



# *Harmful algal blooms and how they are impacting recreation and drinking water*

January 11, 2015

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**COLORADO**  
Parks and Wildlife  
Department of Natural Resources



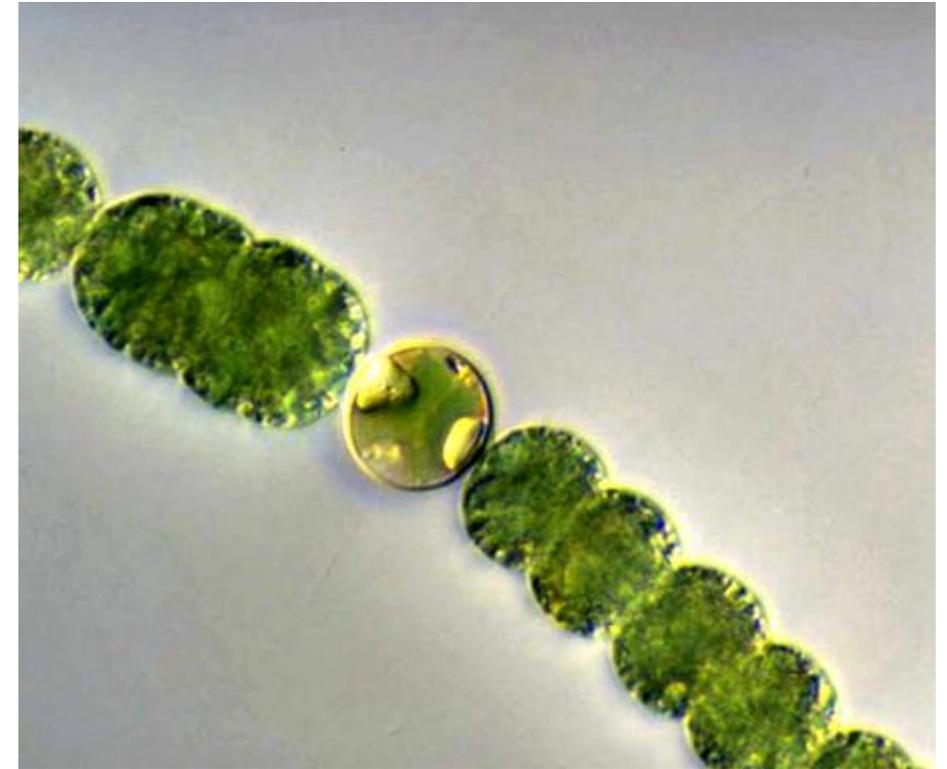
**COLORADO**  
Department of Public  
Health & Environment

# *Cyanobacteria and Cyanotoxins*



# *Cyanobacteria (Blue-Green Algae)*

- Some species capable of producing toxins
- Optimal growth rate at relatively high water temperatures
- Heterocysts - fix atmospheric nitrogen
- Aerotopes - gas vacuoles regulate buoyancy in the water column



# *Cyanotoxins*

Toxins are very potent

- Ricin
- Cobra venom
- Sarin
- Strychnine



# Cyanotoxins

Types of algal toxins	Type of toxin	Exposure Routes when Recreating
Microcystin	Liver toxin	Ingestion
Anatoxin-a	Neurotoxin	Ingestion, inhalation, skin contact
Cylindrospermopsin	Kidney & Liver toxin	Ingestion
Saxitoxin	Neurotoxin	Ingestion

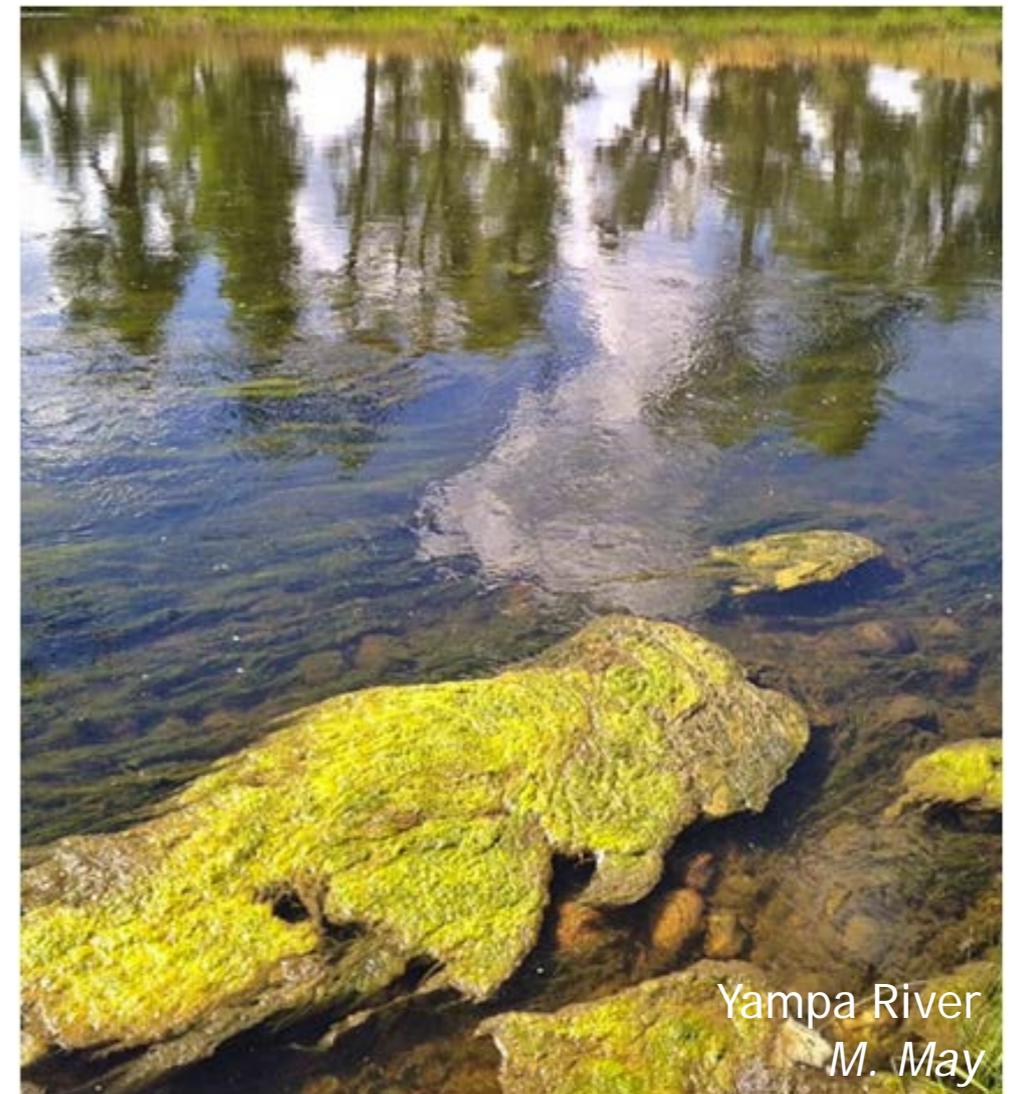
# Cyanotoxins

Cyanobacteria Taxa	Microcystin	Anatoxin	Cylindro-spermopsin	Saxitoxin
<i>Anabaena circinalis</i>	X	X		X
<i>Anabaena flos-aquae</i>	X	X		
<i>Anabaena planctonica</i>		X		
<i>Anabaena spiroides</i>		X		X
<i>Aphanizomenon flos-aquae</i>		X	X	X
<i>Cyanobium sp.</i>	X			
<i>Microcystis aeruginosa</i>	X			
<i>Planktothrix agardhii</i>	X	X		



# *Toxin Production*

- Unpredictable
- Not all species are toxic
- Toxic species have both toxic and non-toxic strains
- Toxic strains don't produce toxins all the time
- Toxins are *generally* produced in warm, stagnant, high-nutrient waters.



Yampa River  
M. May

# Signs of Toxins

- Dog fatalities
- Livestock fatalities
- Wildlife fatalities



## Update: Toxic blue-green algae in Utah Lake contributed to dog's death

POSTED 11:40 AM, OCTOBER 7, 2014, BY [ASHTON EDWARDS](#) AND [ROBERT BOYD](#), UPDATED AT 01:23PM, OCTOBER 14, 2014

INDUSTRY

## Blue-green algae poisoning threatens livestock

By [Gerald Stokka, NDSU](#) June 16, 2014 | 2:39 pm EDT

COMMENTS

f t @ g+ ✉

PRINT

### DEADLY ALGAE

## Toxic algae blamed for elk deaths in northeastern New Mexico

Print Font Size: - +

Recommend 35 Tweet 4 g+ 1 Pinit 0 Share 11

Posted: Tuesday, October 22, 2013 4:14 pm | Updated: 12:06



# *Signs of Toxins*

- Human symptoms
  - Nausea
  - Vomiting
  - Diarrhea
  - Skin or throat irritation
  - Allergic reactions
  - Difficulty breathing



