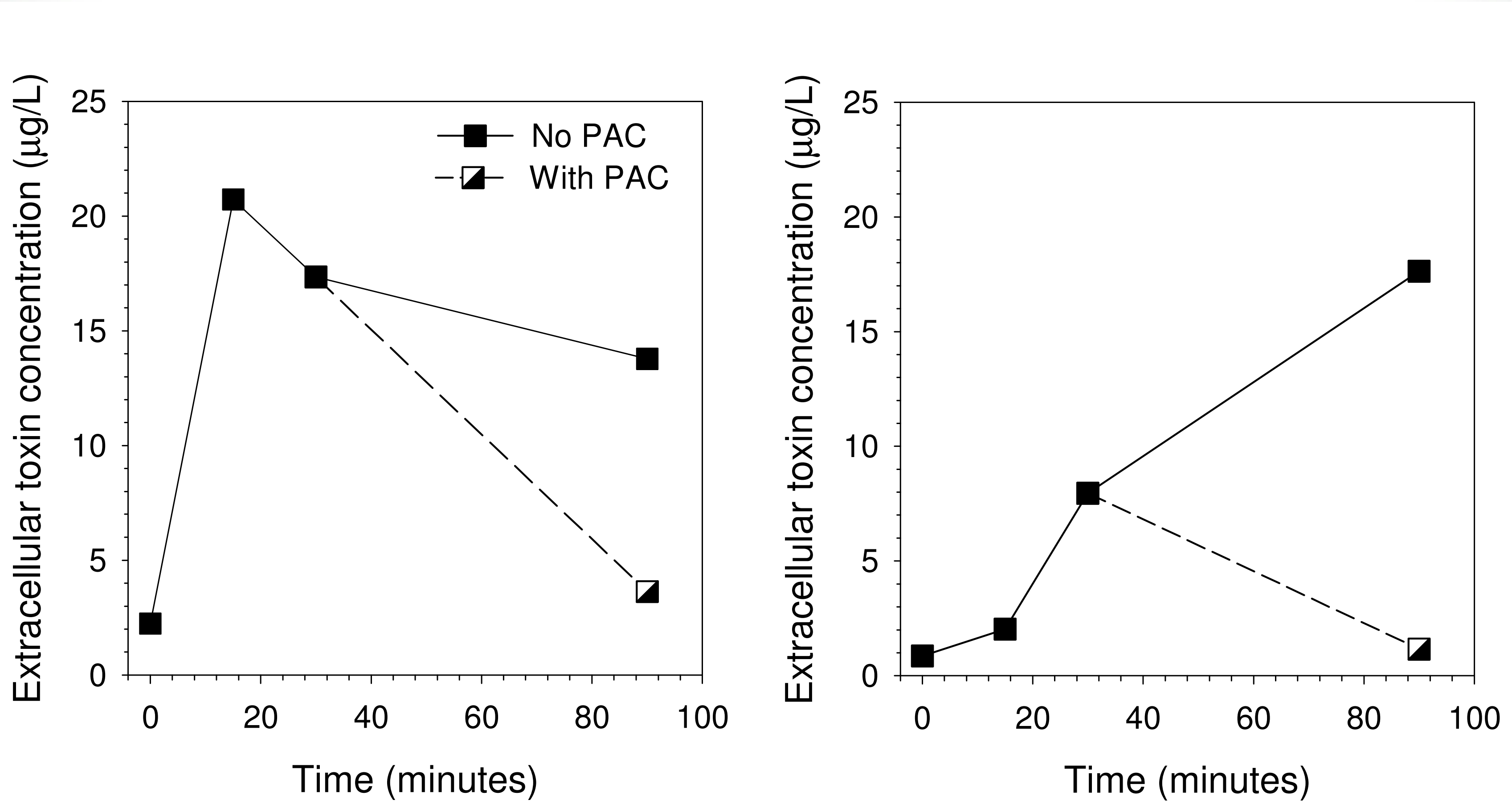
Conventional surface water treatment process



