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HARMFUL ALGAL BLOOM MANAGEMENT PLAN

ARKANSAS STATE WATERS

Arkansas Harmful Algal Bloom Workgroup

ARKANSAS
ENERGY & ENVIRONMENT | ENVIRONMENTAL QUALITY

PREFACE

In July 2014, the U.S. Army Corps of Engineers closed swim beaches on Nimrod Lake due to high levels of cyanobacteria. At the time, Arkansas did not have a protocol in place to respond to cyanobacterial events, assign action values or analyze samples for the presence of toxins. Although cyanobacterial cell counts were elevated (<100,000 cells/mL), toxins never rose above 5 µg/l. After this event, water resource professionals across the state gathered to form the Arkansas Harmful Algal Bloom (HAB) Workgroup. Goals of the Arkansas HAB Workgroup include:

1. Forming a plan for state wide assessment of risks to public health from cyanotoxins.
2. Developing sampling, testing, and protocols for cyanoHABs.
3. Developing strategies to reduce nutrient pollution in watersheds across Arkansas to prevent future cyanoHABs.

This cyanotoxin management plan is intended to assist relevant organizations, agencies, and the general public in responding to potentially toxic harmful algal blooms. The plan includes steps for monitoring, treatment, and communication during a suspected cyanoHAB event. Here, we provide guidance for responding to most cyanoHAB events, but individual events may require strategies that have not been outlined in this document. As the population grows and temperatures continue to rise, cyanoHABs are expected to become a more prevalent problem throughout Arkansas. There is still much to be learned regarding when and why these blooms occur and what conditions cause toxin production. As research progresses and states, including Arkansas, gain experience with cyanoHAB events, response protocols may be altered. This response plan should exist as a living document with continual review. Organizations that are interested in becoming involved in the cyanoHAB response process should contact the Harmful Algal Bloom Workgroup (habs@adeq.state.ar.us).

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CYANOHAB OVERVIEW

All water bodies require primary producers, such as phytoplankton and filamentous algae, to make up the base of the food chain. Several factors will determine the extent and type of primary producer found in a specific water body. Considerations such as light penetration, water body shape and morphology, nutrient input, and predator structure should be assessed when predicting a system's capacity to maintain a healthy community. Concerns arise when water bodies become dominated by one or a few species, typically occurring at the primary producer level. This has especially become a problem with the increasing use of fertilizers over the past 70 years. Some sources predict that by 2030 the use of nitrogen in fertilizers will increase over 13 times of levels used in the 1950s (Smith et al., 1999).

One of the most problematic consequences of eutrophication is algal blooms, particularly cyanobacterial blooms, also known as harmful algal blooms (HABs) or "CyanoHABs." Although categorized as an algal bloom, cyanobacteria are actually plant-like bacteria that have the ability to photosynthesize. It can be difficult to visually distinguish true algae from cyanobacteria. In many cases, especially in lentic (slow or non-flowing) systems, cyanobacteria tend to be planktonic or suspended in the water column. However, there are some species of cyanobacteria that form filamentous mats. Although similar in appearance to true algae, one of the major distinctions is that cyanobacteria have the ability to produce toxic substances that can be harmful to wildlife, livestock, pets, and humans.

Cyanobacteria can be found in all water bodies to some extent; they are often part of the native flora. During certain conditions, cyanobacterial growth may increase drastically into a cyanoHAB. It is generally accepted that cyanoHABs are formed during periods of high temperatures and in water bodies that contain, have historically contained, and/or are receiving high nutrient loads (nitrogen and phosphorus, specifically). It is not understood how or under what specific conditions cyanoHABs produce toxins, and it is common for cyanobacterial blooms to occur with minimal to no detectable toxins. Unfortunately, whether a bloom is toxic or not can only be determined by laboratory analysis or specialized field equipment. If you suspect that a water body is experiencing a cyanobacterial bloom, contact the Arkansas Division of Environmental Quality (DEQ), Arkansas Department of Health (ADH), Arkansas Water Resources Center (AWRC) or the local lake manager and avoid making contact with the water.

CYANOHAB CASE STUDIES

The earliest documented occurrence of a cyanoHAB occurred in Australia in 1878, where the author witnessed the death of wildlife that drank from the river, which had been covered in a "thick scum like green oil paint" (Francis, 1878). Although cyanoHABs were present historically, an increase in fertilizers and warming temperatures seem to exacerbate this problem, causing them to occur more frequently and at higher intensities (Paerl, et al., 2011). Some of the most devastating occurrences have come about in recent years. Case studies can be found below:

GRAND LAKE, OKLAHOMA (2011):

High toxin levels led to a swimming advisory on Grand Lake at the height of a busy tourist season. Several people reported cyanoHAB-related illnesses to the Oklahoma State Department of Health. Toxin concentrations were 18 times greater than safe levels suggested by the World Health Organization (Grand Lake and harmful algal blooms – 2011, 2012).

TOLEDO, OHIO (2014):

Lake Erie has become notorious for its nearly annual cyanoHABs, particularly in the western basin. The primary cause of blooms has been traced to dissolved phosphorus from surrounding watersheds. Toxins were so high in August 2014 that city officials banned use of city water, including bathing. The event affected 500,000 people and became so bad that the National Guard and the American Red Cross were brought in to manage water distribution centers after all bottled water in the city sold out (Wines, 2014). The economy was severely impacted both directly and indirectly as businesses and public services were temporarily closed. (Ho & Michalak, 2015)

LAKE OKEECHOBEE, FLORIDA (2016/2018):

In recent years Lake Okeechobee and its two primary receiving canals have experienced cyanoHABs similar to those seen in Lake Erie. Several species of cyanobacteria were found throughout the lake and canals and toxins were measured at levels greater than what the World Health Organization advises as safe. A State of Emergency was issued by Florida Governor Rick Scott, and the Army Corps of Engineers suspended discharges from the lake for several days (State of Florida Office of the Governor, 2016).

In 2018, the lake and its receiving canals experienced another cyanoHAB. Although not quite a repeat of 2016, these freshwater cyanobacterial blooms from the highly eutrophic Lake Okeechobee are believed to have amplified the marine harmful algal blooms. These marine blooms, identified as Red Tides, have wreaked havoc on marine life and have been identified as the cause of death for more than 500 manatees, which are protected under the Endangered Species Act (Pittman, 2018).

CYANOBACTERIA

In most cases, freshwater harmful algal blooms come about by a dominance of a cyanobacterial species. There are several physiological adaptations of cyanobacteria that allow them to out compete other groups of non-toxin-forming algae. Some species of cyanobacteria contain specialized nitrogen-fixing cells called heterocysts. These cells allow for extraction of atmospheric nitrogen, which can be converted to usable forms, potentially reducing nitrogen limitation and increasing phosphorus limitation. Many cyanobacteria contain gas vacuoles, which enable them to control their buoyancy throughout the water column. In the summer, it's typical for lakes in Arkansas to stratify or form layers of dissolved oxygen and temperature. For most algae, movement is restricted to currents and wind or density and temperature gradients. However, cyanobacteria with gas vacuoles can selectively float to the surface for more access to sunlight, thereby shading out competing species.