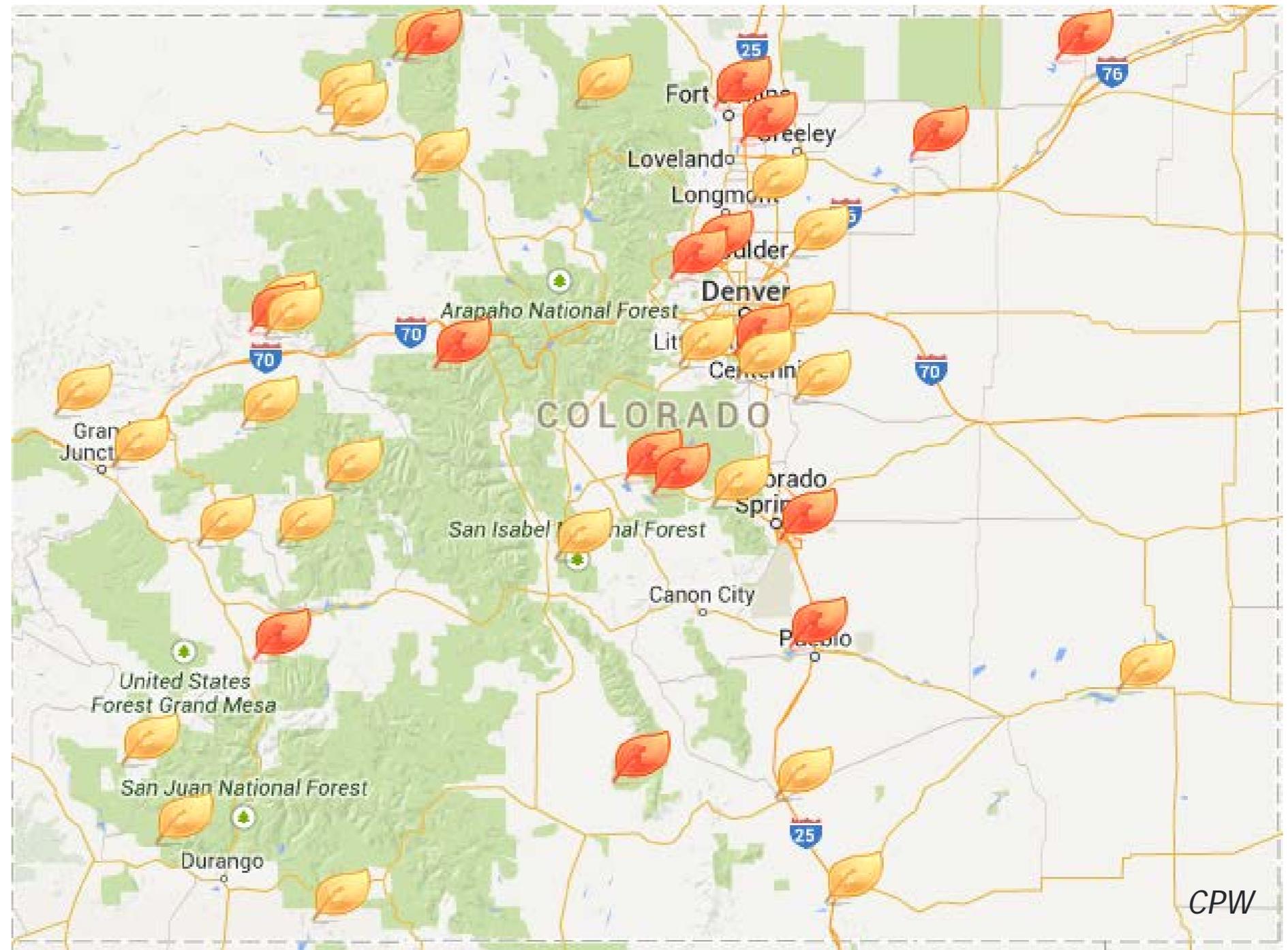
WHO: rash caused by exposure to algae *Lyngbya*

# *Algal Toxins in CPW Lakes: 2014*



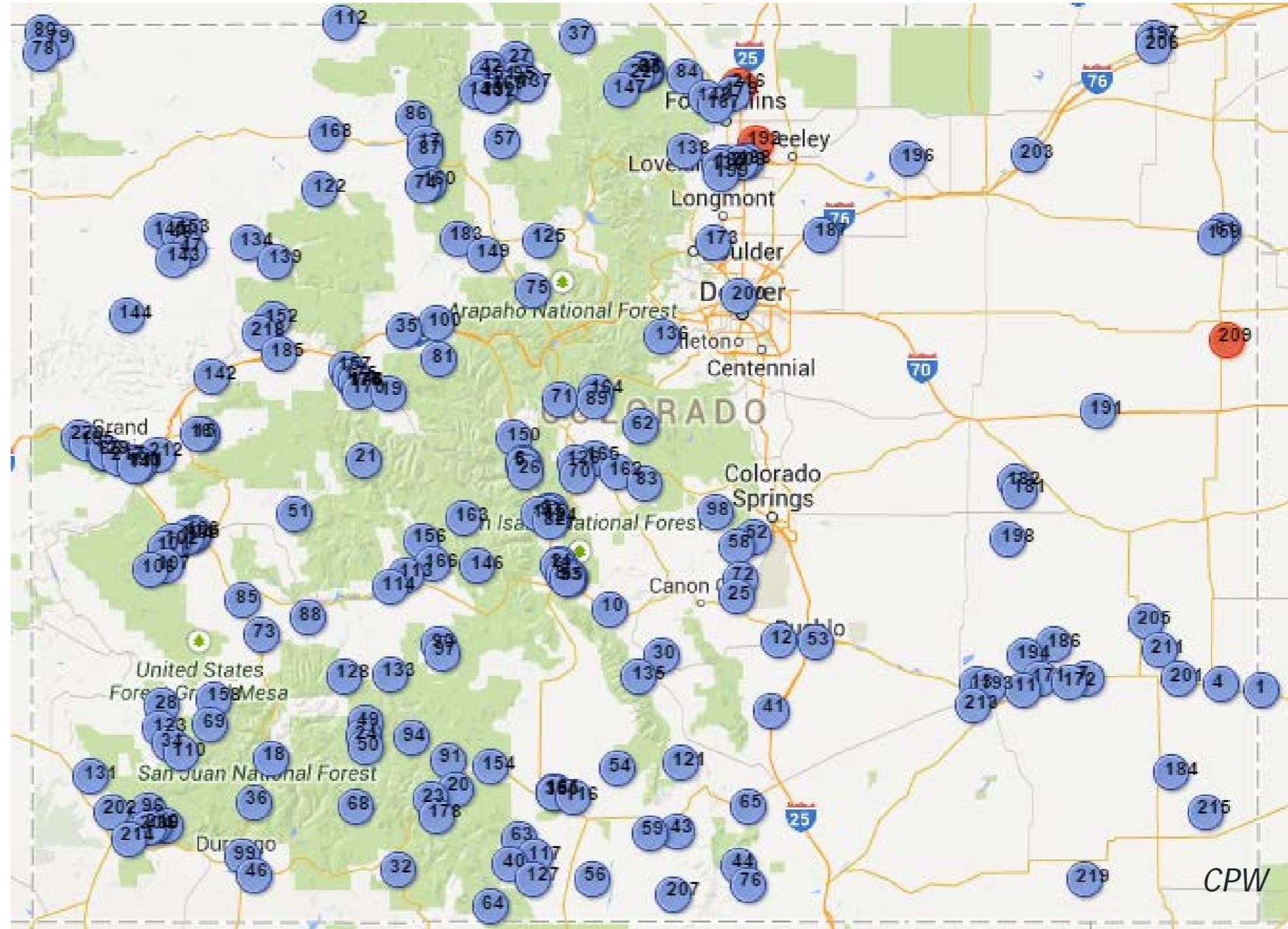
# State Parks

42 State Parks



# State Wildlife Areas

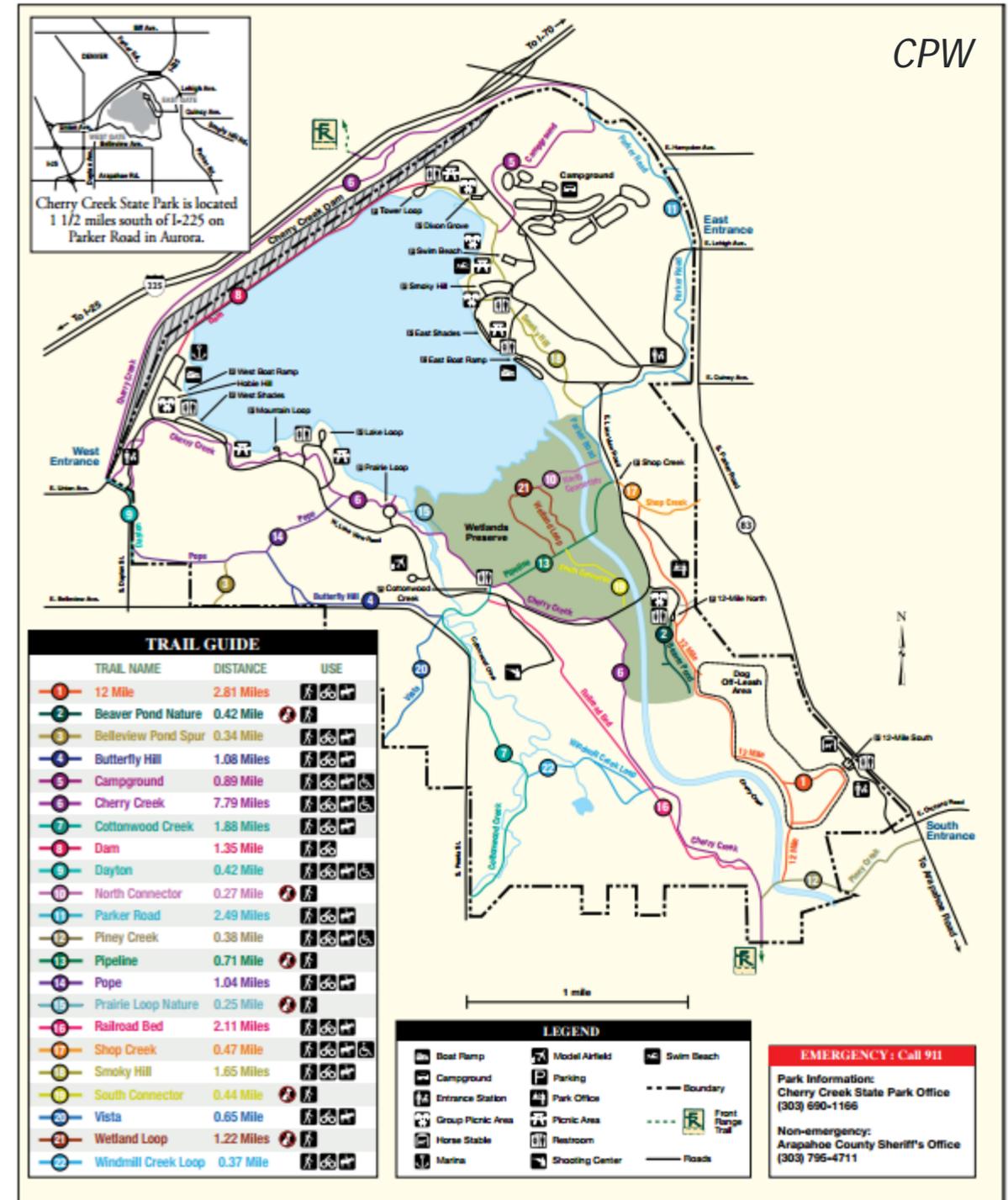
220 SWAs with  
fishing or  
boating access