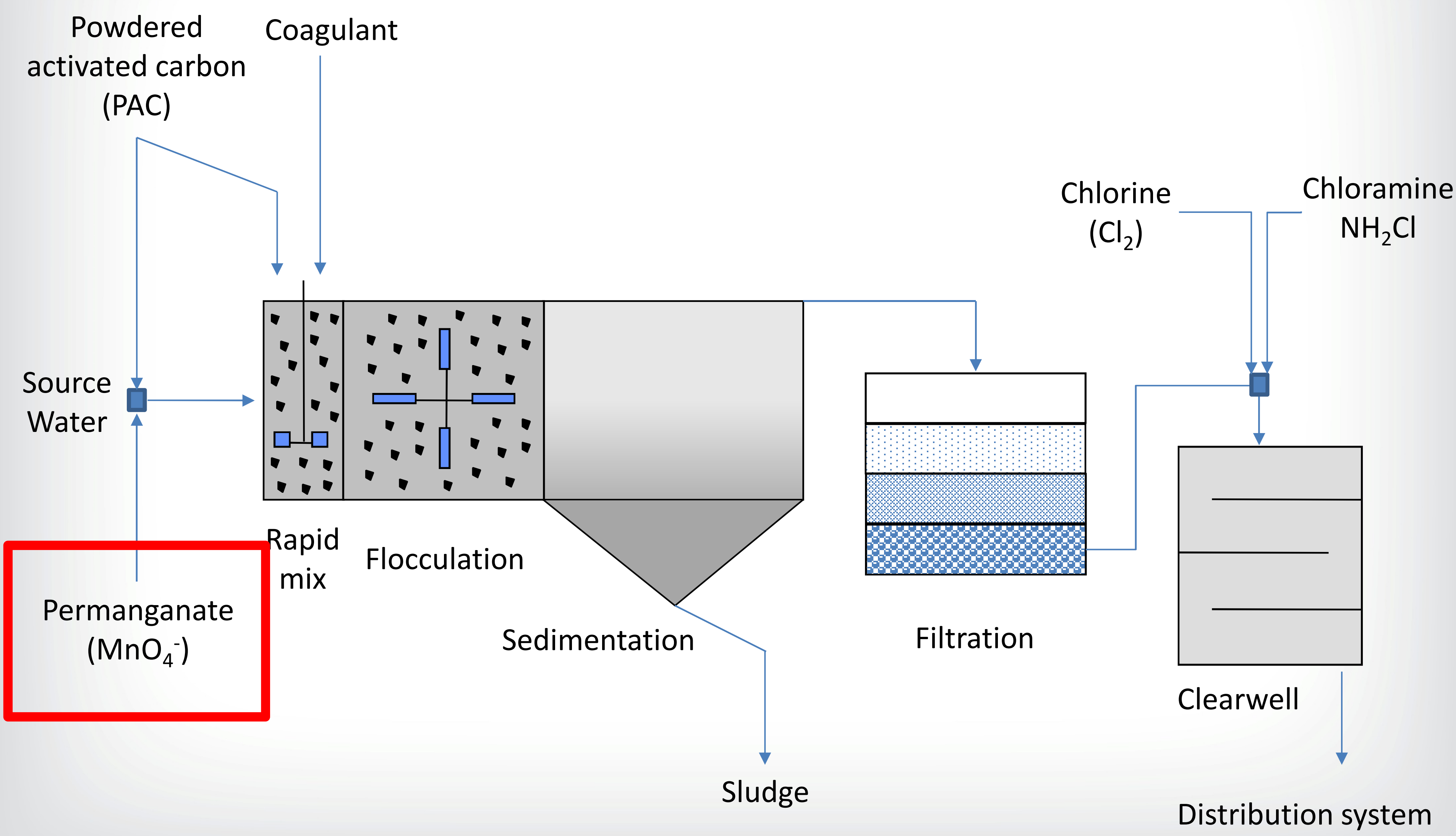
Impact of powdered activated carbon (PAC) addition – microcystin spiked into raw surface water