Despite these adaptations for establishing dominance, there are plenty of circumstances where algal blooms may consist of non-cyanobacterial species. Flowing waters are more prone to what is often referred to as "Nuisance Algae Blooms" (NABs), which are typically composed of non-toxin-forming filamentous green algae that can attach to substrata. Historically, flowing waters were thought to have less ideal conditions for cyanobacterial blooms, although many recent instances of riverine and benthic cyanoHABs have been identified and have resulted in illness and death in dogs. Literature is not as extensive for benthic cyanobacteria, but researchers have been increasingly studying these kinds of cyanoHABs. Some of the most commonly implicated species of benthic cyanoHABs include *Microseira spp.* (formerly *Lyngbya spp.*) *Cylindrospermum spp., Pseudanbaena spp., Geitlerinema spp., Phormidium spp., Tricholeus spp.,* and *Microcoleus spp.,* which may appear as filamentous mats or slimes.

Lentic systems such as lakes and ponds may also experience non-cyanobacterial algal blooms. Depending on conditions leading up to the event, one species of another algal group such as green or golden algae, diatoms, euglena, etc., may gain a competitive advantage and result in a visible bloom.

CYANOBACTERIAL TOXINS

Cyanotoxins will typically affect the nervous system (neurotoxins), skin (dermatoxins), or the liver (hepatotoxins). Several cyanotoxins have been isolated, and some of the more commonly known toxins include:

- Saxitoxin
- Anatoxin
- Lyngbyatoxin
- Microcystin
- Cylindrospermopsin

SAXITOXIN

Saxitoxin is a neurotoxin and is also known in marine systems as paralytic shellfish poisoning. This toxin is the most potent known natural toxin and can cause death if ingested in as small a volume as 1 mg (Kirkpatrick et al., 2004). Symptoms of saxitoxin poisoning include tingling and loss of feeling in extremities within several hours. The most common way to come into contact with saxitoxin is through ingestion as it is known to concentrate in fish and shellfish tissue. Exposure pathways also include inhalation and exposure to open wounds. Health issues from saxitoxins have primarily been isolated to consumption of marine shellfish. To date, human illness or death from saxitoxins in freshwater systems have been rare or absent.

ANATOXIN

Anatoxin exposure routes include direct ingestion or consumption of contaminated water or food, bathing in contaminated water and inhalation. Anatoxins are neurotoxins that are considered highly toxic, although they are not found in the environment as frequently as other toxins. Anatoxins have resulted in rapid death in laboratory mice, but a lethal dose has not been identified in humans (EPA, 2015). Human illness and multiple cases of wildlife and livestock death have been a result of anatoxin poisoning. Anatoxin was implicated in one human death after ingestion of lake water containing a bloom of *Anabaena flos-aquae,* but was never officially diagnosed (van der Merwe, 2015). Symptoms of anatoxin poisoning include loss of coordination, muscle twitching, convulsions, and respiratory failure.

LYNGBYATOXIN

Lyngbyatoxin is a dermotoxin produced by one of the few species of filamentous, macroalgal cyanobacteria, *Lyngbya* (now *Microseira* and *Moorea*) (see page 9). Typically referred to as “swimmers itch,” lyngbyatoxin has been primarily associated with dermal affects. Consumption of contaminated meat has also led to gastrointestinal distress and common symptoms of food poisoning. Recently, lyngbyatoxin has been identified as a tumor producer, which may make chronic exposure more of a concern for this toxin. (Jiang et al., 2014)

MICROCYSTIN

One of the more intensively studied cyanotoxins is microcystin, a hepatotoxin. According to the Environmental Protection Agency’s (EPA) National Lakes Assessments conducted in 2007 and 2012, microcystin was detected in 32 and 39 percent of lakes sampled, respectively (D’Anglada, 2016). Microcystin binds primarily to proteins in the liver, but has also demonstrated negative kidney and reproductive effects (EPA, 2015b). Exposure is generally by ingestion. Symptoms of microcystin poisoning include headache, sore throat, vomiting, nausea, stomach pain, and liver failure. There have been numerous incidences of livestock and wildlife deaths as a result of consuming microcystin-contaminated water (CEPA, 2009). Fifty-two human fatalities in Caruaru, Brazil resulting from liver failure have also been linked to microcystin-contaminated water used for dialysis (Azevedo, et al., 2002). In 2015, EPA released 10-day health advisories for microcystin in drinking water (Table 1). In June 2019, EPA released recommended criteria for recreational waters (Table 2).

CYLINDROSPERMOPSIN

Much like microcystin, many laboratory and field studies have focused on the toxicity of the hepatotoxin, cylindrospermopsin. Symptoms and effects of cylindrospermopsin are also similar in that the most heavily affected organs are the liver and kidneys, but absorption has also been witnessed in the spleen (EPA, 2015c). Symptoms of cylindrospermopsin poisoning include fever, headache, vomiting, bloody diarrhea, an enlarged liver, and kidney damage. Exposure pathways consist of consumption of contaminated drinking water or food, dermal contact and inhalation. In 2015, EPA released 10-day health advisories for cylindrospermopsin in drinking water (Table 1). In June 2019, EPA released recommended criteria for recreational waters (Table 2).

HEALTH ADVISORIES

In 2015, the EPA released a 10-day health advisory for select cyanotoxins in drinking water (Table 1). This health advisory is based on available occurrence data, detection methods, potential for adverse health effects, and methods of treatment. Currently, there are health advisories for microcystin and cylindrospermopsin, the toxins of which data is most abundant. Under the Safe Drinking Water Act, EPA continues to gather data to inform future regulations on these and other cyanotoxins.

TOXIN	10-DAY HEALTH ADVISORY	
	BOTTLE-FED INFANTS & PRESCHOOL CHILDREN	SCHOOL-AGE CHILDREN & ADULTS
Microcystins	0.3 µg/L	1.6 µg/L
Cylindrospermopsin	0.7 µg/L	3 µg/L

Table 1. 10-day Health Advisories in Finished Drinking Water (EPA, 2015b)

Health advisories are determined by short-term (usually seven to 30 days) studies in which a reference dose and the NOAEL (No Observed Adverse Effect Level) for the containment are calculated (EPA, 2015b). For more information on the determination of these advisories see:

epa.gov/sites/production/files/2017-06/documents/cylindrospermopsin-report-2015.pdf
epa.gov/sites/production/files/2017-06/documents/microcystins-report-2015.pdf

In June 2019 EPA released recommended water quality criteria for cyanobacterial toxins in recreational waters (Table 2) with a recommended action at one occurrence. As with the drinking water criteria, recreational criteria are based on available occurrence data, detection methods and potential for adverse health effects. For more information regarding calculation and determination of recreational criteria, see:

epa.gov/sites/production/files/2019-05/documents/hh-rec-criteria-habs-document-2019.pdf

MICROCYSTINS	CYLINDROSPERMOPSIN
8 µg/L	15 µg/L

Table 2. EPA 2019 recommended magnitude for microcystins and cylindrospermopsin (EPA, 2019).

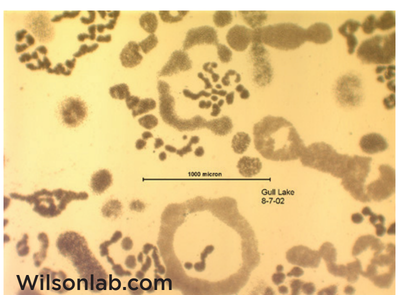
The Arkansas HAB Workgroup recommends use of the 2019 EPA values (Table 2). Swimming advisories should be issued if microcystins exceed 8 µg/l and cylindrospermopsin exceeds 15 µg/l on any given day. There are no recommendations for other cyanotoxins at this time.

CYANOBACTERIAL GENERA

Although there are more than 60 genera of cyanobacteria, some tend to be more common than others (or have been more commonly documented in Arkansas), especially in the case of toxin production.