# Cherry Creek Reservoir

## Most visited State Park

- Swim Beach
- Marina
  - Boating
  - Fishing
  - Water Skiing
  - Jet Skiing
- Dog Park

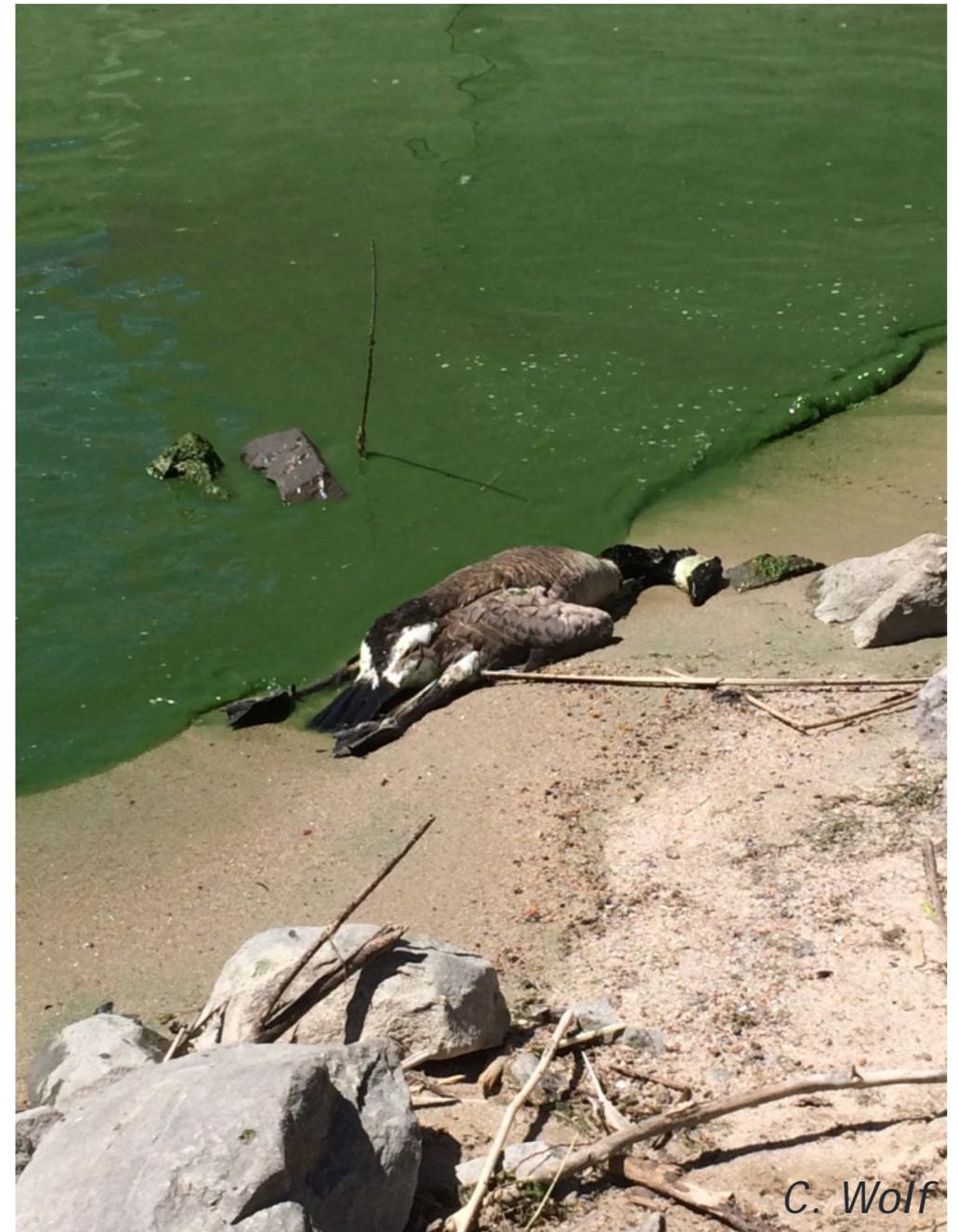


# Cherry Creek Reservoir HAB

Cherry Creek Basin Authority

June 2014

Microcystin



# *What do we do?*

- Is it safe for the public to swim?
  - Is it safe to eat fish caught from the lake?
  - Is it safe for dogs?
- 
- How should we communicate with the public?



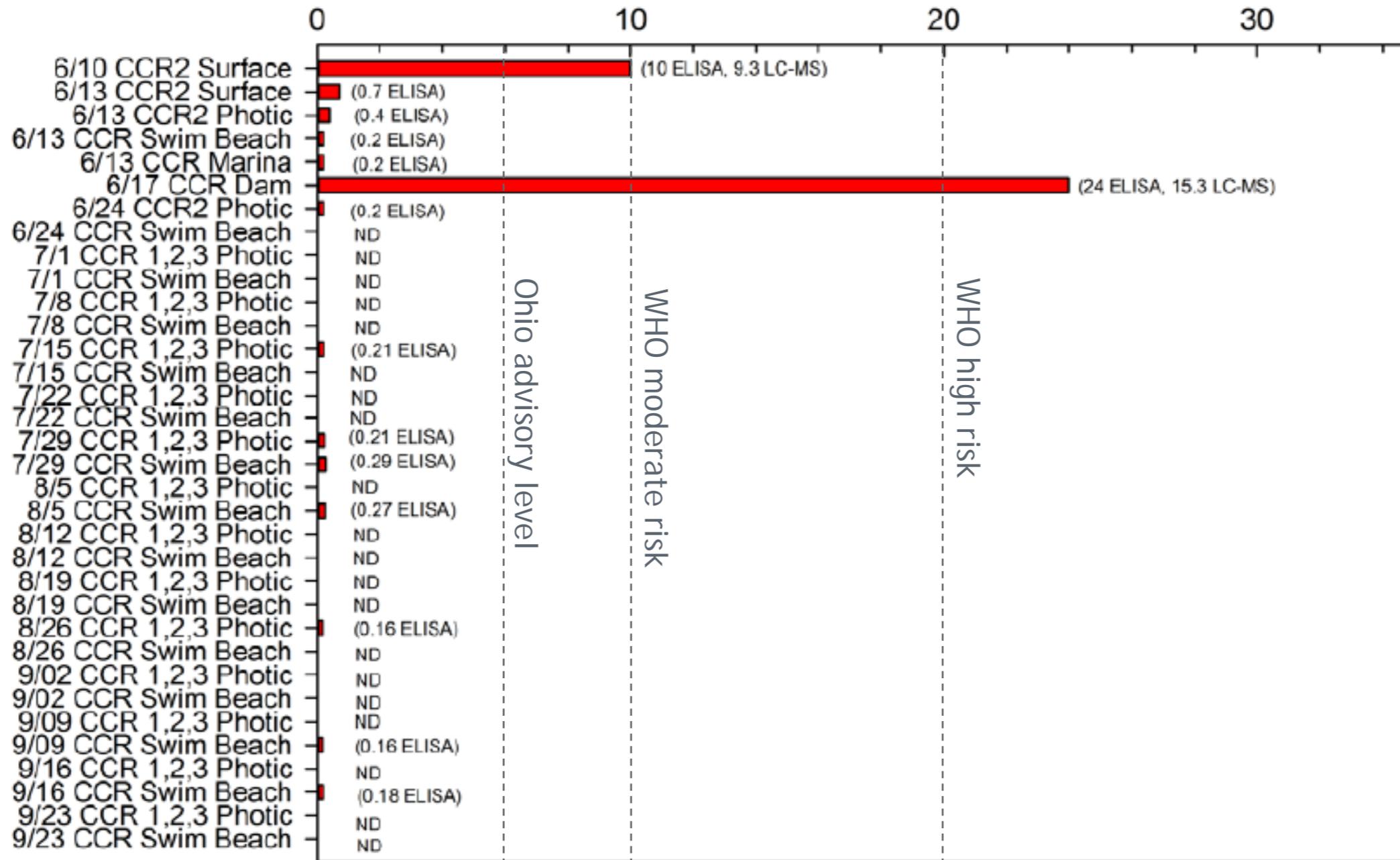
# Human Health Thresholds -Recreation

Action	Agency	Microcystin ug/L
advisory	California	0.8
reduce contact	Indiana	4
avoid contact	Kansas	4
advisory	Ohio	6
closure	Washington	6
closure	Australia	10
advisory	Oregon	10
low risk	WHO	<10
advisory	Massachusetts	14
advisory	Rhode Island	14
moderate risk	WHO	10-20
advisory	Broomfield, CO	20
caution	Iowa	20
contact restricted	Kansas	20
health alert	Nebraska	20
closure	Ohio	20
high risk	WHO	>20



# Microcystin June-Sept 2014

Microcystins ( $\mu\text{g/L}$ )



# **ADVISORY**

## **TOXIC ALGAE MAY BE PRESENT**

**Cherry Creek reservoir is experiencing a higher than normal algae bloom. This algae bloom is potentially toxic to humans and animals.**

- **Avoid contact with visible surface scums. Showers are located at the swim beach restroom facility for free, and in the campground for a small fee.**
- **Keep pets away.**
- **Clean fish well and discard guts.**