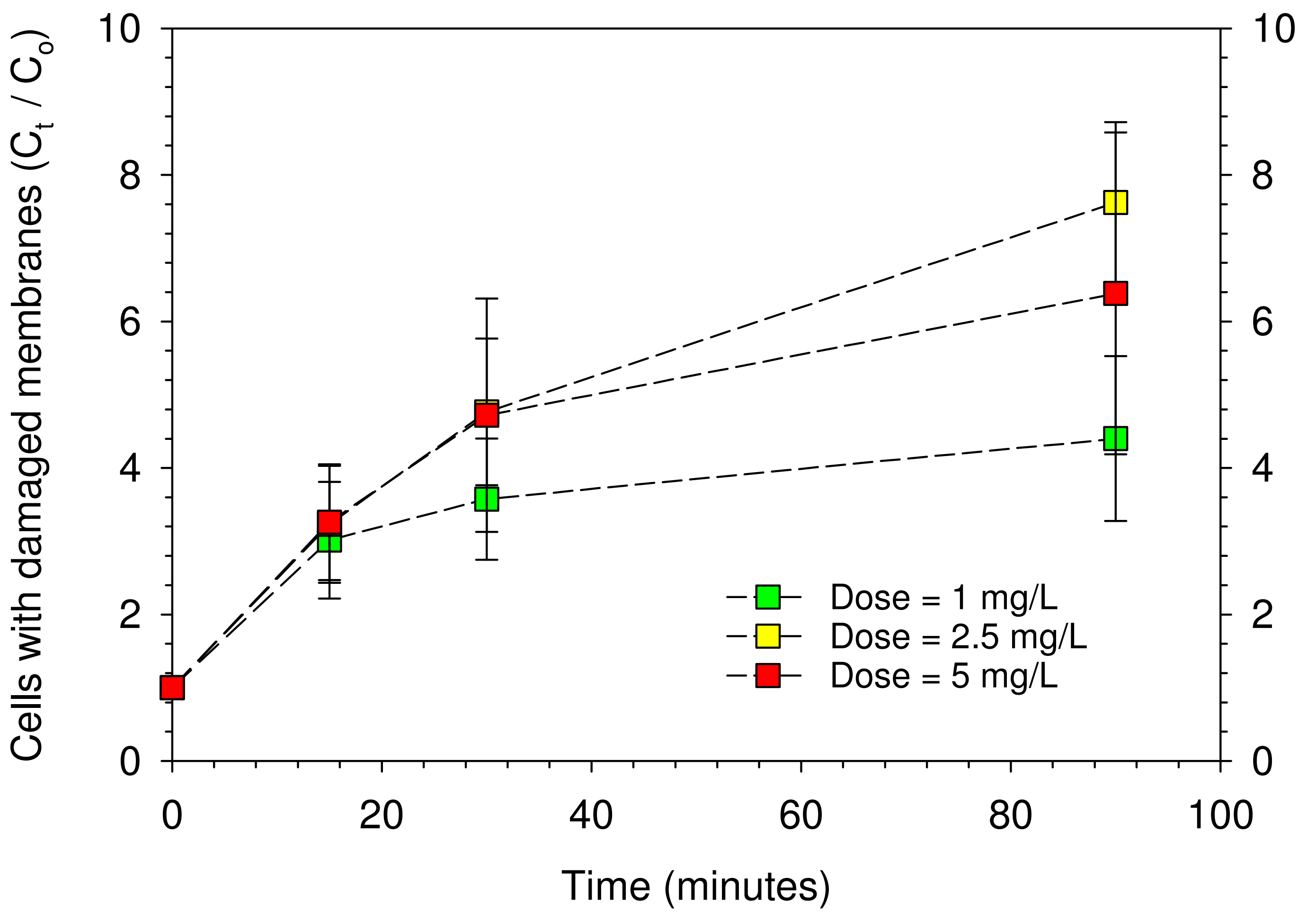
Impact of powdered activated carbon (PAC) addition – carbon added after toxin release from cyanobacterial cells