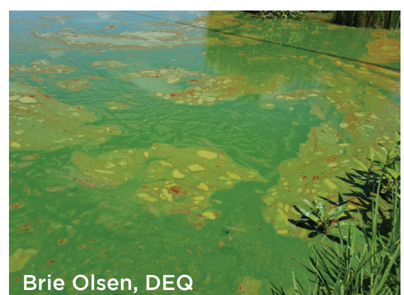
MICROCYSTIS

Microcystis is a colony-forming cyanobacterium and can produce microcystin (Table 3), a liver toxin. This genus does not have heterocysts and is therefore unable to fix nitrogen. Blooms can appear as a scum on the water's surface, which may resemble spilled bluish-green paint or may just look like green clumps suspended throughout the water column. *Microcystis* is the most common bloom-forming cyanobacteria and has been responsible for some of the more recent major events, including the 2014 bloom on Lake Erie and the 2018 bloom on Lake Okeechobee. Scums formed from *Microcystis* blooms can dry out on shoreline edges and remain toxic for many months after an occurrence.



Microcystis spp. **colonies**

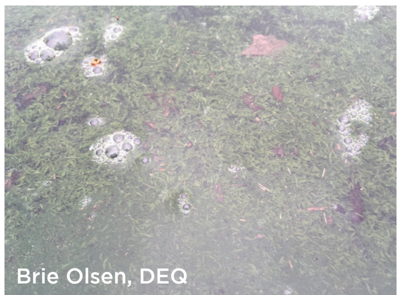
Microcystis spp. **bloom with individual colony formation**



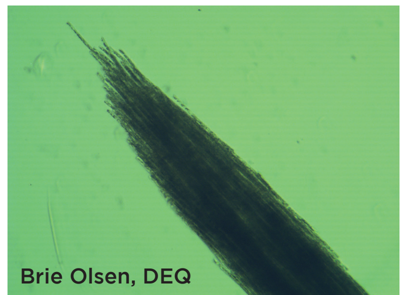
Microcystis spp. **bloom**

APHANIZOMENON

Aphanizomenon primarily grows in solitary filaments and can sometimes be identified by their tapered or hyaline ends. Heterocysts are intercalary and are typically off-center (closer to one end of the filament), but can fail to appear when environmental conditions permit (Komarek & Hauer, 2014). Filaments can form akinetes (specialized storage cells), which tend to be long and oval. *Aphanizomenon* can also be seen in large clumps or rafts of several filaments that have the appearance of hair or clipped grass. The most well-known and common species is *A. flos-aquae*. Toxin production by *Aphanizomenon* includes anatoxin and cylindrospermopsin (Table 3).



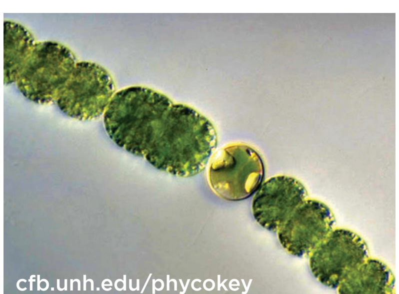
***Aphanizomenon spp.* bloom**



***Aphanizomenon spp.* colony**

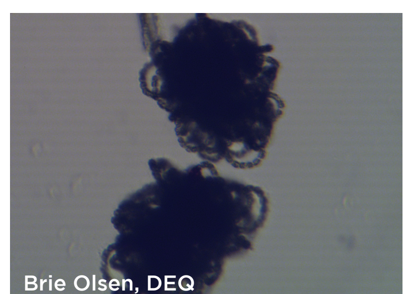
ANABAENA

Anabaena typically grows in long filaments, which can either form in a straight or curling orientation. This is a genus that is well known for its nitrogen-fixing abilities and will almost always contain a heterocyst. Under especially anoxic conditions, one heterocyst can form for every 10 vegetative cells (Golden & Yoon, 2003). Heterocysts will only form within a chain of vegetative cells (intercalary heterocysts) as opposed to forming on either end (terminal). Many *Anabaena* species are composed of filaments resembling a string of beads. Toxins isolated by species within this genus include microcystin, anatoxin, and saxitoxin (Table 3). As with many types of cyanobacterial blooms, *Anabaena* can form a blue-greenish scum on the water's surface. Some *Anabaena* blooms have just appeared as green-tinted water.



***Anabaena spp.* filament**

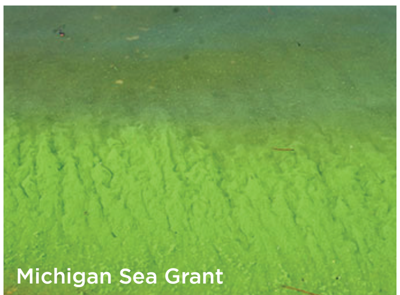
***Anabaena spp.* filament**



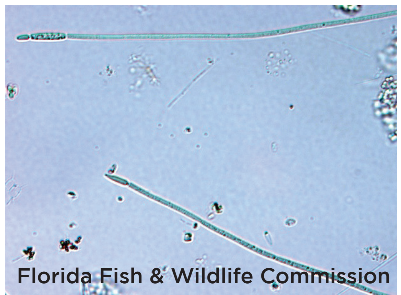
***Anabaena spp.* colonies**

CYLINDROSPERMOPSIS

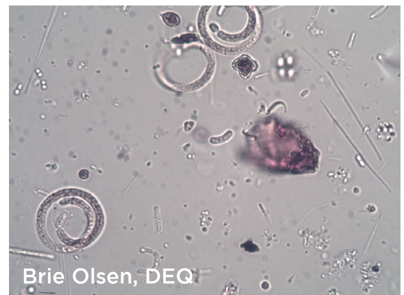
Although typically associated with tropical/subtropical climates, *Cylindrospermopsis spp.* ranges have expanded to temperate climates and can be found throughout most of the northern hemisphere (Falconer & Humpage, 2006). This genus forms long, tubular, segmented filaments with terminal heterocysts. Vegetative cells that make up most of the filament tend to be more rectangular in shape and cell walls can sometimes be barely visible. Heterocycts may be conical and filaments can develop large oval akinetes near heterocysts. Toxin production for *Cylindrospermopsis* includes cylindrospermopsin (Table 3) and saxitoxins (Antunes et al., 2015).



Cylindrospermopsis spp. **bloom**

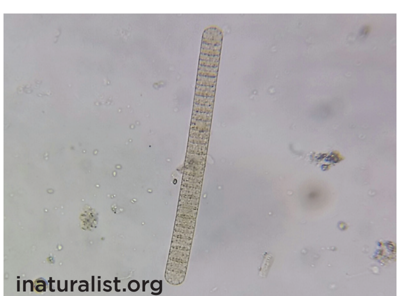


Cylindrospermopsis spp. **filament**



Cylindrospermopsis spp. **filament**

Oscillatoria spp. **filament**



Oscillatoria spp. **filament**

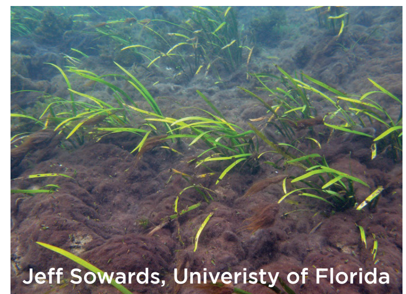
OSCILLATORIA AND *PLANKTOTHRIX*

Although classified as two different genera, it was only recently that *Planktothrix* was separated into its own genus on the basis of 16s rDNA sequencing. Morphologically, these genera are almost indistinct from one another and will be grouped together for the purposes of this document. This genus has neither heterocyst nor akinete. *Oscillatoria* and *Planktothrix* are a fairly unremarkable cyanobacterium that forms in a filament with cells of various sizes although many times cells are wider than tall. Filaments are rarely solitary and are typically found in relatively large groups or mats. These genera (belonging to Order Oscillatoriales) are named for the oscillating movements of the filaments, which will glide along adjacent filaments. Some have suggested that this movement is due to a response to light, but the literature is scarce (McBride, 2001). Toxins produced by *Oscillatoria* and *Planktothrix* include anatoxin, microcystin (Table 3) and lyngbyatoxin (Sivonen and Jones, 1999).