**The Cherry Creek Basin Water Quality Authority and Colorado Parks and Wildlife will continue to monitor the water quality of Cherry Creek reservoir. If the algae conditions worsen additional precautions will be posted.**

**For additional information please visit [cpw.state.co.us](http://cpw.state.co.us) or [www.cherrycreekbasin.org](http://www.cherrycreekbasin.org)**



# DeWeese Reservoir

State Wildlife Area

Popular fishing destination

- Boat Ramp
- Camp Grounds

Other access

- Vacation homes SW shoreline



# *DeWeese Reservoir HAB*

EPA tested

July 2014

Microcystin ~3 ug/l



# *DeWeese Reservoir HAB*

- CPW took no action
- Microcystin level was below all known recreational thresholds



# *Stagecoach Reservoir*

- Drinking water system (seasonal)
- Swim Beach
- Marina
  - Boating
  - Fishing
  - Water Skiing
  - Jet Skiing

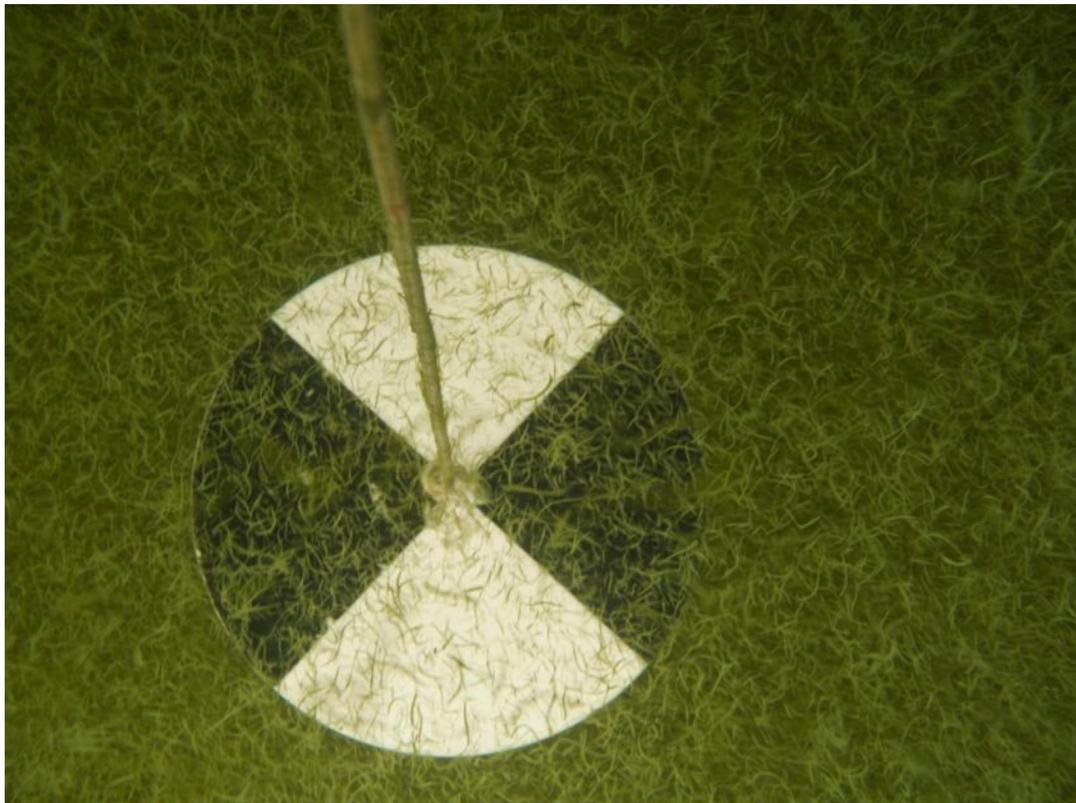


# *Stagecoach Reservoir HAB*

CPW tested September 2014

Microcystin 1.21 ug/L

Cylindrospermopsin 0.22 ug/L



# *Stagecoach Reservoir HAB*

- CPW took no action
- Toxin level was below all known recreational thresholds
- Water system was shut down for the season