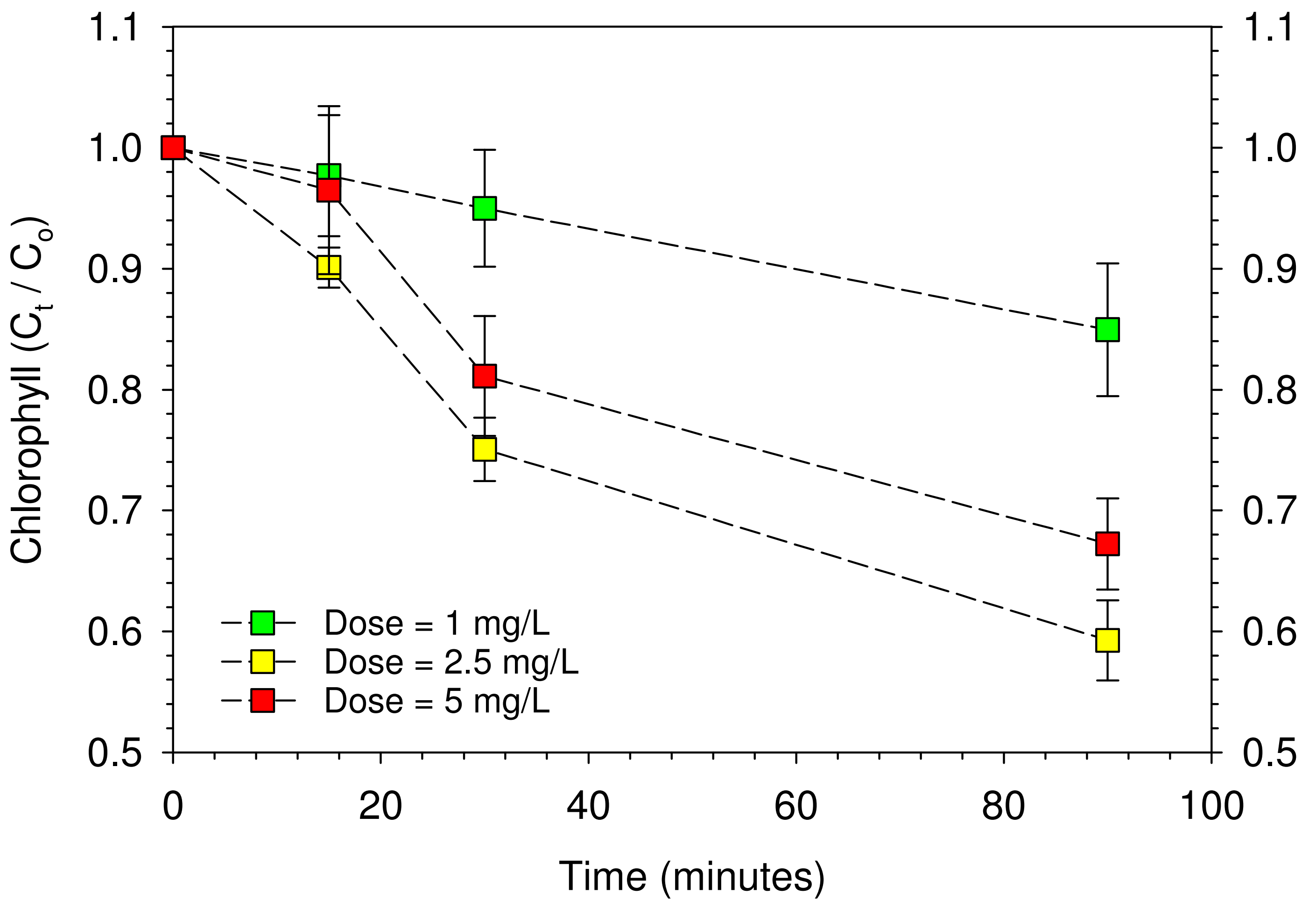
Conventional surface water treatment process



