GUIDE FOR PUBLIC HEALTH RESPONSE TO CYANOBACTERIAL HARMFUL ALGAE IN RECREATIONAL FRESHWATER IN TEXAS

PREPARED BY TOXIC SUBSTANCES COORDINATING COMMITTEE HARMFUL ALGAL WORKGROUP

REVISED FEBRUARY 2024

The members of the Toxic Substances Coordinating Committee Harmful Algal Workgroup thank the following agencies/programs for their participation and continued interest in this joint project:

- Texas Parks and Wildlife Department (TPWD)
- Texas Department of State Health Services (DSHS)
- Texas General Land Office (GLO)
- Texas Commission on Environmental Quality (TCEQ)
- Texas Animal Health Commission (TAHC)
- National Oceanic Atmospheric Administration (NOAA)
- United States Geological Survey (USGS)
- Texas Poison Center Network (TPCN)
- Texas A&M University Corpus Christi

Contact: DSHS Environmental Surveillance and Toxicology Branch 1-888-681-0927, **epitox@dshs.texas.gov**.

Harmful Algal Bloom in West Guth Park Corpus Christi, Texas (May 2020)

Table of Contents

List of Figures

List of Tables

Purpose

In Texas, responses to cyanobacterial harmful algal blooms (HABs) in water bodies fall on local governments and health departments. Since there are no state regulations on cyanobacterial HABs, appropriate responses to protect public health are often not clear. The purpose of the *Guide for Public Health Response to Cyanobacterial Harmful Blooms in Recreational Fresh Water of Texas* is to provide statewide guidance for responding organizations, including local governments, local health departments, waterbody managers, and others, for use if a lake, river, stream, pond, or other type of freshwater system may be impacted by cyanobacterial HABs.

The objectives of the guidance are to provide:

- tools for identification of cyanobacterial HABs;
- ways to protect humans and animals from HABs in recreational fresh water;
- assessment tools to determine public health risk from cyanobacterial HABs;
- tools to allow communities to develop appropriate responses to protect public health and safety;
- guidance for public information strategies; and,
- Appropriate contact information if additional state or federal resources are needed.

This is not statewide policy, but serves as a guidance document. The information in this document is gathered from other states and federal agencies that have established HAB guidelines.

Introduction

Certain environmental conditions can cause algae to reproduce rapidly in bodies of fresh and marine water causing algal blooms. These blooms have the potential to cause harm to human health or aquatic ecosystems known as harmful algal blooms or HABs. In freshwater, cyanobacteria (also known as blue-green algae) can produce HABs because some cyanobacteria can produce toxins. Cyanobacterial HABs and their toxins can harm people, animals, or the environment.

Cyanobacteria HABs can be found on the surface of fresh water (planktonic cyanobacteria) or growing on the bottom of the water (benthic cyanobacteria) or near the surface growing on submerged vegetation or debris (benthic cyanobacteria). They may be visible as scums, mats, and discolorations of water. Cyanobacteria can form blooms at specific light intensities and depths. Certain

conditions, such as warm and still water, high nutrient levels, and abundant sunlight can make these organisms reproduce rapidly (Gilbert et al. 2018). However, benthic cyanobacteria can also proliferate in clear waters with low nutrient levels, conditions that allow penetrating light to reach bottom substrates (WHO 2021, Wood et al. 2020).

Toxins produced by multiplying cyanobacteria generally stay inside the cells, but some toxins may leak out into the surrounding water, especially if the bloom has been growing over a long time. Cyanobacteria also can release toxins into the water when their cells die and break apart. However, cyanobacteria do not always produce cyanotoxins, and the environmental conditions that cause cyanotoxin production are not fully understood. Therefore, visual identification of a bloom does not necessarily correlate with toxicity. In addition to toxic effects, the high biomass of blooms can kill fish and plant populations by causing low oxygen levels in the water column or by blocking sunlight needed by animals and plants in the water body.