# *Algal Toxins in CPW Lakes: 2015*



# *Cherry Creek Reservoir*

May 27, 2015

Widespread bloom reported and tested at 3 locations

- Swim beach
- open water
- marina

No toxins at any site

Microcystin < 0.15 ug/L

Anatoxin < 0.05 ug/L

Cyclindrospermopsin < 0.10 ug/L

Saxitoxin < 0.05 ug/L



# Cherry Creek Reservoir

May 28, 2015



June 1, 2015



# *Barr Lake*

July 28, 2015

Algae accumulation  
near boat ramp

Microcystin= 82 ug/L

Anatoxin<0.05

Cyclindrospermopsin<0.05

Saxitoxin<0.05

No widespread bloom



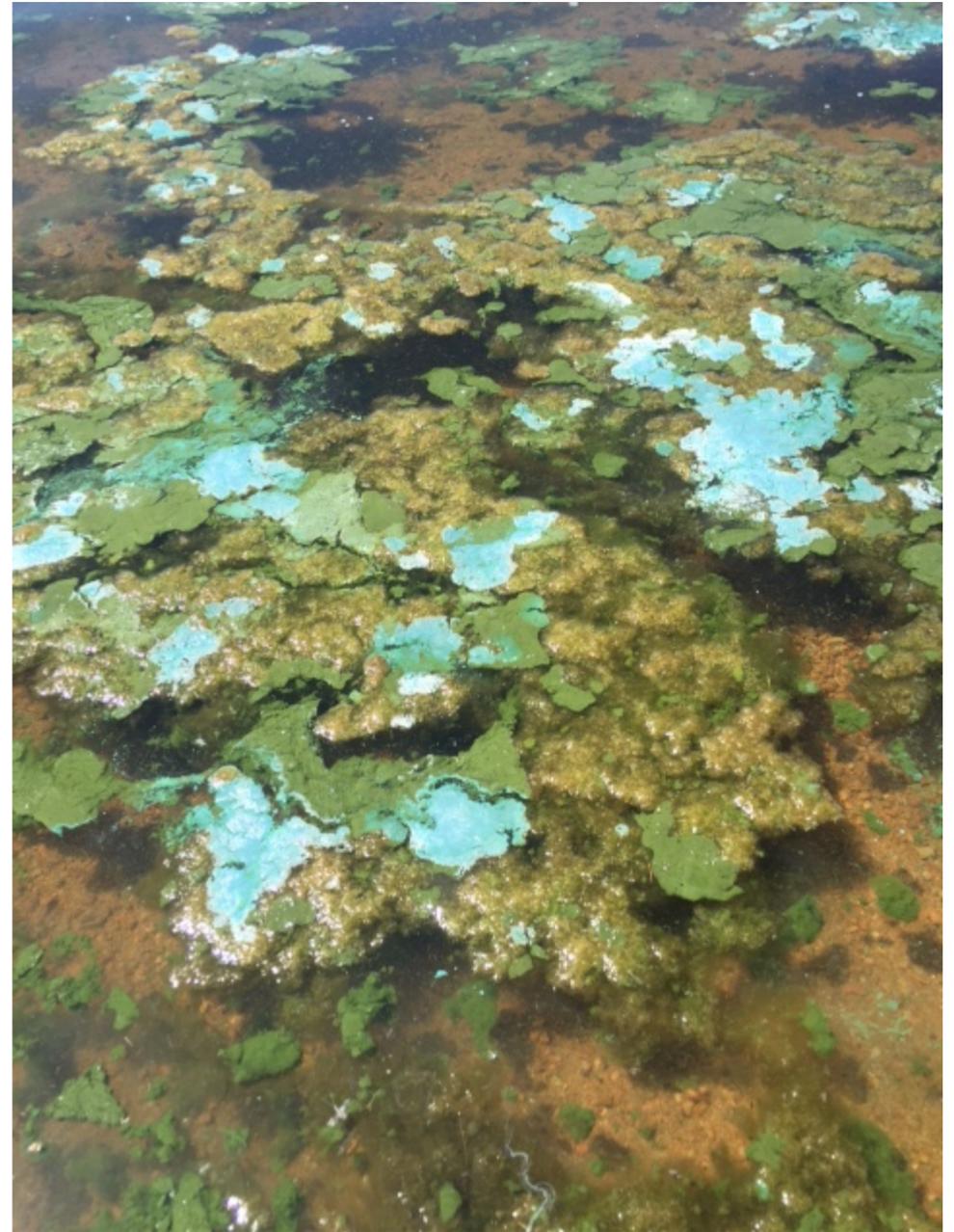
# *DeWeese Reservoir*

Aug 13, 2015

Widespread algae bloom  
reported by EPA

Microcystin < 0.175 ug/L

No other toxins tested

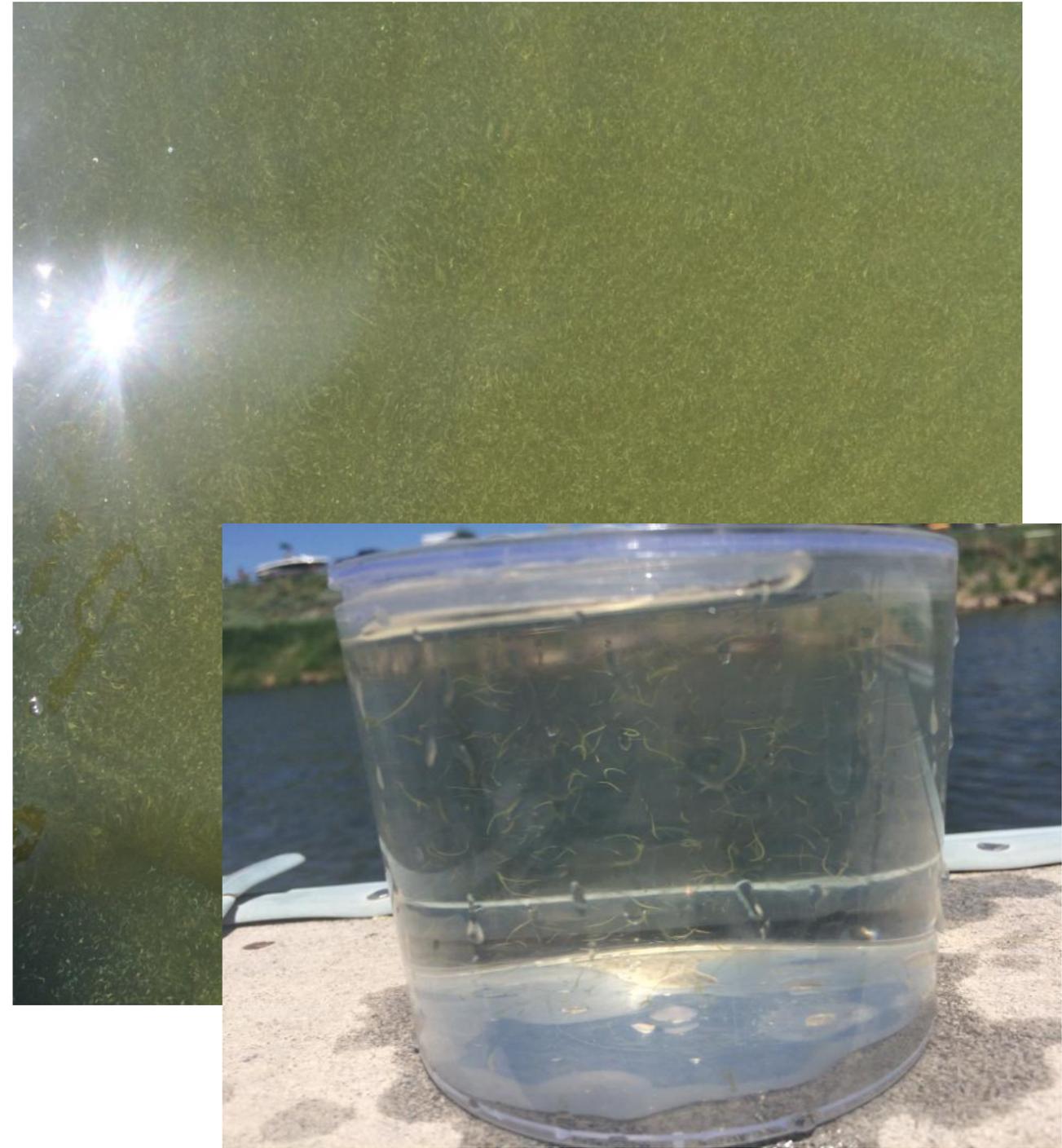


# *Stagecoach Reservoir*

Weekly testing with  
Abraxis dipsticks  
(microcystin only)

June 30, 2015

Annual algae bloom  
began earlier than  
usual



# *Stagecoach Reservoir*

July 21, 2015

Bloom worsens and is  
widespread

First positive test for  
microcystin

Microcystin = 3-5 ug/L



# *Stagecoach Reservoir*

July 24, 2015

Marina/swim beach location

Microcystin ~1 ug/L



# *Stagecoach Reservoir*

July 24, 2015

Dam location

Microcystin ~1 ug/L



# *Stagecoach Reservoir*

July 24, 2015

Cove location

Microcystin ~2.5 ug/L



# *Stagecoach Reservoir*

Swim beach/marina



Dam



Cove



# *DeWeese Reservoir*

- Sept 24, 2015
- Widespread algae bloom reported by CPW manager
- Distressed fish reported by locals
- Looks terrible!
  
- Microcystin = 0.19 ug/L
- Anatoxin = ND
- Cylindrospermopsin= ND
- Saxitoxin=ND

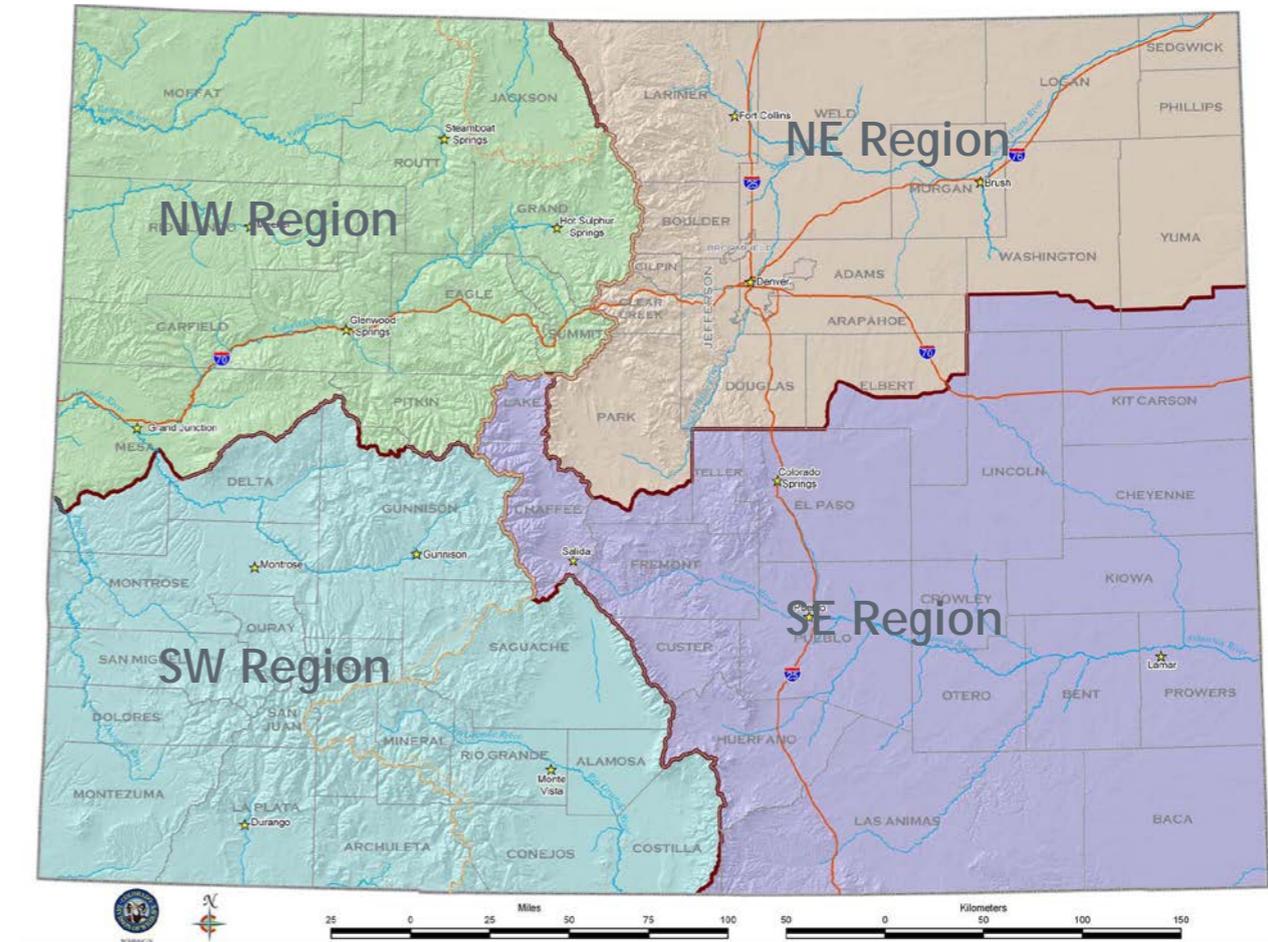


# *CPW Draft Response Plan*



# CPW Algal Toxin Team

- Summer- Fall 2014
  - Education on algal toxins
  - Sought feedback from Regions
- Spring 2014
  - Created Toxin Team
    - Park Managers
    - District Wildlife Managers
    - Area Wildlife Managers
    - Deputy Regional Managers
    - Public Information Officers



# Partnership with CDPHE

- Spring 2015
  - Met with CDPHE (WQCD and Environmental Epidemiology) to request assistance on public health issues
- Fall 2015
  - Met with CDPHE