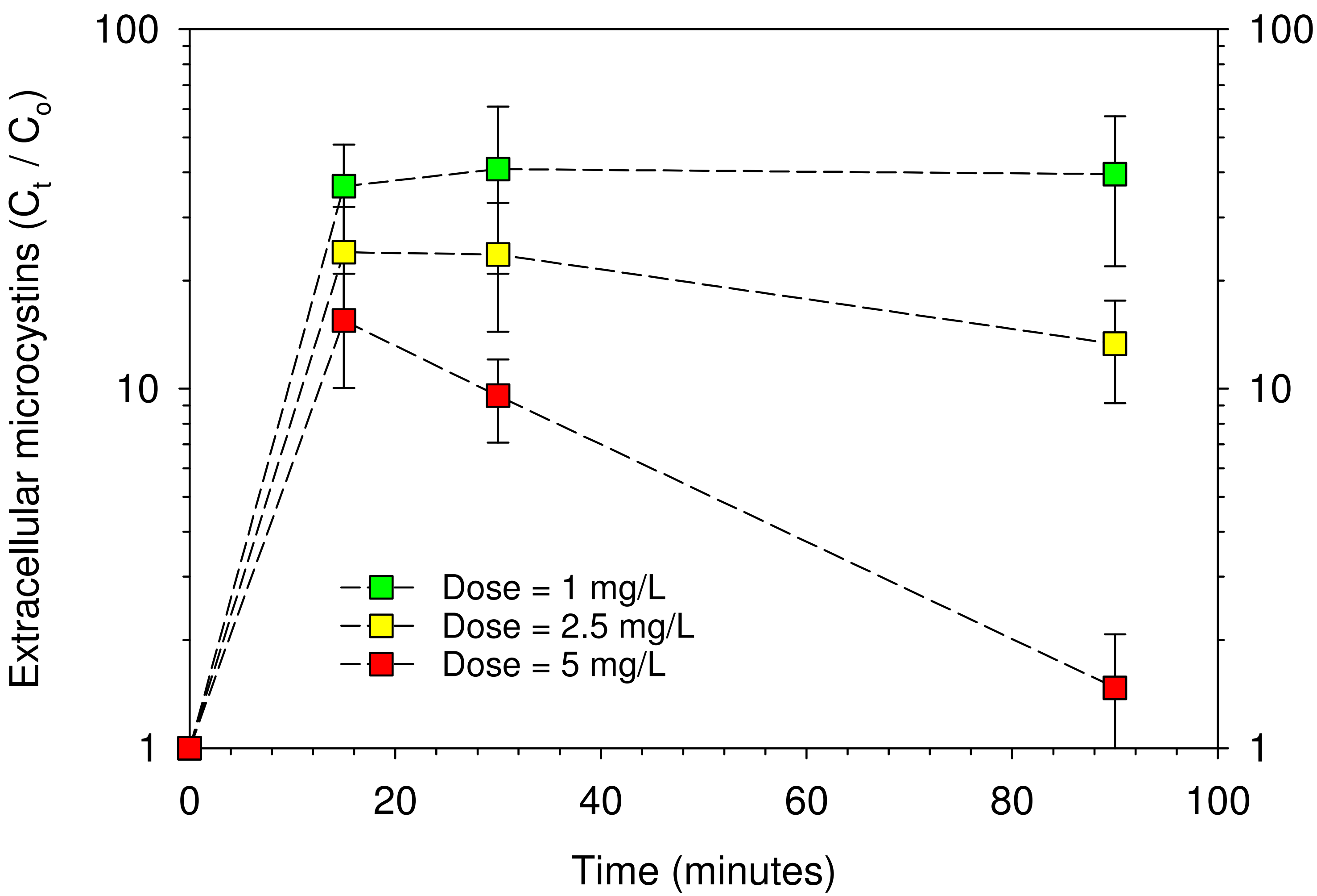
Impact of $KMnO_4$ on cyanobacterial cell membrane integrity