While no human deaths are known to have been caused by cyanobacteria in the United States, cyanobacteria have been implicated in human illness, animal illness, and death in at least 43 states across the country, including Texas (USGS 2017). In 2021, 16 states voluntarily reported 368 HABs to the Centers for Disease Control and Prevention (CDC) One Health Algal Bloom System (OHHABs). These HABs resulted in a total of 117 human illnesses and at least 2,715 animal illnesses (CDC 2021). Because of the differing characteristics and potential health risks of cyanotoxins, it is recommended that local governments and health departments monitor and investigate algal blooms as described in **Figure 4** and take appropriate measures to protect public health and the environment.

Cyanobacterial Toxins

Each cyanobacterial toxin can be produced by more than one cyanobacterial genus (or group marked by common characteristics), and the same genus can produce more than one toxin. Some cyanotoxins are toxic to the liver while others are neurotoxins, which attack the nervous system. Cyanotoxins fall into three groups of chemical structure which include cyclic peptides, alkaloids, and lipopolysaccharides (Table 1) (WHO 1999).

Table 1. List of various cyanobacteria, their toxins, and primary target organs.

Chemical structure	Cyanotoxin group	Primary organ affected	Cyanobacteria producing toxin
Cyclic peptides	Microcystins	Liver, kidney, heart and gills	*Microcystis, Anabaena (Dolichospermum), Planktothrix (Oscillatoria), Nostoc, Hapalosiphon, Anabaenopsis*
	Nodularin	Liver, kidney, heart and gills	*Nodularia*
Alkaloids	Anatoxins	Nervous synapse	*Anabaena (Dolichospermum), Planktothrix (Oscillatoria), Aphanizomenon, Microcoleus (Phormidium)*
	Guanitoxin (*Formerly Anatoxin-a(s)*)	Nervous synapse	*Anabaena*
	Aplysiatoxins	Skin	*Lyngbya, Schizothrix, Planktothrix (Oscillatoria)*
	Cylindrospermopsins	Liver and kidney	*Cylindrospermopsis, Aphanizomemon, Umezakia*
	Lyngbyatoxin-a	Skin and gastrointestinal tract	*Microseira (Lyngbya(*
	Saxitoxins	Nervous axons	*Anabaena (Dolichospermum), Aphanizomenon, Lyngbya, Cylindrospermopsis*
Lipopolysaccharides (LGS)	N/A	Potential irritant; affects any exposed tissue	All

Common freshwater cyanotoxins in the U.S. include microcystins, cylindrospermopsins, anatoxins, and saxitoxins.

In Texas, cyanobacterial blooms do not appear to be as common as other states, and there are few records of their occurrence over the last 20 years. However, it's possible that cyanobacterial blooms have occurred and not been reported. In past 5 years, increases in cyanobacterial blooms in Texas appear to be occurring. For instance, the United States Geological Survey (USGS) monitored Lake Houston from 2006 to 2008 and identified microcystins in 16% of samples at concentrations at or less than 0.2 micrograms per liter (µg/L) (USEPA 2019b). In February through April of 2012, the Grayson County Health Department took water samples from Lake Texoma and found concentrations of cylindrospermopsin ranging from 0.1 to 0.6 µg/L. They also detected other toxins, such as anatoxin-a, microcystins and saxitoxins (Lillis et al. 2012). From 2016 to 2018, the USGS detected cyanotoxins in more than 42% of samples collected from reservoirs across the state (Trevino and Petersen 2020). While microcystins were detected in more than 31% of the samples. In August 2019, a cyanobacterial bloom in Lady Bird Lake in Austin, Texas sickened and killed several dogs (COA 2023). City of Austin has detected HABs on Lady Bird Lake each year since 2019. The USGS Texas Water Science Center currently works in cooperation with river authorities, municipalities, groundwater districts and state and federal agencies to evaluate and track algal blooms and to provide scientific information to resource planners and managers.

Routes of Exposure and Symptoms

Humans

The public may be exposed to cyanotoxins in recreational fresh water by accidental ingestion, dermal contact, or inhalation of tiny airborne droplets or mist during activities such as swimming and wading (Chorus et al. 2010) (Table 2).