LYNGBYA, MICROSEIRA, AND *MOOREA*

Due to recent genetic analyses, several new genera have been classified from *Lyngbya.* Two of the newer genera likely to be encountered in this part of the country are *Microseira* and *Moorea.* Morphologically, these genera are almost indistinct from one another and will be grouped together for the purposes of this document. *Lyngbya, Microseira,* and *Moorea* are unique from the previously described cyanobacteria in that they are a filamentous macroalgae. As with *Oscillatoria/Planktothrix,* these genera contain no heterocysts or akinetes. Morphology is also similar to *Oscillatoria/Planktothrix* in that they are composed of single filaments with discoid cells that are wider than tall. One of the primary differences between *Oscillatoria/Planktothrix* and *Lyngbya/Microseira/Moorea* at a microscopic level is the visible sheath around the *Lyngbya/Microseira/Moorea* filament. Macroscopically, the two genera are very different in that *Lyngbya, Microseira*, and *Moorea* form thick, wooly mats. These mats can be both benthic and float on the surface. Exposure to oxygen with those mats that float on the surface can turn the algae yellow-orange. *Lyngbya, Microseira*, and *Moorea* are known to produce lyngbyatoxin (Burja et al., 2002) and cylindrospermopsin (McGregor and Sendall, 2014).

Lyngbya **(now *Microseira* & *Moorea*) *spp.* filament**



Lyngbya **(now *Microseira* & *Moorea*) *spp.* filament**

ADDITIONAL ALGAL IDENTIFICATION RESOURCES:

Green Water Laboratories: www.greenwaterlab.com/algal-id.html

Algaebase: www.algaebase.org

Phycokey: www.cfb.unh.edu/phycokey/phycokey.htm

FRESHWATER CYANOTOXINS	TYPE OF TOXIN	CAUSATIVE ORGANISM
Anatoxin-a	Neurotoxin	*Anabaena spp.*
Anatoxin-a (s)	Neurotoxin	*Anabaena spp.* *Planktothrix spp.*
Cylindrospermopsin	Hepatotoxin	*Cylindrospermopsis raciborskii,* *Aphanizomenon ovalisporum*
Lyngbyatoxin	Dermal Toxin	*Lyngbya spp.*
Microcystins	Hepatotoxin	*Microcystis aeruginosa* *Anabaena spp.* *Planktothrix spp.*
Saxitoxins	Neurotoxin	*Anabaena circinalis* *Lyngbya wollei*

Table 3. Cyanotoxins and their associated cyanobacterial producer.
This list is not comprehensive. (D'Anglada, L., 2016).

AVOIDING EXPOSURE

If you suspect that a water body is experiencing a harmful algal bloom, it is best to avoid contact.

Generally, children are considered a more sensitive population given lower body weights on average and a higher rate of recreational exposure to water. Skin contact with harmful algal blooms can cause skin irritation along with irritation to mucus membranes, such as the eyes, nose, or throat. Incidental ingestion in children has been estimated at around 128ml (or $^{1}/_{2}$ cup) per hour. Rate of ingestion in children is about 4 times greater than adults (Dufour et al., 2017). In many cases, cyanobacterial blooms will form scums that can concentrate along the shoreline where exposure is more common. Some of the symptoms experienced after ingestion of cyanotoxins include:

- Headaches
- Weakness
- Shortness of breath
- Vomiting
- Diarrhea
- Liver damage
- Kidney damage
- Abdominal pain

Another population that may arguably be the most susceptible to harmful algal bloom poisoning includes pets and livestock. Often, a contaminated water body may be the only water source available to the animal, especially in the case of livestock. Animals, such as dogs, are also likely to ingest toxins when cleaning their fur. Operators of farms that contain livestock can work with their local University of Arkansas Cooperative Extension Service or Conservation District office to develop best management practices or plans for solutions such as alternate water sources for their animals.

https://www.uaex.edu/counties/default.aspx

https://aracd.org/default.htm

Citizens who are interested in long-term solutions to nutrient pollution in general are encouraged to work with the Arkansas Natural Resources Commission (ANRC), which oversees voluntary nonpoint management and pollution prevention in Arkansas.

https://www.anrc.arkansas.gov/divisions/water-resources-management/arkansas-nutrient-reduction-strategy/

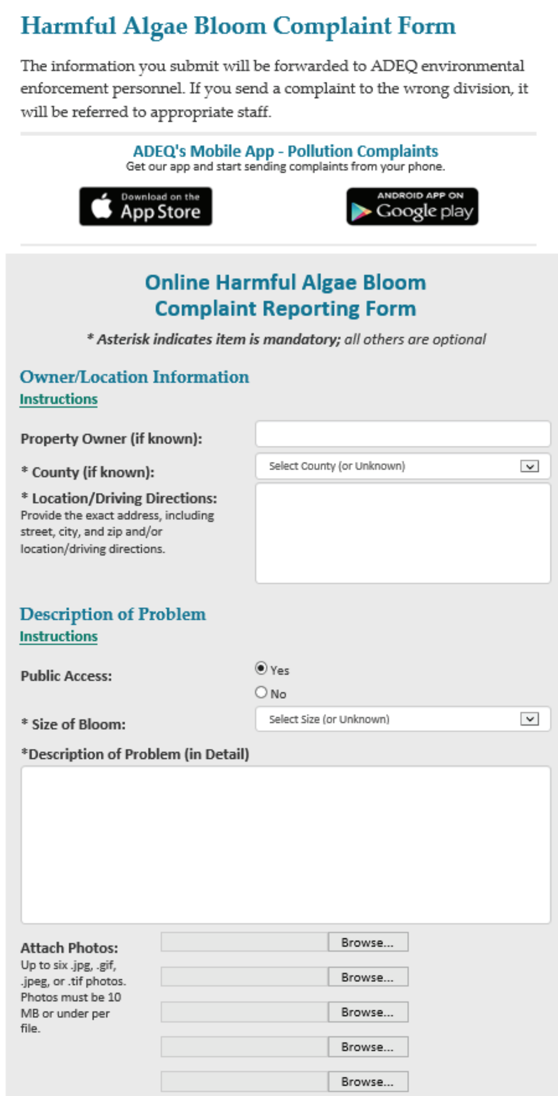
REPORTING HARMFUL ALGAL BLOOMS

If you think you see a harmful algal bloom, report it!

Use the DEQ Pollution Complaint Reporting Tool to describe the location and extent of the harmful algal bloom. DEQ will then work with the lake manager or property owner to test the water for cyanotoxins. DEQ will also use this tool to track any water bodies that may be more susceptible to cyanoHAB events for future monitoring programs.

DEQ Pollution Complaint Reporting Tool:

adeq.state.ar.us/complaints/forms/harmful_algae_complaint.aspx



Harmful Algae Bloom Complaint Form

The information you submit will be forwarded to ADEQ environmental enforcement personnel. If you send a complaint to the wrong division, it will be referred to appropriate staff.

ADEQ's Mobile App - Pollution Complaints
Get our app and start sending complaints from your phone.