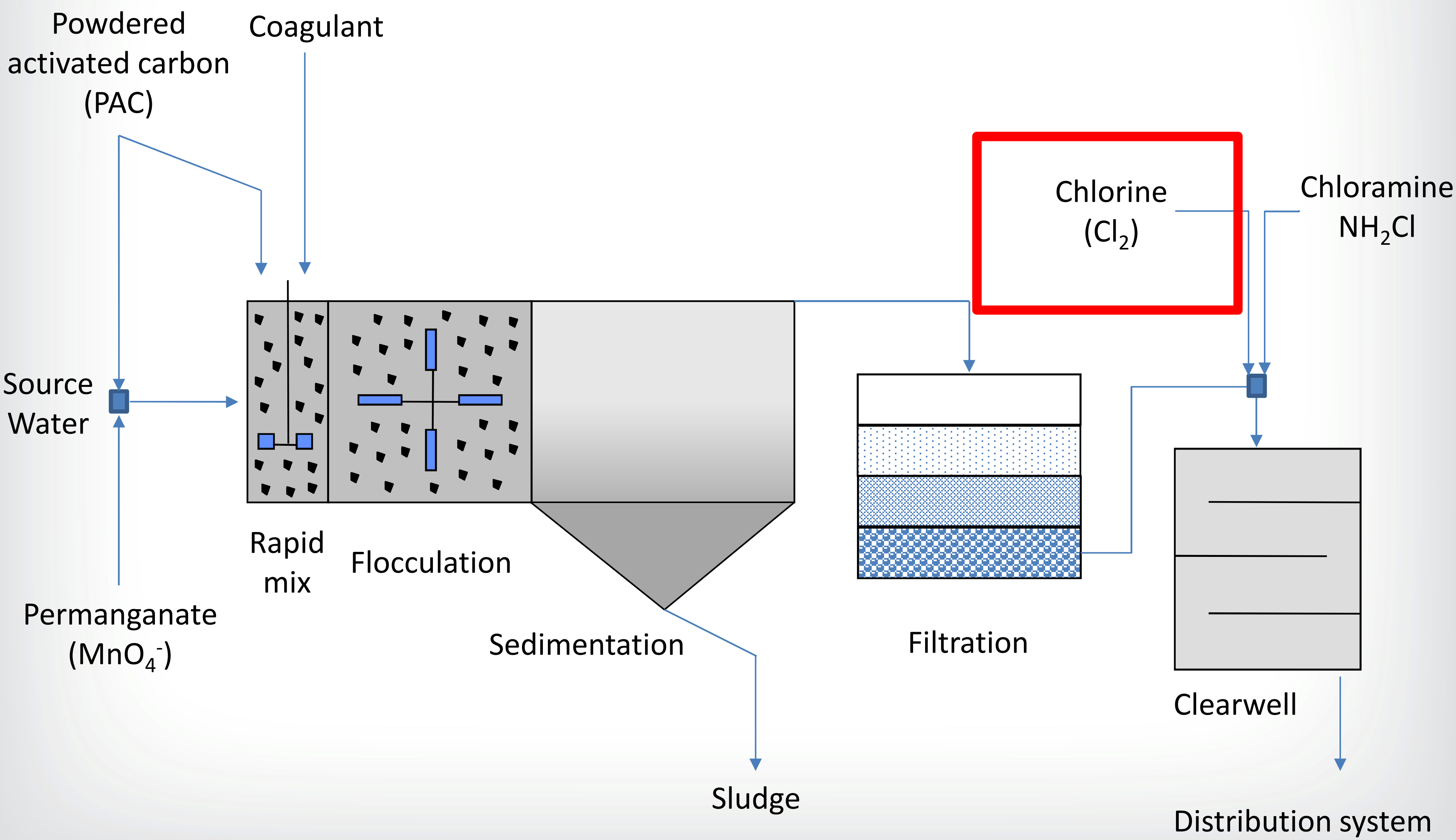
Impact of $KMnO_4$ on chlorophyll in cyanobacterial cells