Table 2. Recreational exposure pathways to cyanobacteria. (Stone and Bress 2007).

Exposure Potential	Activity	Exposure Pathway
High	Swimming, diving	Ingestion / skin
	Water skiing / wake boarding / jet skiing	Ingestion / inhalation / skin
	Wind Suring	Ingestion / inhalation / skin
Moderate	Fish / shellfish consumption	Ingestion
	Paddling / rowing / sailing	Skin
Low to none	Motor boating	Skin
	Catch and release fishing	Not applicable
	Hiking / sight seeing	Not applicable

Another route of exposure is the consumption of fish caught from cyanotoxin contaminated water (Buratti et al. 2017). Although there have been no reports of people becoming sick from eating freshwater fish caught during a HAB, fish organs should be discarded before consumption and fillets rinsed with tap or bottled water to avoid cyanotoxin exposure. Studies have shown that microcystins bioaccumulate up to 20 times in fish liver and other internal organs compared to fish muscle (Buratti et al. 2017).

If you think you have been exposed to a harmful algal bloom:

- Watch for symptoms
- Call the Texas Poison Center Network at 1-800-222-1222
- Consult with your primary physician

Cyanotoxins can cause many different types of adverse health effects that vary from mild to severe. The type and severity of the adverse health effects depend on factors such as the amount and type of toxin, and the route and length of exposure to the toxin. The specific short-term and long-term health effects are difficult to predict because there is limited information on human health effects following cyanobacterial exposure (Koreiviene et al. 2014). Generally, people exposed to cyanotoxins through inhalation or direct skin contact could experience skin, eye, nose, throat and general respiratory irritation. People who ingest high levels of cyanotoxins could experience vomiting, diarrhea, headaches, abdominal pain, and

neurological symptoms, such as loss of coordination and muscular twitching. Long-term exposure can lead to liver and kidney damage (Table 2) (CDC 2017).

Children are at higher risk for illness from exposure to toxins than adults because they can ingest a large dose of toxin relative to their size and body weight. They are also more likely to play in thick blooms near the shoreline.

Individuals who believe they may have been exposed to HABs and are concerned about their health should immediately contact their healthcare provider, or the Texas Poison Center Network at 1-800-222-1222.

Animals

Pets (e.g., dogs, cats), livestock (e.g. sheep, cattle), and wildlife (including birds and mammals) can be exposed to cyanotoxins through direct contact, drinking contaminated water, or ingesting algal mats. Dogs are at greater risk than people because they are more likely to drink contaminated water, swim in it, and ingest algae or scum from their fur after swimming. Animals exposed to cyanotoxins could experience symptoms such as vomiting, fatigue, excessive salivation, difficulty breathing, and neurological symptoms, such as convulsions and staggered walking (Table 2). Liver failure and death can occur hours to days following exposure to high levels of cyanobacterial toxins (CDC 2017).

If you think your pet has gotten into a harmful algal bloom
• Rinse them off immediately with fresh water • Don’t let the animal lick its fur • Watch for symptoms • Call a veterinarian

Animal owners should contact their veterinarians with concerns. They may also call the ASPCA Animal Poison Control Center at 1-888-426-4435 or the Pet Poison Helpline at 1-855-764-7661, if they have questions about their animal (there is a fee for these calls).

Table 3. Possible symptoms in humans and animals after cyanotoxin exposure (CDC 2017).

Human symptoms	Animal symptoms
Skin, eye, nose, and throat irritation **Vomiting and diarrhea** **Headaches** **Abdominal pain** **Neurological symptoms** **Liver and kidney damage**	Vomiting Fatigue Excessive salivation Difficulty breathing Convulsions Staggered walking Liver failure Death

How to Identify and Report a Cyanobacterial HAB

Cyanobacterial blooms can look like thick pea soup or spilled paint on the water's surface (Figure 1). It can create a thick mat of white or gray foam along the shoreline. Cyanobacteria are generally green or turquoise (cyan) in color but can also appear red or gold. A bloom may be made up of small specks floating on or just beneath the surface. Cyanobacterial benthic mats, also known as benthic cyanobacterial proliferations, may also occur under the surface or floating on top of the water, appearing as scum or blobs (Figure 2) (Wood et al. 2020). The color of the benthic mat may be brown or dark brown. Cyanobacterial HABs can often be confused with non-toxic algae and plants. Figure 1 provides guidance on the key visual differences between cyanobacterial HABs and non-toxic algae and plants (CWB 2020). However, laboratory tests are the only way to tell if a cyanobacterial HAB is producing toxins.