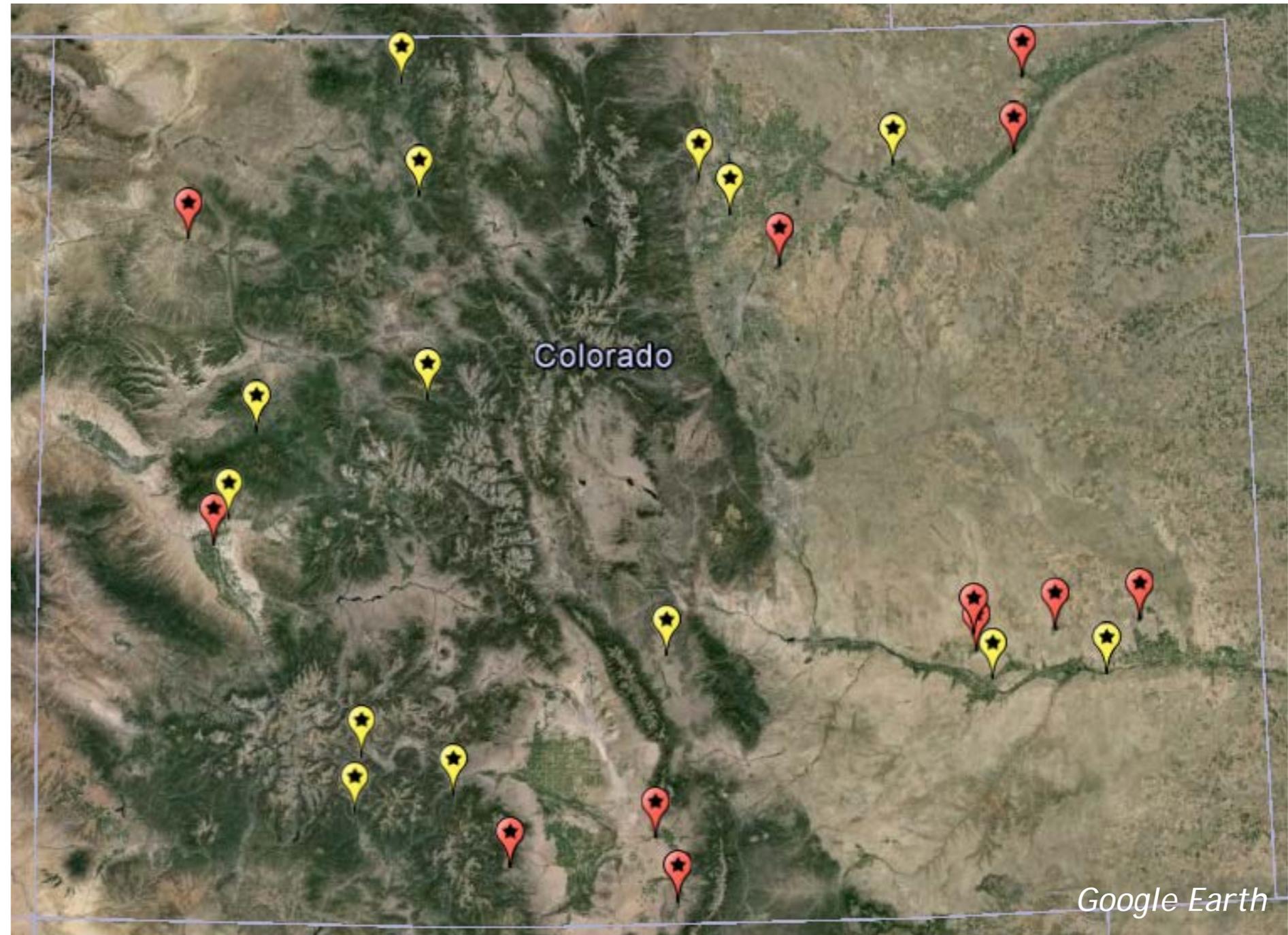


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# *Prioritize lakes by assessing risk*

- Phytoplankton cell count data
- WHO cell count threshold
- 100,000 cells potentially toxic species



# *Recreation Algal Toxin Response*

- Monitoring Plan
  - Visual bloom monitoring
  - Bottle and stick tests
  - Testing
    - Microcystin field test
    - Four-toxin lab test
- Action plan for notifying the public of health risks
  - Communication plan
  - Caution action level
  - Warning action level



# *Visual Bloom Monitoring*

- What do cyanobacteria blooms look like?
- High Risk 3-days
- Moderate Risk 14-days



# *Bloom Identification*

- Bottle Test



Cyanobacteria float to the surface or remain suspended in the water column

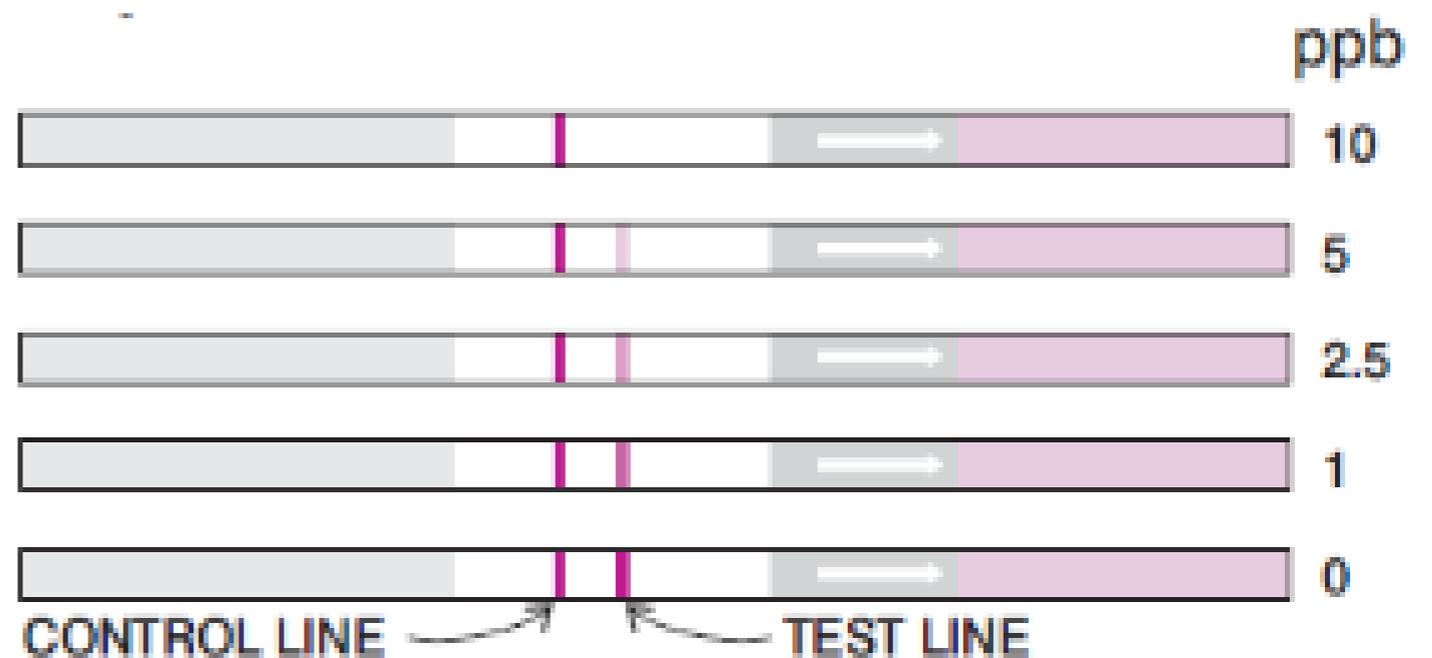
# *Bloom Identification*

- Stick Test
- Long strands are probably NOT cyanobacteria



# Testing

- Abraxis test strips
- Easy to use
- \$26-36 per test
- Microcystin only, but additional strips coming this spring



## INTERPRET TEST

CONTROL LINE	TEST LINE	INTERPRETATION
NO CONTROL LINE PRESENT	NO TEST LINE PRESENT	INVALID RESULT
CONTROL LINE PRESENT	NO TEST LINE PRESENT	> 10 ppb
CONTROL LINE PRESENT	MODERATE INTENSITY TEST LINE PRESENT	BETWEEN 0 AND 10 ppb



# Testing

- Lab Testing
- Tests 4 toxins
- \$650 per test



## LC-MS/MS ANTX-A

Liquid chromatography/ mass spectrometry/ mass spectrometry (LC-MS/MS) was utilized for the determination of ANTX-A. The  $[M+H]^+$  ion for ANTX-A (166  $m/z$ ) was fragmented and the product ions (91, 106, 131 & 149  $m/z$ ) were monitored. The current LOD is 0.1  $\mu\text{g/L}$  for ANTX-A.

### Summary of Results ( $\mu\text{g/L}$ )

<u>Sample</u>	<u>MC</u> (ELISA)	<u>CYN</u> (ELISA)	<u>STX</u> (ELISA)	<u>ANTX-A</u> (LC-MS/MS)
CC515F-1	ND	ND	ND	ND
CC515F-2	ND	ND	ND	ND
CC515F-3	ND	ND	ND	ND
<i>Detection Limits (<math>\mu\text{g/L}</math>)</i>	<i>0.15</i>	<i>0.10</i>	<i>0.05</i>	<i>0.05</i>

ND = Not detected above detection limit



# CDPHE guidance



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## Draft Toxic Algae Risk-Based Guidance

For Management of Recreational Waters

### + Recommended provisional guidelines for toxic algae

Threshold (µg/L)	<u>Microcystin*</u>	Cylindrospermopsin	Anatoxin	<u>Saxitoxin*</u>
Caution	10	7	7	4
Warning / Avoid Contact	20	**	**	**

\*Microcystin and saxitoxin guidelines are intended to be applied to total concentrations of all reported congeners of those toxins.

\*\*There are not sufficient data to recommend warning levels for cylindrospermopsin, anatoxin, and saxatoxin.



# Caution Level

## CAUTION

### Toxic Algae May be Present

- No pets in water!
- Do not drink lake water
- Avoid contact with floating algae mats



- **Fishing Permitted** - rinse fish well and discard guts
- **Boating Permitted** - avoid algae mats

Call your doctor or veterinarian if you or your animals have nausea, vomiting, diarrhea, rash, irritated eyes, seizures or breathing problems.

Poison Control Center 1-800-222-1222



# Caution Level

- Posted when bloom first observed
- Testing at least once per week
- Removed after two tests are below “Caution” thresholds (ex. Microcystin 10 ug/l) or bloom subsides
- Upgraded to Warning if single test is above “Warning” threshold (ex. Microcystin 20 ug/l)



# Warning Level

## WARNING

### Toxic Algae Present

#### AREA IS CLOSED TO FULL-BODY CONTACT

- No Pets in Water!
- Do Not Drink Lake Water
- No Swimming or Body Contact
- No Water Skiing
- No Jet Skiing
- No Paddle Boarding



- Boating Permitted - avoid algae mats
- Fishing Permitted - rinse fish well and discard guts

Call your doctor or veterinarian if you or your animals have nausea, vomiting, diarrhea, rash, irritated eyes, seizures or breathing problems.