Download on the App Store | ANDROID APP ON Google play

Online Harmful Algae Bloom Complaint Reporting Form

** Asterisk indicates item is mandatory; all others are optional*

Owner/Location Information
Instructions

Property Owner (if known):

* County (if known): Select County (or Unknown)

* Location/Driving Directions: Provide the exact address, including street, city, and zip and/or location/driving directions.

Description of Problem
Instructions

Public Access: Yes / No

* Size of Bloom: Select Size (or Unknown)

*Description of Problem (in Detail)

Attach Photos: Up to six .jpg, .gif, .jpeg, or .tif photos. Photos must be 10 MB or under per file.

Browse...
Browse...
Browse...
Browse...
Browse...

To the extent possible, DEQ will analyze cyanotoxin samples free of charge, but is restricted to public water bodies. Within a 20-mile radius of Arkansas Energy and Environment headquarters, DEQ staff will collect water samples if resources allow. Complaints submitted outside a 20-mile radius of E&E headquarters should be shipped overnight by those who have submitted the complaint unless other arrangements can be made. If complainants cannot collect a sample and fall outside of a 20-mile radius of E&E headquarters, DEQ staff will reach out to state/federal agencies, conservation districts, universities, etc., in a best effort to collect a sample.

See the next two sections for sample collection and shipment instruction. Samples should be sent to:

ATTN: Water Planning HAB
Arkansas Energy and Environment, Division of Environmental Quality
5301 Northshore Drive, North Little Rock, AR 72118-5317

Private water bodies that experience HAB events are encouraged to contact the following fee-based labs:

Arkansas Water Resources Center
awrcwql@uark.edu
479-502-9843
Fayetteville, AR

BSA Environmental Services
info@bsaenv.com
216-765-0582
Beachwood, OH

Greenwater Laboratories
info@greenwaterlab.com
386-328-0882
Palatka, FL

COLLECTING SAMPLES FOR APPROVED DEQ ANALYSIS

1. If you have the ability to collect a sample, make arrangements with the DEQ Office of Water Quality representative assigned to you to have the samples received and analyzed and follow the steps below. Depending on the situation, your DEQ representative may give you specific instructions regarding sample collection.

2. If you do not have the ability to collect a sample, DEQ will collect samples within a 20-mile radius of E&E headquarters. If you cannot collect a sample and fall outside of a 20-mile radius of E&E headquarters, DEQ staff will reach out to state/federal agencies, conservation districts, universities, etc., in a best effort to collect a sample. See page 16 (Jar and Stick Test) for more that you can do if you do not have the ability to collect samples. For the purposes of this program, you will be asked to collect a "grab sample." To collect the complete suite of samples you will need the following:
    - Pole sampler* (preferred) or bucket
    - Funnel
    - 50 mL glass or PETG container **
    - Cooler with ice
    - Aluminum foil
    - Large (1 gal.), sealable container labeled with date and location
    - Rubber gloves
    - Sampling Form (See Appendix 5)

* a pole sampler can be composed of a large-mouth bottle or bucket attached to a long pole— the purpose of the sampler is to avoid having to physically enter the water

** optional, but may provide better cyanotoxin results

Samples are typically collected where the bloom is most concentrated and where the water body is most easily accessed (boat ramp, swim beach, naturally low spot on the shoreline). Blooms tend to concentrate along the shoreline between they're heavily impacted by wind and currents. However, if the bloom is difficult to access by land or occurs in open water, it may be necessary to access it by boat. Do not collect a sample if your safety will be compromised by doing so.

Because you are sampling a potentially toxic bloom, take care to wear rubber gloves and avoid as much skin contact with the water as possible. Rinse the pole sampler or bucket, funnel, and other sampling devices 3 times in the water body being sampled. Try your best not to disturb the area you will be sampling. Pour out rinse water well away from the sampling location. If sampling a flowing water body, rinse the equipment downstream of the anticipated sampling location.

With as little disturbance to the water body as possible, dip the pole sampler or bucket directly into the water, and slowly turn the sample container so the opening is facing sideways. Be careful that the air trapped in the sampling container doesn't disturb the water too much. Submerse approximately 1 – 2" under the surface. Try and take a sample in a location that is at least 2 feet deep while collecting as much of the surface scum (if present) as possible. Avoid stirring up dirt and other debris. Collect enough water to fill the 1 gallon container.

Gently pour the sample into the sealable container. Gently swirl the bucket while pouring to homogenize the sample. If using a glass or PETG container, fill approximately halfway full with homogenized sample. Place the container in a cooler with plenty of ice. Ensure that the container has limited access to sunlight—sunlight will cause degradation of chlorophyll and diminish the integrity of the data. Wrap aluminum foil around the container if you anticipate opening the cooler several times before delivery to the lab.

SHIPPING/DELIVERING SAMPLES

See "Reporting Harmful Algal Blooms" for instructions about what samples DEQ will receive. Before delivering samples to the Water Quality Lab, contact DEQ at (501) 682-0744 to make sure there will be someone available to receive the samples.

Keep the sample cool and try to get it to the DEQ within 36 hours of collection.
If shipping your sample by mail, use overnight delivery and send it to:

> ATTN: Water Planning HAB
> Arkansas Energy and Environment
> Division of Environmental Quality
> 5301 Northshore Drive
> North Little Rock, AR 72118-5317

Samples **must be** accompanied by a Chain of Custody and a datasheet (Appendix 5).

On the Chain of Custody, "Sample ID" can be 1, 2, 3 etc. but must come with the time and location collected. Ensure that the "Sample ID" matches the description on the sample bottle. Masking tape and a permanent marker works well for samples that will be on ice. If the samples are being sent via mail, note the carrier company in the "Received by" box. Otherwise, **the Chain of Custody has to be signed anytime it is exchanged to a different handler.**

JAR AND STICK TEST

(Austin et al., 2018)

If you are unsure about collecting a sample for testing, the HAB Workgroup recommends performing a Jar and Stick Test. The Jar Test (Appendix 7) entails collecting a water sample in a quart size mason jar and letting it sit in the refrigerator overnight. To collect the sample, wear disposable gloves and fill the jar approximately 1/4 to 1/2 full.

- If the algae settle to the bottom of the jar, this is an indication of green algae.
- If the algae form a ring at the top of the water in the jar, then this is an indication that cyanobacteria are present in the water.

The Stick Test is performed by pushing a stick into the surface algal scum or mat of concern and then lifting the stick out of the water.

- If the stick pulls up strands that look like green hair or thread, then the algal mat likely consists of filamentous green algae.
- If the stick comes out looking like it had been stuck into a can of paint, then the algal mat likely consists of cyanobacteria.

These tests can provide a quick and easy way for determining if an algal bloom consists of cyanobacteria and thus having the potential to produce toxins. However, not all cyanobacteria produce toxins, and the verdict is still out about whether a cyanobacterial bloom should be considered a HAB if toxins are not present. Water testing is the only sure way of knowing if toxins are present. The AWRC's Water Quality Lab and DEQ are able to test public waters for the presence and concentration of cyanobacterial toxins. If using AWRC, contact the AWRC Water Quality Lab or DEQ directly for a sample bottle and instructions on how to collect your sample for testing. See page 14 for collecting and delivering samples to DEQ. If collecting on a private water body, see page 13 for a list of labs that analyze cyanotoxins for a fee.