The public can report potential cyanobacterial HABs to the local health authority (LHA) or waterbody authority (such as the river authority or the U.S. Army Corps of Engineers; see Appendices G and H). Local health authorities may also be contacted using the 311-phone service.

When reporting a cyanobacterial HAB, it is helpful to provide information such as the waterbody name or location, the location of the bloom, and other general observations, as well as photos. These details can be used to track the HAB and its impact. For more information on taking photos of HABs, see Appendix A of this document. Table A5 in Appendix J provides examples of information that are useful in a HAB report.

Local health authorities or other agencies responding to HABs have the option to assist DSHS with reporting HABs to the CDC OHHABS. OHHABS collects reports on HAB events and associated human and animal illnesses as part of a national database to better understand the science and responding to HABs. See Appendix J for more information on OHHABS and what details are needed for reporting.

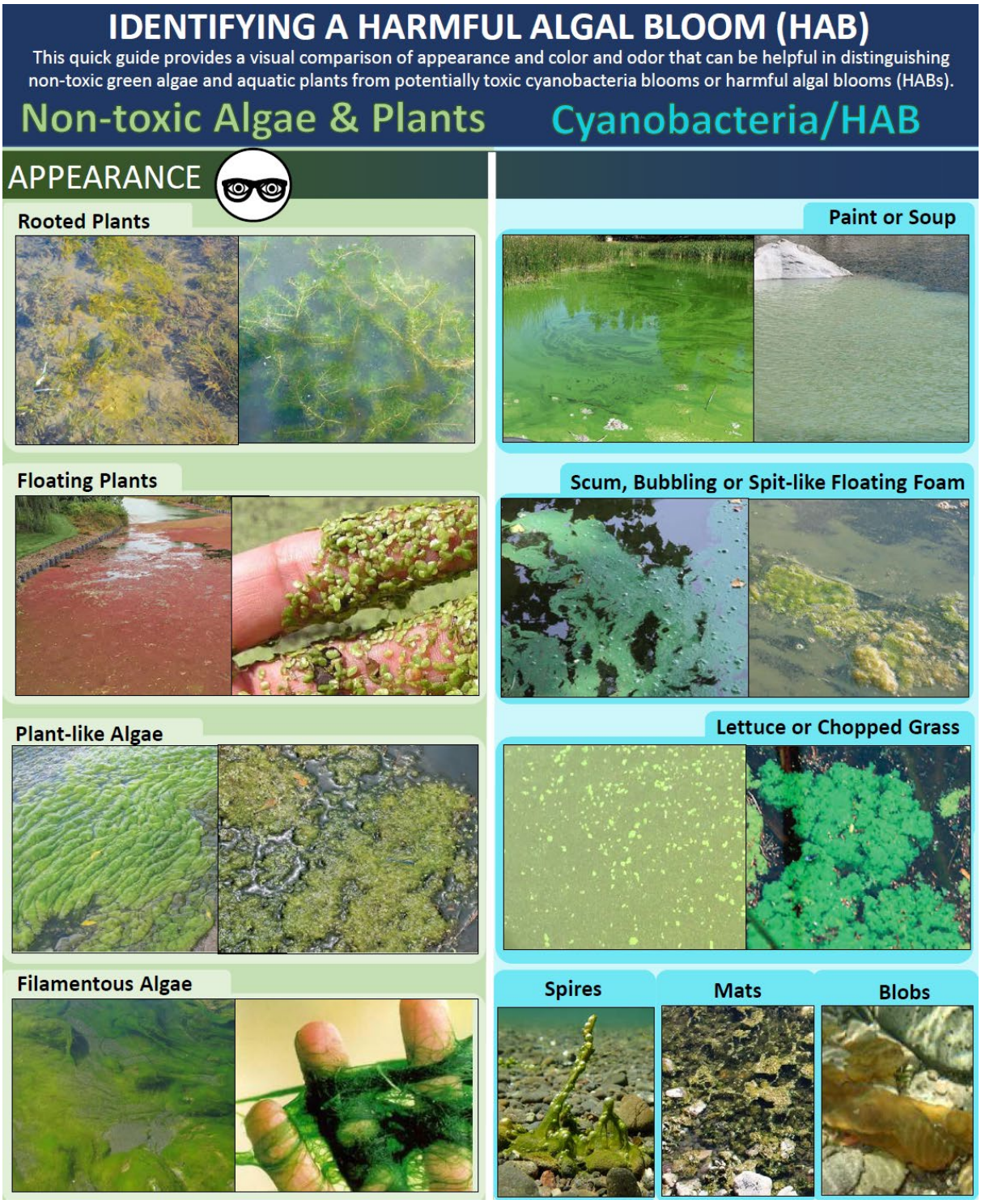


Figure 1. Identification of a cyanobacterial harmful algal bloom (CWB 2020).

Figure 2. Benthic algal mats, also known as benthic proliferations, and scum from Lake Travis, TX, March 2021. Photos courtesy of Lower Colorado River Authority.

Sampling and Analysis

Cyanobacterial HABs cannot be identified based on visual observation alone; they need to be monitored and evaluated using samples analyzed by a laboratory to confirm the presence and concentration of cyanotoxins. Worldwide, about 75% of algal bloom samples tested contained toxins. It is likely that this is an underestimation because algal blooms have a highly variable distribution, horizontally, vertically and over time. Wind, for instance, can drive them to other locations (Buratti et al. 2017). It is also important to note that many species produce cyanotoxins, mainly microcystins, that are contained in the cells and are released into the water after cell destruction (lysis). Other species release toxins during both their growth period and cell death (Chorus et al. 2010). Therefore, it is important to sample bodies of water that are used for recreational purposes, when there is evidence of a HAB. Detailed sampling methods are described in Appendix B for planktonic blooms and Appendix C for benthic blooms.