Poison Control Center 1-800-222-1222



# *Warning Level*

- Posted when toxin levels exceed “Warning” thresholds
- Testing at least twice per week
- Removed or downgraded to “Caution” when two tests are below thresholds



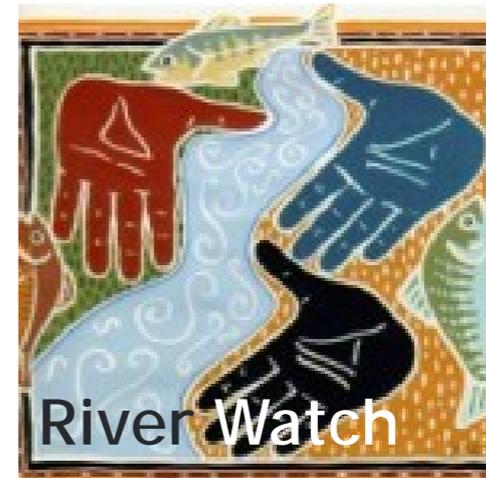
# *Communication Plan*

- Internal chain-of command
- Other state agencies
- Local health departments
- Local livestock producers
- Water providers
- Watershed groups
- Press release
- Educational materials



# Ongoing Work

- CPW -Finalizing draft response plan
- CPW -Distributing signs
- CPW-Fact Sheet
- River Watch -Seeking volunteer groups to help monitor remote CPW-managed “high-risk” lakes
- EPA draft algal toxin criteria for microcystin and cylindrospermopsin May/June 2016



# *Geography quiz*

- What are we looking at?



# Geography quiz

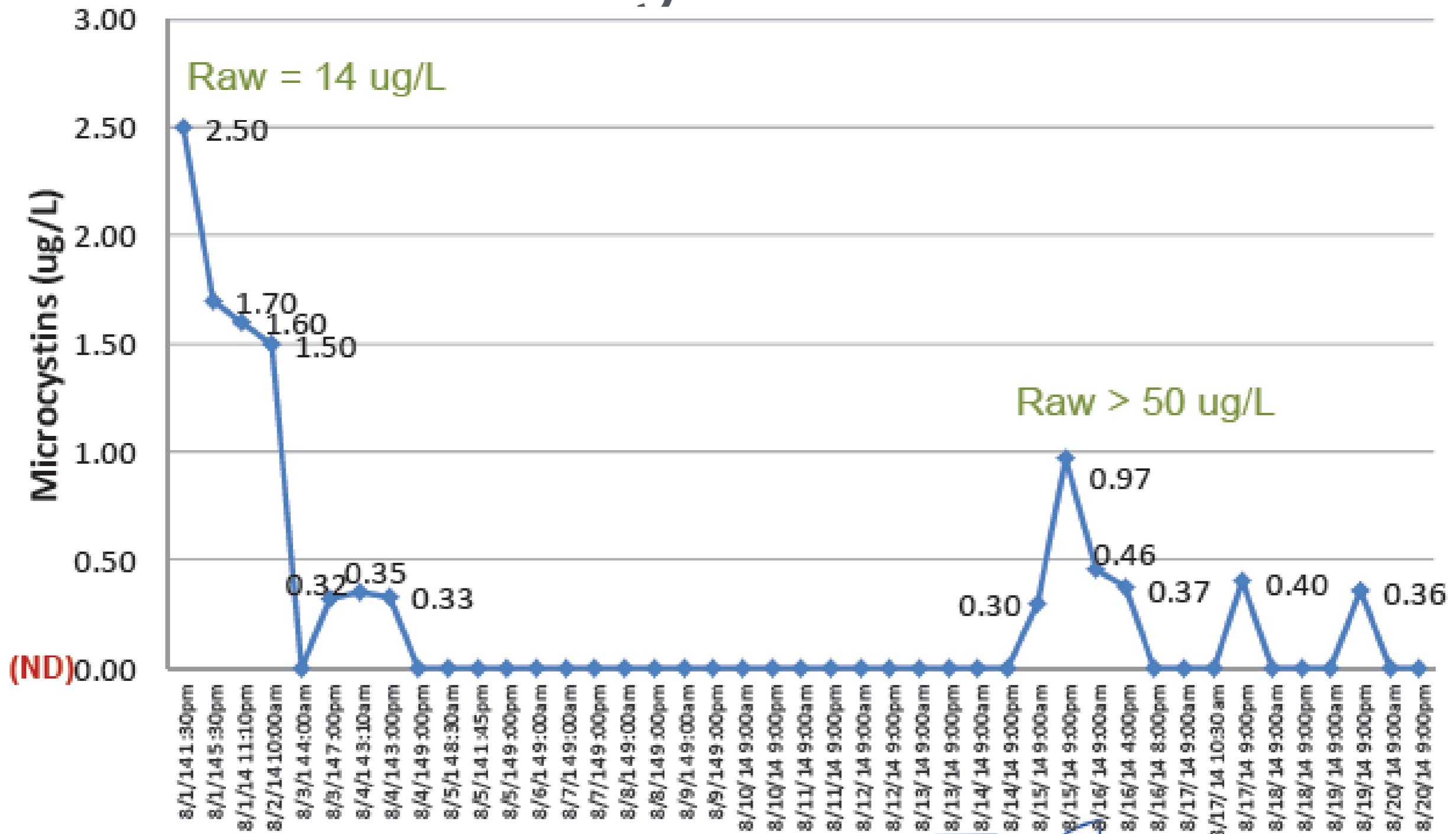
- What are we looking at?



# *City of Toledo - chronology*

- August 1, 2014:
  1. Sudden bloom spike overwhelmed plant before they could adjust treatment.
  2. Ohio EPA notified by City of microcystin sampling results above drinking water advisory threshold of 1.0 ug/L.
  3. 2<sup>nd</sup> set of samples taken and confirm levels above threshold.
- August 2, 2014:
  1. City issues “Do Not Drink Advisory” to 500,000 people.
  2. Governor declares state of emergency
- August 4, 2014:
  1. All sample results below threshold and advisory lifted.

# Microcystin concentrations in Toledo's finished drinking water



Microcystins also detected at 31 distribution sites

ND= Not Detected (Concentration <0.30)



Data Source: Toledo PWS

# *Beyond Toledo - nationwide panic*

- EPA national study finds around 1/3 of lakes have microcystin



# Beyond Toledo - nationwide panic

- Recreational and economic impacts

OREGONLIVE  
The Oregonian

## Future of blue-green algae in Willamette River still uncertain; users frustrated

Volunteers for the Oregon Health Authority have put up warning signs in Willamette, Sellwood, Waterfront, and East Bank Esplanade parks. These signs caution river users against drinking or cooking with the water due to blue-green algae bloom scum that can produce harmful toxins. (Adrianna Rodriguez)

Toxic algae forces cancellation of Portland regatta

## Algae Bloom In Willamette River Means No Swimming In Portland Triathlon

OPB | Sept. 19, 2014 12:51 p.m. | Updated: Sept. 19, 2014 3:43 p.m. | Portland

**Like** 71  
**Tweet** 7  
**Share** 78  
**Email**

CONTRIBUTED BY:  
  
Lizzy Duffy

PART OF SERIES:  
OPB News Blog

The Portland Triathlon has been forced to change its course due to the toxic scum floating around in the Willamette River.

Event organizers decided Friday to err on the side of caution before Portland health officials announced Friday afternoon that the massive blue and green algae bloom between Ross Island and the Fremont Bridge is harmful.

“The city and state Willamette River managers were unable to give us definitive safe to swim information,” the triathlon says on its website. “Because the information is incomplete, we have decided to lean on the side of safety for all our athletes.”

As OPB’s Kristian Foden-Vencil reported on Thursday, exposure to some types of algae can create a numb, tingling or dizzying feeling that could lead to difficulty breathing or heart problems.

Instead of swimming to running to bicycling, participants will start with

Dogs sickened by algae toxins in Willamette River



# Beyond Toledo - nationwide panic

- Reports of dead cattle, fish, dogs



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Dogs sickened by algae toxins in Willamette River

# *Beyond Toledo - nationwide panic*

## EPA do something!!

- Feb 2015 - Safe Drinking Water Act amended for algal toxins
  - EPA must submit to Congress a strategic plan for assessing and managing risks with algal toxins in drinking water

instead of swimming to running to bicycling, participants will start with

Dogs sickened by algae toxins in Willamette River

# EPA responds

- Studies find liver, kidney, and reproductive toxicity
- Health Advisories are informal technical guidance, **non-regulatory** concentrations estimated for specific exposure durations where health effects aren't anticipated to occur