RECOMMENDED ACTIONS

Although it may depend on the resources available to the lab, the recommended first step in acquiring a cyanobacterial sample is to determine algal species present and to categorically estimate abundance. A sample can quickly be checked using a Sedgwick Rafter Counting Chamber and a compound microscope. A sample that is dominated by cyanobacterial species is a good candidate for cyanotoxin testing. If the lab has the resources, it is recommended that the phytoplankton be preserved and settled for quantitative counting using inverted microscopy (Utermohl, 1931). Counting by inverted microscopy can take several hours for both sample sedimentation and counting. It is not recommended that lake managers wait for cell count data before making a management decision. However, these counts can be useful for determining how long monitoring for the event should continue.

Toxin measurement and phytoplankton counting methods may vary among labs, and lab personnel should coordinate with the HAB Workgroup to ensure comparable methodologies. The Arkansas HAB Workgroup has agreed upon using the 2019 EPA recommended values of 8 and 15 µg/L for microcystins and cylindrospermopsin advisories and closures, respectively (see "Avoiding Exposure").

Because sample analysis is relatively costly (>$100 per sample) and time consuming (6-8 hours for sample processing and analysis), the HAB workgroup recommends screening the sample with Microcystin or Cylindrospermopsin Abraxis Strip Tests. Abraxis Strip tests are a semi-quantitative way of estimating the magnitude of cyanotoxins in a water sample. They are a quick and cost-effective (about $25 per sample) way of detecting the presence or absence and relative concentration of microcystins and cylindrospermopsins. Specific instructions for strip tests are included in every order from Abraxis.

If Abraxis Strip Tests indicate that microcystins or cylindrospermopsin is present in a sample, the HAB workgroup recommends more quantitative analysis with Abraxis test kits, liquid chromatography-mass spectrometry (LCMS), high-performance liquid chromatography (HPLC) or other approved methodologies. For samples sent to DEQ, results will be reported according to what the lab sampling schedule permits, typically less than a 10-day period depending on when the sample is delivered.

Samples sent to fee-based labs may have faster turn-around times. Results of phytoplankton counting, toxin strip tests and/or quantitative analysis at DEQ (whatever is applicable for the sample) will be recorded on the Arkansas CyanoHaB Collection and Analysis Log (Appendix 6). Labs that do their own testing are welcome to use this format for their records as well. This may aid in consistent reporting and recording of HAB events in the state.

Currently, the data available linking cyanobacterial cell counts to negative health effects is scarce. Cell counting can also vary widely by equipment and expertise. Therefore, the Arkansas HAB Workgroup has chosen not to use cell counts for recommending actions, but as a metric to determine continued monitoring of cyanotoxins. A document from the World Health Organization published in 2003 recognized cyanobacterial cell counts of 20,000 – 100,000 cells/mL as a "moderate risk" with anything above 100,000 cells/mL being recognized as a "high risk". If there is uncertainty regarding a decision to run toxins based on cell counts, the Arkansas HAB Workgroup recommends using WHO cell counts and chlorophyll *a* as guidance (Table 4). **It is at the discretion of the lake manager to alert the public to high cell counts in the absence of toxins.**

RELATIVE PROBABILITY OF ACUTE HEALTH EFFECTS	CYANOBACTERIA (cells/mL)	CHLOROPHYLL a (μg/L)	ESTIMATED MICROCYSTIN LEVELS (μg/L)[a]
Low	< 20,000	< 10	< 10
Moderate	20,000-100,000	10-50	10-20
High	100,000-10,000,000	50-5,000	20-2,000
Very High	> 10,000,000	> 5,000	> 2,000

Table 4. WHO recreational guidance values for cyanobacteria, chlorophyll a, and microcystin. Microcystin concentrations are derived from cyanobacterial cell density levels. (WHO, 2003)

PUBLIC EDUCATION

More than 1 million people per year visit some of the more popular reservoirs in Arkansas. Increased nutrient runoff and temperatures have been identified as contributors to an anticipated rise in harmful algal blooms. In order to protect public health and understand where and why these events occur, water resource managers rely on the public and local entities to report these occurrences. The HAB Workgroup recommends educating the public on site to prevent illness and increase reporting. It is recommended that water body managers place informational signs like the one found in Appendix 2 at boat ramps and swim beaches throughout the primary contact recreational season (May 1 – September 30) or whenever swimmers are present.

ADVISORY

Regardless of toxin concentration, presence, or absence, it is recommended that if a cyanobacterial bloom is visually identified, water resource managers communicate the risk to the public by issuing an advisory. Water samples should be collected ASAP. Each sample should be reported as total toxins, which will require cell lysis. If total toxins are below EPA recommended 8 μg/L microcystins and 15 μg/L for cylindrospermopsin, the Arkansas HAB Workgroup recommends continued monitoring until the bloom dissipates. Monitoring should continue as often as possible, but not longer than every 2 weeks. If possible, a full suite of analytes should be collected (toxins, chlorophyll, nutrients, cell counts). Trends in additional analytes such as cell counts and chlorophyll over time can indicate if a system is moving toward or away from developing a worsening harmful algal bloom. If you are undecided about a continued monitoring plan, contact the Harmful Algal Bloom Workgroup to discuss next steps (habs@adeq.state.ar.us). Water body managers can use the ADVISORY sign provided in Appendix 3.

CLOSURE

The Arkansas HAB Workgroup recommends that total toxin values over the EPA recommended values of 8 μg/L and 15 μg/L microcystins and cylindrospermopsin, respectively, be treated as a closure. A closure notifies the public that there are elevated cyanotoxins present in the water body and that the area is closed to recreation in the water. Water body managers can use the CLOSURE sign provided in Appendix 3.

See Appendix 4 for a flow chart outlining recommended actions.

NOTIFICATION PROCEDURES

As mentioned in the previous section, public education and outreach is an important step toward reducing negative health effects of cyanoHABs. It is recommended that informational signs be placed in publicly accessible locations, especially on water bodies that have had a history of cyanoHAB events or tend to be more nutrient rich.

In the event of an advisory or a closure, it is important that all of the appropriate organizations, key people, and the public who would have used the water body are notified. Lake managers should prepare a list of contacts that might include local municipal governments, health agencies, veterinarians, community groups, etc. A template consisting of recommended contacts can be found in Appendix 1. It is recommended that you reach out to contacts before a cyanoHAB event notifying and confirming that they can be contacted during a possible cyanoHAB. This can reduce response time and help prepare local contacts for a cyanoHAB event. It is also recommended that your contact list be stored somewhere that's easily accessible.

Clearly marked signs should be posted around swim beach areas, public boat ramps, fishing piers, or other places where the public may have access to the water or its resources. Signs and other notifications should contain the following elements:

- Level of notification (closure, advisory, monitoring)
- List of unsafe activities
- Reason for notification (elevated cyanotoxins, suspected cyanoHAB event with monitoring underway, etc.)
- Location affected
- Potential consequences
- How to get more information
- Contact information

See Appendix 3 for examples of signs that can be issued during an advisory, closure, or suspected cyanoHAB event with monitoring underway.

It is important that notification measures be taken promptly and that signs remain in place until the advisory or closure changes. Ensure that signs are well maintained throughout the closure or advisory period.

Prepare to answer questions that the public and media may have. Some frequently asked questions include:

- What is a cyanobacterial bloom? What are the health effects of exposure to a bloom?
- What are you doing to "fix it?" What caused the bloom?

Other notification options include posting on social media or creating a press release.

APPENDIX 1
CONTACT LIST

The following is a template for water body managers to fill out. Establishing relationships with the organizations on your list of contacts can lead to a quicker response in the event that a harmful algal bloom does happen on your water body. Blank cells below are available for additional contacts.