Planktonic cyanobacteria

Following visual detection of a potential planktonic cyanobacterial HAB, cyanobacterial HAB can be confirmed by the number of cyanobacterial cells, the presence of cyanotoxins, and presence of photosynthetic pigments such as phycocyanin, which is unique to cyanobacteria, in the water sample (WHO 1999).

Benthic cyanobacteria

Benthic algal mats have different issues to consider than a planktonic bloom. Because toxins are typically contained in the algal cells and not in the water, the water sample analysis alone is not sufficient to evaluate benthic mats (ITRC 2023B, Wood et al. 2020). Sampling the mat material and testing it for cyanotoxins is necessary to identify if benthic mats may pose a hazard to human and animal health. There is not a threshold value for cyanotoxin concentration in the algal tissue that would trigger a warning or danger advisory. Instead, the presence of cyanotoxins is the best indicator for the LHA to decide whether to issue a warning advisory. Anatoxin-a and dihydroanatoxin-a are typically the cyanotoxins associated with toxic benthic algal mats. See Appendix C for information on benthic cyanobacteria.

Analysis of samples

There are several screening tests and laboratory methods to detect and identify cyanobacterial cells and cyanotoxins in water. A list of laboratories that can conduct analytical tests is provided in Appendix D. This non-exhaustive list is not intended to provide specific approval or recommendations of laboratories.

Quick laboratory methods for monitoring large numbers of water bodies or sampling sites have been developed. One standardized method for cell density involves counting a 0.5 milliliter (ml) sample of water for two minutes and determining the number of cyanobacterial units present. This gives the number of cells per ml (cells/ml) of water. Microscopic direct enumeration of cyanobacteria assesses the presence of organisms that could potentially produce toxins (WHO 1999).