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



## Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water

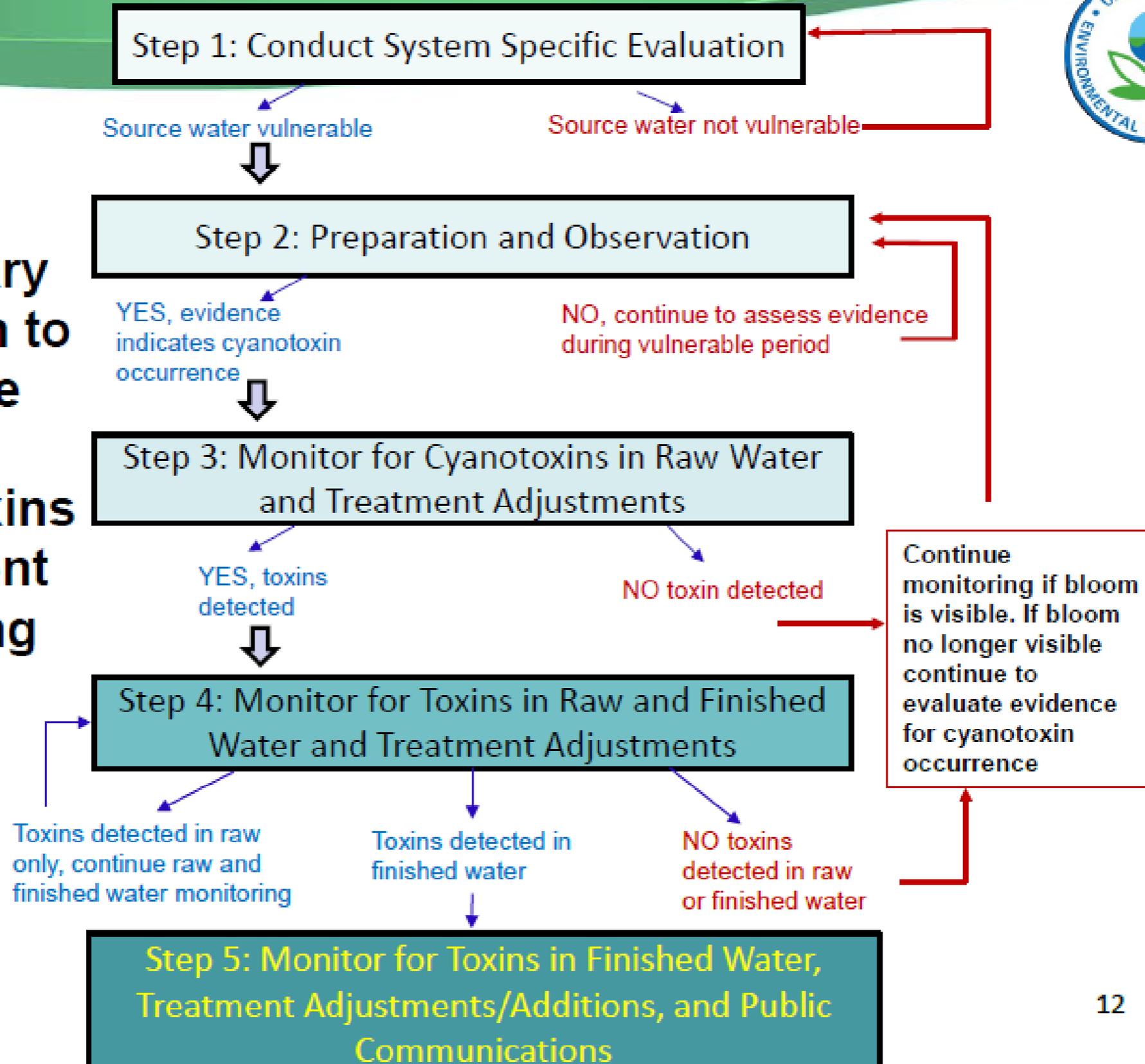
June 2015



# EPA's 5 step approach



## Preliminary Approach to Determine Whether Cyanotoxins are Present in Drinking Water



# *The challenges*

- Need to educate and raise awareness among surface water systems that could be impacted
  - New acute health advisory with potentially devastating PN
  - FEMA estimates value of lost water is \$103 per person per day
  - 500,000 people with a week long advisory ~ \$500M
- No database of toxin data in Colorado but we know many systems with blue-green algae and taste and odor issues
- No Colorado lab capacity
  - High analytical costs, 3-4 day turnaround time
  - Debate among analytical methods

# *Colorado's drinking water solution*

- Collaboration between Colorado's Drinking Water Program, Colorado Water Utility Council, and now others
- Guidance by systems for systems
- Resources to help systems large and small
  - Guidance, trainings, troubleshooting, lab support, data sharing, TTX
- Meetings to share successes and challenges, Google Group to communicate quickly, and a library to share information



# Colorado's drinking water guidance

<p><b>Step 1:</b> <b>Observe and prepare</b></p>	<p>Visually inspect source waters for algae bloom (at least weekly during bloom season). Taste and odor events, shorter filter runs, changes in source water quality may indicate presence of a bloom. If source waters are susceptible to algae blooms, be prepared and order toxin field tests before bloom season starts.</p> <p><i>*If bloom observed near intake continue to step 2</i></p>	<p>Resources: CLRMA (<a href="http://www.clrma.org">www.clrma.org</a>) can assist with bloom identification</p>
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# Colorado's drinking water guidance

<b>Step 2: Blue-green algae identification</b>	Use bottle test, stick test, microscopic identification, and/or Hach BART test to identify presence of blue-green algae in bloom (immediately after observing bloom and then at least weekly during presence of bloom).  <i>*If blue-green algae are present continue to step 3</i>	Resources: CLRMA ( <a href="http://www.clrma.org">www.clrma.org</a> ) can assist with algae identification
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# Colorado's drinking water guidance

<p>Step 3: Toxin presence in raw water</p>	<p>Monitor raw water at intake for presence of microcystins using a field test such as Abraxis Microcystins Strip Test for source drinking water (immediately after identifying blue-green algae and then at least weekly during presence of blue-green algae). You can also use the Strip Test for finished drinking water if you freeze then thaw sample three-times to release toxins in cells prior to analysis. Make treatment adjustments. Identify and contact lab in advance about sampling procedures and sample turnaround time in case toxins are detected in finished water.</p> <p><i>*If microcystins are present in raw water continue to step 4</i></p>	<p>Resources: CDPHE Local Assistance Unit (303-692-3665) can assist with toxin sampling in raw water and treatment strategies</p>
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# Colorado's drinking water guidance

<p><b>Step 4: Toxin presence in finished water</b></p>	<p>Monitor finished water at entry point for presence of microcystins using a field test such as Abraxis Microcystins Strip Test for finished drinking water (immediately after detecting presence of microcystins in raw water and then at least weekly during presence of microcystins in raw water). Make treatment adjustments.</p> <p><i>*If microcystins are present in finished water continue to step 5</i></p>	<p>Resources: CDPHE Local Assistance Unit (303-692-3665) can assist with toxin sampling in finished water and treatment strategies</p>
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# Colorado's drinking water guidance

<p>Step 5: Quantitative lab analysis of finished water</p>	<p>Send finished water sample after quenching chlorine residual to lab for microcystin and cylindrospermopsin quantification (immediately after detecting presence of microcystins in finished water and then at least weekly during presence of microcystins in finished water). Make treatment adjustments.</p> <p><i>*If microcystin values are above 0.3 ug/L and/or cylindrospermopsin values are above 0.7 ug/L (EPA's health advisory values) consult CDPHE (1-877-518-5608) prior to taking a confirmation sample of the finished water within 24 hours and sending to lab. Consider monitoring for toxins at various points throughout distribution to look for toxin degradation and extent of impacted area using a field test such as Abraxis Microcystins Strip Test for finished drinking water.</i></p>	
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# *Cyanotoxin treatment*

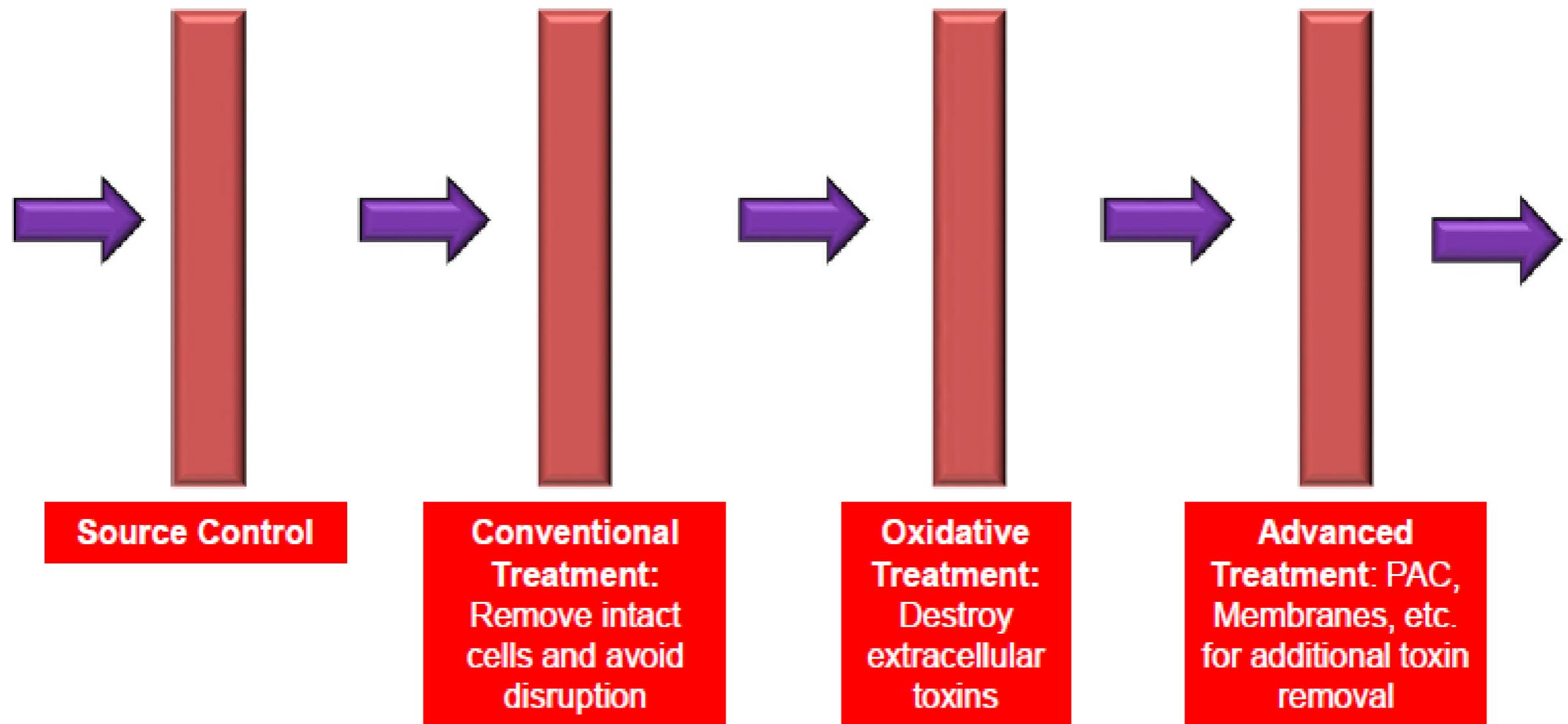
- Intercellular toxins
- Extracellular toxins



- Toxins within the cell and dissolved toxins present outside the cell require different treatment strategies
- Ohio had 5 systems in 2015 exceed microcystin limit - they worked with all systems to optimize before taking repeat samples and avoid advisory

# *Cyanotoxin treatment*

## Multiple Barrier Approach



# Questions?

Mindi May

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303-291-7124



**COLORADO**

Parks and Wildlife

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303-692-3605



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