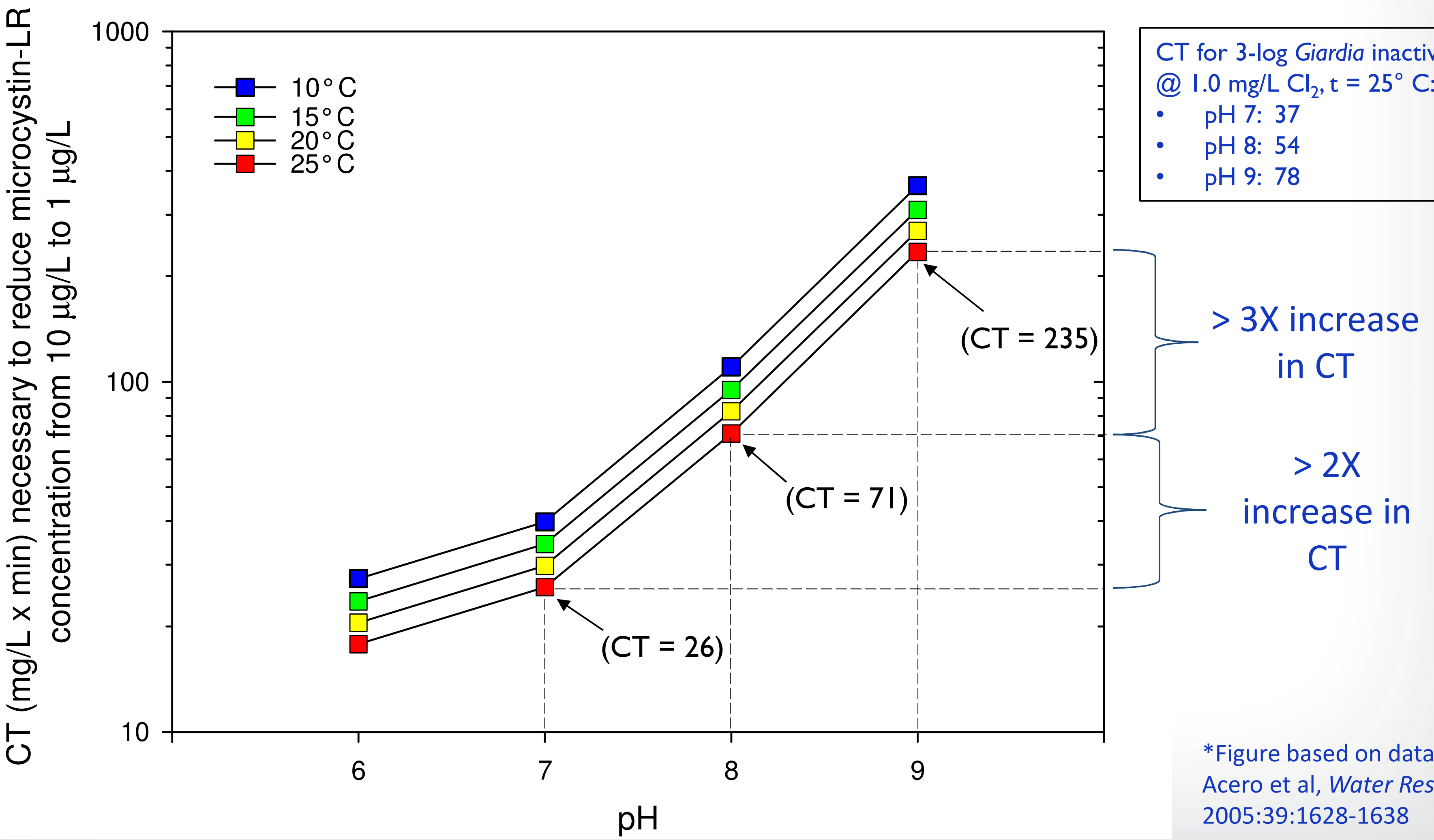
Impact of $KMnO_4$ on toxin release from cyanobacterial cells and subsequent degradation



Conventional surface water treatment process



Impact of chlorination on microcystin concentrations



CT for 3-log *Giardia* inactivation @ 1.0 mg/L Cl_2, t = 25° C:

- pH 7: 37
- pH 8: 54
- pH 9: 78

*Figure based on data from Acero et al, *Water Research*, 2005:39:1628-1638

UV irradiation

- UV contactors installed toward the end of the treatment process – cells and intracellular toxins have been removed, only extracellular toxin remaining
- Required UV doses for 2-log disinfection of *Cryptosporidium* = 5.8 mJ/cm^2, *Giardia* = 5.2 mJ/cm^2, virus = 100 mJ/cm^2
- These doses drive full-scale UV contactor design
- UV doses required for microcystin degradation are significantly higher – existing UV infrastructure not a barrier to toxin passage

Ozone and chlorine dioxide

- Chlorine dioxide, at the doses used in drinking water treatment (to limit the formation of chlorite) is not considered effective against microcystins – reaction rate is approximately 3 orders of magnitude lower than permanganate
- Ozone has been proven effective at degrading microcystins as well as cylindrospermopsins and anatoxin – reaction rate is sufficient to achieve degradation within the confines of ozone contactors used in full-scale drinking water treatment

Conclusions

- Core conventional treatment processes – coagulation, flocculation, sedimentation, filtration - are highly effective at removing cyanobacterial cells – shown to work across a range of coagulants
- PAC effectively adsorbs microcystins – however, the exact carbon dose will vary depending on the type of carbon and the concentration of background of organic material

Conclusions

- Chlorine effectively degrades microcystins – but the rate of degradation is temperature and pH dependent
- Ozone effectively degrades microcystins
- Chlorine dioxide and UV, at the dose levels commonly employed in drinking water treatment, are not effective
- Permanganate effectively degrades dissolved microcystins – however, the typical location for permanganate addition, early in the treatment process where cyanobacterial cell concentrations are still high, sets up a potential for toxin release – vigilance is recommended

Disclaimer

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