These are several methods recommended by EPA to analytically determine concentrations of cyanotoxins in water (expressed as micrograms per liter; mg/L):

When testing a water sample for microcystins and nodularins:

- Liquid chromatography/tandem mass spectrometry (LC/MS/MS) in ambient freshwater (USEPA 2017b).
- Enzyme-linked immunosorbent assay (ELISA) in drinking water and ambient water (USEPA 2016).

When testing a water sample for cylindrospermopsin and anatoxin-a:

Liquid chromatography/tandem mass spectrometry (LC/MS/MS) in ambient freshwater (USEPA 2017a).

For more information on setting up a monitoring plan for a HAB event, resources are available on the Interstate Technology Regulatory Council (ITRC) website (https://itrcweb.org/home). See Strategies for Preventing and Managing Harmful Cyanobacterial Blooms (HCB-1) for planktonic blooms and Strategies for Preventing and Managing Benthic Harmful Cyanobacterial Blooms (HCB-2) for benthic blooms (ITRC-A 2023, ITRC-B 2023).

Guidelines and Advisories

Recreational Water

Two-tiered approach to protect public health during an HAB event in a recreational water body

This guideline proposes a two-tiered approach to respond to and manage cyanobacterial HABs in freshwater. The type of advisory issued should be based on the recommendations in Tables 1 and 2 and the decision flow chart (Figure 3). Advisories will rely on visual observations and determinations of cyanobacterial cell density and cyanotoxin concentration with different methods for planktonic or benthic HABs.

Outreach and educational efforts will encourage the public to notify their LHA or waterbody authority when a potential bloom is observed. Observers should look for

surface accumulations and developing blooms. Scum formations and blooms are transitory in nature; therefore, a notification should be made as soon as possible. Upon notification, the LHA should coordinate with state and local partners to determine if sampling and testing is needed. After results are received, the LHA should decide which advisory tier, if any, is warranted.

Benthic HABs

As best practice, the LHA can investigate the benthic bloom looking for algal mats under the water surface, floating on the surface of the waterbody, or accumulated on the shore. A caution advisory may be issued if the description of the algal mat material is consistent with a potentially toxic cyanobacterial algal mat. Further investigation to visually confirm cyanobacterial algal mat material, identify algal genera as potentially cyanotoxin producing or laboratory analysis to detect cyanotoxins in algal material can be used to issue a warning or danger advisory for toxic benthic algal mats.

Tier I – Caution Advisory

A caution advisory should be issued based on visual reports of a bloom, reports of animal or human illness, or water samples with cyanobacterial density or cyanotoxin concentrations below "warning advisory" levels (Table 4). People should use caution when in contact with the body of water and avoid areas of algae accumulation (Appendix E). Caution signs should be posted at all primary public access locations and include the following information:

- Cyanotoxins may be present, and the water may be unsafe for people and animals.
- Discourage people from having contact with the water with visible algal blooms.
- Keep pets away from either drinking or swimming in affected water. Pets should not lick the algae off their fur or eat dried algae. Pets should be rinsed off with clean water.
- If fish are caught where HABs may be present, all internal organs should be removed prior to consumption and fillets rinsed with clean water.
- Contact information for the posting authority.
- Date of the posting.
- What to do in case of contact with the water.
- Who to call in case of both human and animal illness related to potential exposure.

Tier II – Warning Advisory

A warning advisory should be issued if one or more of the following conditions are true (Table 4):

- Cyanobacteria cell density is greater than or equal to 20,000 cells/mL.
- Microcystin concentrations are greater than or equal to 8 µg/L.
- Cylindrospermopsin concentrations are greater than or equal to 15 µg/L.
- Anatoxin-a concentrations are greater than or equal to 60 µg/L.
- Anatoxin-a is detected and benthic algal mats are present.