ORGANIZATION	FUNCTION/ RESPONSIBILITY	CONTACT
Laboratory	Testing and analysis of cyanobacteria and toxins (see www.epa.gov/nutrient-policy-data/states-resources)	NAME: PHONE: EMAIL:
Poison Control	May receive illness calls and should be alerted	NAME: PHONE: EMAIL:
Emergency Medical Facilities	May need to provide medical services for people	NAME: PHONE: EMAIL:
Veterinary Facilities	May need to provide medical services for pets and livestock	NAME: PHONE: EMAIL:
Other Water Managers or Water body Users	Public drinking waters systems, other recreational locations, agricultural users	NAME: PHONE: EMAIL:
State Health Department	State-level organization that can provide health services	NAME: PHONE: EMAIL:

State Department of Homeland Security and Emergency Response (or its equivalent)	**Provide resources for large-scale environmental or public health issues, such as flooding, a large toxic bloom, or avian flu.**	**NAME:** **PHONE:** **EMAIL:**
State Waterborne Disease Coordinator	**Person within state public health agency to notify CDC of waterborne disease outbreaks**	**NAME:** **PHONE:** **EMAIL:**
Local Public Health Agency	**County-level organization that can provide health services**	**NAME:** **PHONE:** **EMAIL:**
Local Government	**Overall management of local resources and potential public notification responsibilities**	**NAME:** **PHONE:** **EMAIL:**
Media/ Communication Specialists	**Provide resources for large-scale environmental or public health issues, such as flooding, a large toxic bloom, or avian flu.**	**NAME:** **PHONE:** **EMAIL:**
Environmental Agency	**County or state level organization that can provide environmental monitoring and management services and collect information on blooms (for example, the state fish & wildlife service, the state parks and recreation department)**	**NAME:** Arkansas Division of Environmental Quality - Water Planning Section **PHONE:** 501.682.0947 OR 501.682.0744 **EMAIL:** habs@adeq.state.ar.us
Federal Partners/Agencies	**Regional personnel for US EPA, Centers for Disease Control and Prevention (CDC), US Army Corp of Engineers may be able to provide assistance and other federal agencies may be impacted, for example the National Park Service, depending on the location and nature of the bloom.**	**NAME:** **PHONE:** **EMAIL:**

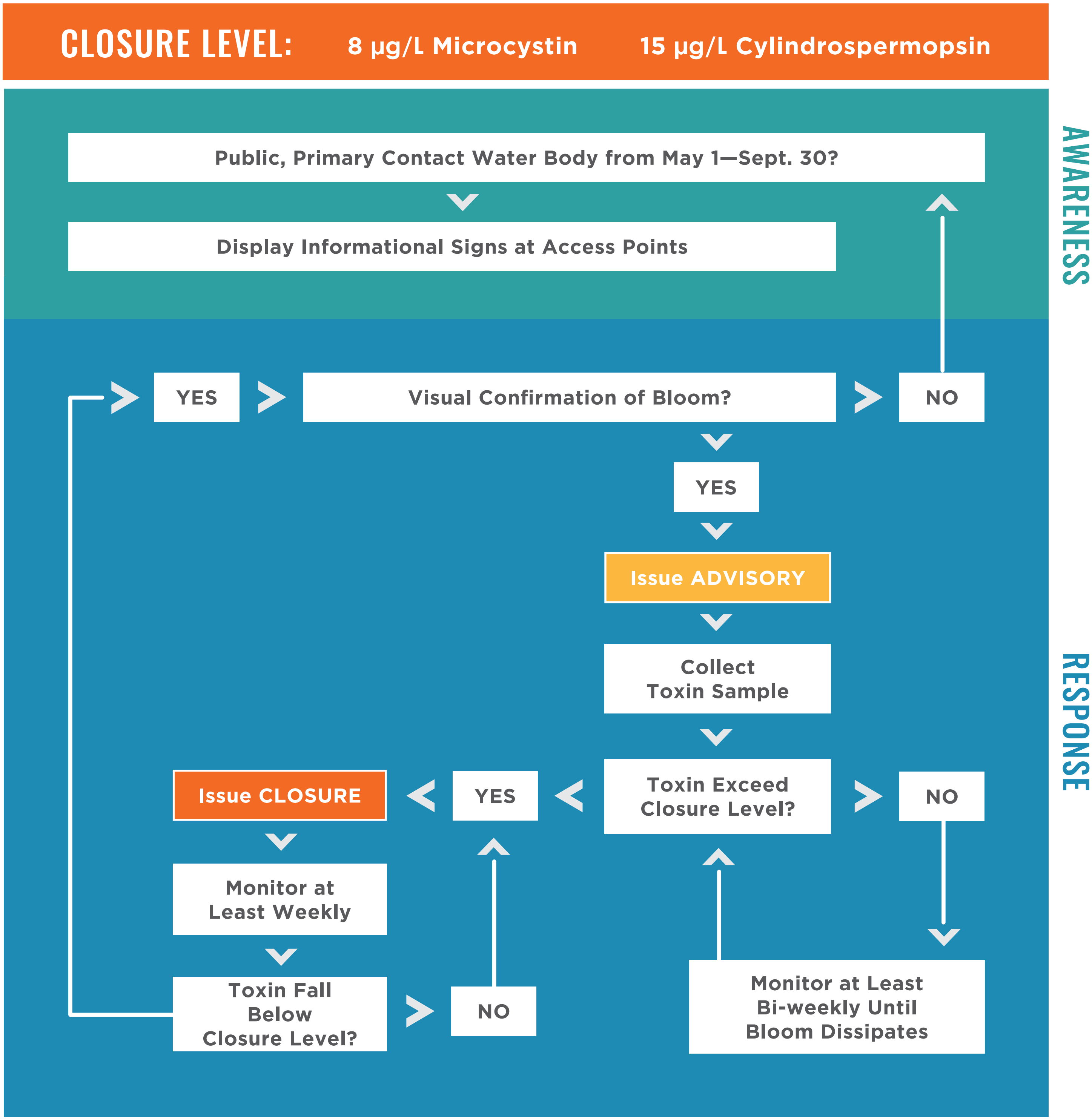
APPENDIX 2
INFORMATIONAL SIGN EXAMPLE

APPENDIX 3

ADVISORIES AND CLOSURE SIGNS EXAMPLE 1

ADVISORIES AND CLOSURE SIGNS EXAMPLE 2

APPENDIX 4
ARKANSAS RECREATION HAB RESPONSE PLAN DIAGRAM



APPENDIX 5

HAB CHAIN OF CUSTODY SHEET

PAGE 1 OF 2

DIVISION OF ENVIRONMENTAL QUALITY
CHAIN-OF-CUSTODY

Date		Sampler (print)	
Site Identification			
Site Address			

Sample ID	Sample Remarks	Time (hhmm)	Latitude	Longitude	Lab ID

Lab Use Only: Custody seal on each container ?: YES NO Labels/COC agree ?: YES NO

Date/Time	**Relinquished By**	**Received By**
Date	Name/Title	Name/Title
Time	Signature	Signature
Date	Name/Title	Name/Title
Time	Signature	Signature
Date	Name/Title	Name/Title
Time	Signature	Signature
Date	Name/Title	Name/Title
Time	Signature	Signature

Legal COC Form
Revision 002

Effective Date: 10/1/2019

HAB CHAIN OF CUSTODY SHEET
PAGE 2 OF 2

ARKANSAS ENERGY & ENVIRONMENT | ENVIRONMENTAL QUALITY

Division of Environmental Quality
Lab Data Requisition Form for Titan
For Non-enforcement Samples ONLY

Rev.1 Effective date October 1, 2019

Sample Collectors:	ADEQ Division or Other:	Project Name:	Work Order #	Avg Temp (°C) Upon Receipt:	Received on Ice YES NO

Lab Number	Sample ID	Date (mm/dd/yy)	Time (hh:mm)	Gage/Flow	DO (mg/L)	pH	Water Temp (°C)	SC (Cond) (uS/cm)	Turb (NTU)	Sample Remarks	E.Coli cfu/100ml	Fecal cfu/100ml

HAB FIELD DATASHEET

Harmful Algae Bloom Field Datasheet

Water body name:

Collector(s) and affiliation(s):

Has this incident been reported on the DEQ HAB complaint website?