It is recommended that actions be taken over and above those listed for the Tier I – Caution Advisory. Signs should include the following information:

- Cyanotoxins are present, and the water is unsafe for people and animals.
- Restrict swimming, water skiing, boating and other activities that would involve direct, incidental, or accidental contact with the affected water.
- Warn owners not to allow pets to drink or swim in the water. Pets should not lick the algae off their fur or eat dried algae. Pets should be rinsed off with clean water.
- If fish are caught where HABs may be present, all internal organs should be removed prior to consumption and fillets rinsed with clean water.
- Contact information for the posting authority.
- Date of the posting.
- What to do in case of contact with the water.
- Who to call in case of both human and animal illness related to potential exposure.
- If benthic algal mats are present, include warnings to keep people and pets away from algal material.
- Consider closure of recreational areas.

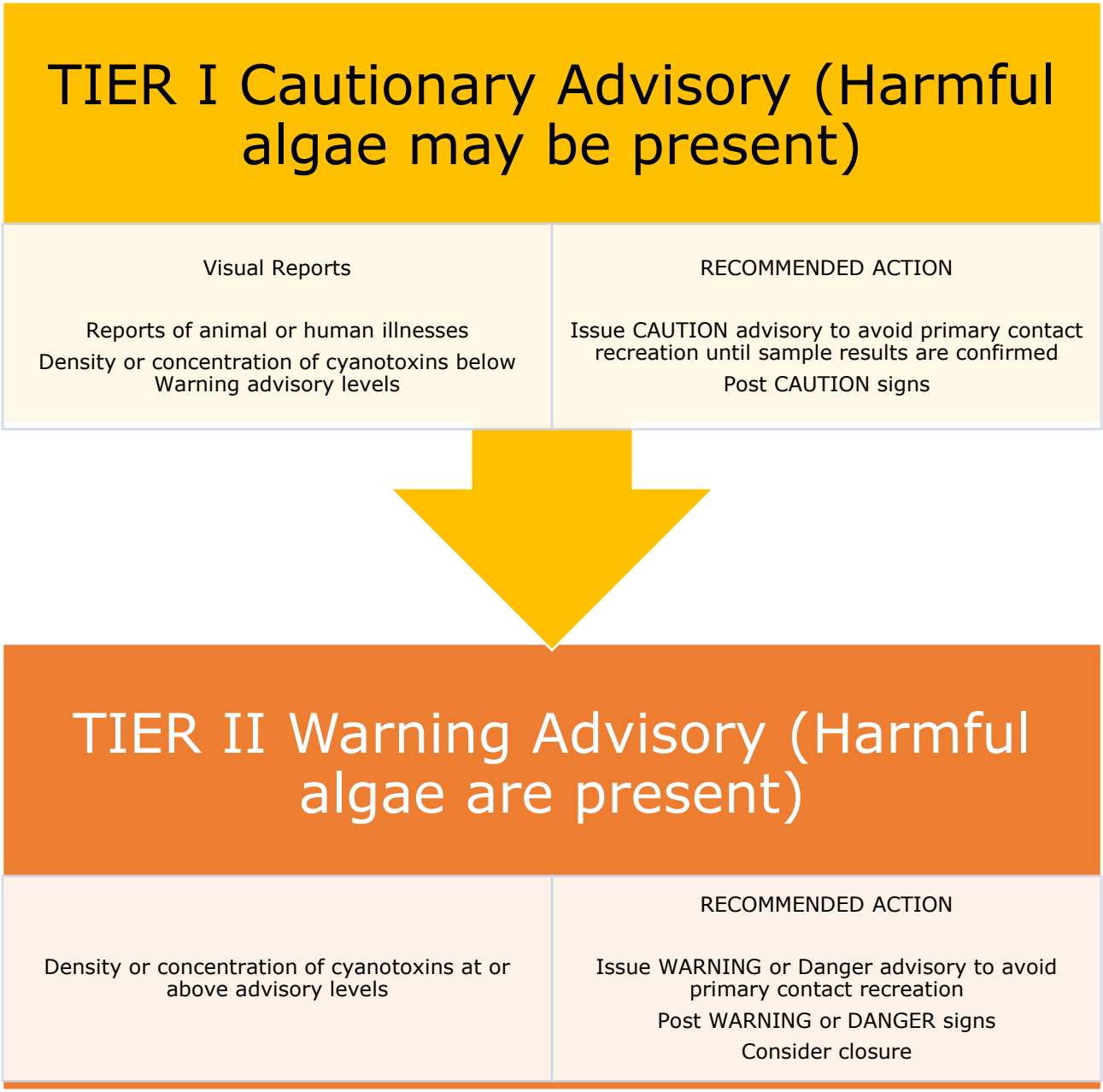


Figure 3. Two-tiered approach to protect public health during a HAB event in a recreational water body (See Table 4 for advisory levels).