○ Yes ○ No

Have you contacted ADEQ to arrange sample drop off/shipment?

○ Yes ○ No

Date/Time :	Latitude:	Longitude:

Precipitation :
○ None ○ Light ○ Heavy

Surface Conditions:
○ Flat ○ Ripples ○ Choppy ○ Whitecaps

Cloud Cover ○ 0% ○ 25% ○ 50% ○ 75% ○ 100%

Odor: ○ Yes ○ No Description:

Scum: ○ Yes ○ No Description:

Please add a full description of the bloom including pictures, if possible, during time of sampling. Include location of sampling relative to the shoreline.

APPENDIX 6

ARKANSAS CYANOHAB COLLECTION AND ANALYSIS LOG

PAGE 1 OF 2

Arkansas CyanoHAB Collection and Analysis Log

Instructions: Fill out to best ability where applicable. If not applicable, put N/A. Avoid leaving questions unanswered. Include measuring units where needed.

Sample Collection

Date of Notification: _______________ Date of Collection: _____________________

Collected by: _____________________ Collector Affiliation: ____________________

Collector Phone Number: ____

Water body type: O Lake O Pond O River O Other _______________________________

Public Access: (Y) (N)

Collection Location: ____

Dipstick test performed in field? (Y) (N)

If (Y) describe results: O Microcystin ______________________________________

O Cylindrospermopsin ________________________________

Collection Method: O Grab sample O Integrated sample (depth __________)

O Other (describe) ______________________________________

Secchi depth: ____________

In situ meter? (Y) (N) In situ meter type: _________________________________

In situ surface (0.1 - 0.5 m) readings:

Depth__________ Temp.___________ pH___________ DO_____________

Scum present? (Y) (N) Approx. vol. of water colected: _________________________

Mode of delivery to lab: ____

Sample Processing: For Lab use only

Received by: __________________________ Institution: ____________________________

Received on: __________________________

Temperature upon Delivery: ____________

Processed for:

Live phytoplankton? (Y) (N)

Taxonomy & relative abundance: _______________________________________

Dipstick test performed in lab? (Y) (N)

If (Y): O Microcystin ____

O Cylindrospermopsin ___________________________________

Chlorophyll	(Y)	(N)	Volume filtered_______________
Phycocyanin	(Y)	(N)	Volume filtered_______________
Phytoplankton (preserved)	(Y)	(N)	Preservative_________________
Cyanotoxins	(Y)	(N)	
Nutrients	(Y)	(N)	
TOC	(Y)	(N)	

ARKANSAS CYANOHAB COLLECTION AND ANALYSIS LOG
PAGE 2 OF 2

Sample Analysis (include units): For lab use only

Technician(s): ____

Chlorophyll: ____________________________

Phycocyanin: ____________________________

Cyanobacteria spp. present (preserved sample): ____________________________

____

Cyanobacteria cell count: ____________________________

Cyanobacteria biovolume: ____________________________

Microcystin value: ____________________________ Curve QC: (P) (F)

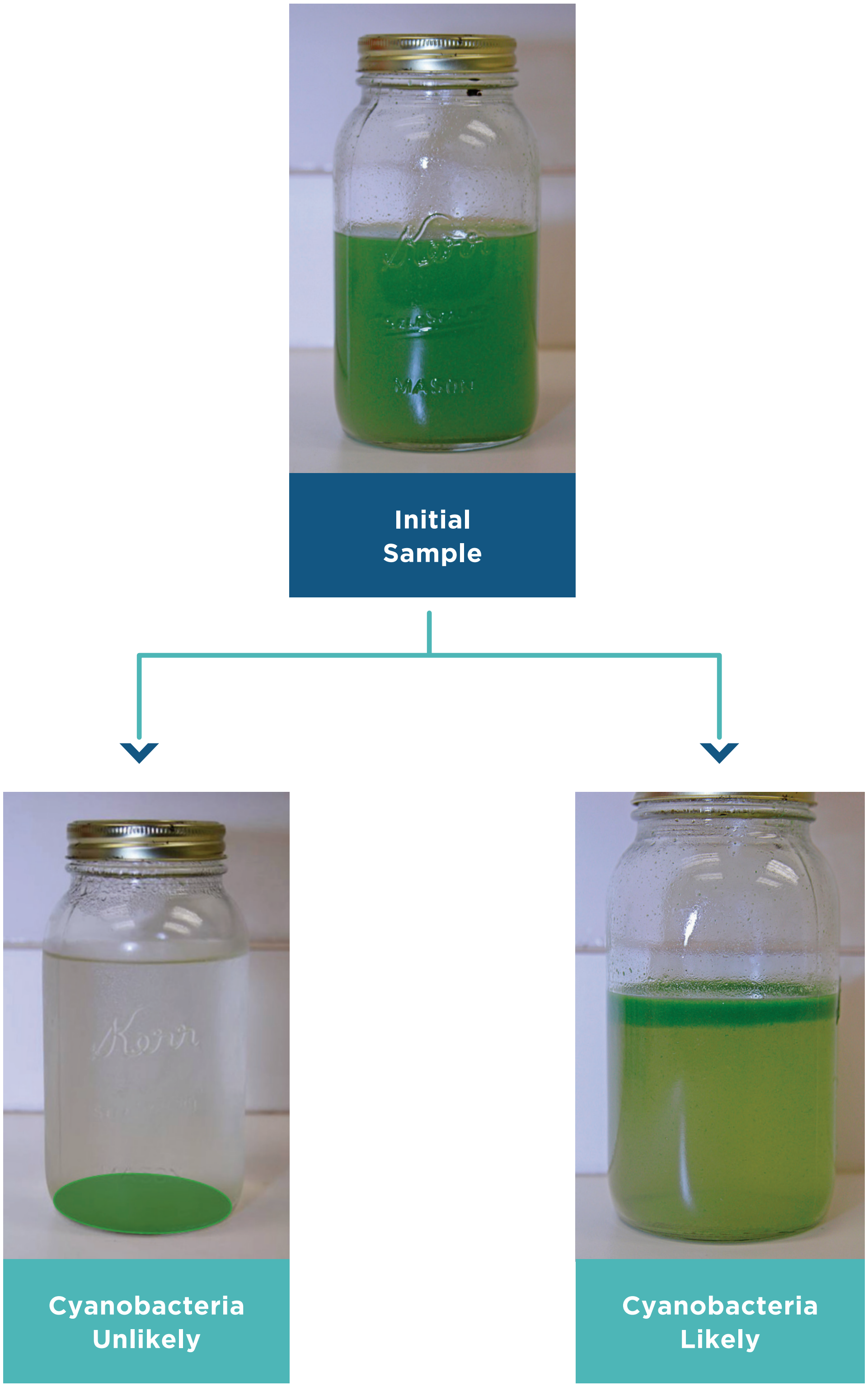
Cylindrospermopsin value: ____________________________ Curve QC: (P) (F)

Other toxins analyzed? ____________________________ Curve QC: (P) (F)

Notes

____

APPENDIX 7
JAR TEST (KDHE, 2019)



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