Table 4. Two-tiered approach values for cyanobacterial harmful algal bloom response. See Appendix K for details on threshold selection.

	Tier I Caution Advisory	Tier II Warning / Danger Advisory
Cyanobacterial cell density (cells/mL)	[a]	≥20,000 in water[b]
Total Microcystins (µg/L)	[a]	≥8 in water[c]
Cylindrospermopsin (µg/L)	[a]	≥15 in water [c]
Anatoxin-a (µg/L)	[a]	Detected[d] in benthic algal mat or ≥60[e] in water
Recommended action	Issue CAUTION advisory to avoid primary contact recreation until sample results are confirmed Post CAUTION signs	Issue WARNING advisory to avoid primary contact recreation Post WARNING or DANGER signs Consider closure

[a] Tier I is triggered with visual reports, reports of animals or human illness, density or concentrations of cyanotoxins below "Warning advisory" levels.
[b] [WHO] World Health Organization. 2003. Guidelines for safe recreational water environments. Volume 1 Coastal and Fresh Waters.
[c] [USEPA] United States Environmental Protection Agency. 2019b. Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin.
[d] Tier II is triggered by any detectable concentration for anatoxin-a and the presence of benthic algal mat material.
[e] [WHO] World Health Organization. 2020. Cyanobacterial toxins: anatoxin-a and analogues, Background document for development of WHO Guidelines for drinking-water quality and Guidelines for safe recreational water environments.

Drinking Water

Harmful algal blooms can create taste and odor problems in drinking water when the impacted body of water supplies a public water system. Drinking water with cyanotoxins can also pose health risks to humans and animals. The U.S. Environmental Protection Agency (EPA) has published national drinking water Health Advisories for microcystins and cylindrospermopsin[a]. The EPA Health Advisory levels are 0.3 µg/L for microcystins and 0.7 µg/L for cylindrospermopsin for children under six years old, and 1.6 µg/L and 3.0 µg/L, respectively, for children six and older and adults. Advisories are non-enforceable and non-regulatory limits. No maximum contaminant level or maximum contaminant level goal has been established under the Safe Drinking Water Act (SDWA) for cyanotoxins. The World Health Organization has a draft anatoxin-a short-term drinking-water health-based reference value of 30 µg/L (WHO 2020). There is currently insufficient information in the scientific literature to derive a long-term health-based reference value for anatoxin-a. In addition, there is currently no regular monitoring for cyanotoxins in drinking water in Texas.

Animal exposure and protective values

Ingestion of cyanotoxins by domestic animals and wildlife has resulted in several lethal poisonings in the United States and the world, especially by drinking contaminated water (Buratti et al. 2017). Federal animal standards for drinking water have not been established. In addition, cyanotoxins are not usually tested as part of regular water quality sampling and testing. If there is an algal bloom or mat, it should be considered a risk for acute adverse health effects and all domesticated animals (including livestock) should be denied access to the area. A Tier I caution advisory should be issued regardless of its location, color, or time of occurrence (Carlson 2018). Appendix C and Table A3 has information on animal exposures to benthic blooms including protective thresholds. Appendix F can be used as educational material.

[a] **https://www.epa.gov/cyanohabs/epa-drinking-water-health-advisories-cyanotoxins**

HAB Response

In Texas, currently there is not a specific state statute related to HABs or a state agency tasked with regulating HABs. Often the response falls on local governments and health departments. Therefore, the Toxic Substances Coordinating Committee (TSCC) HAB Workgroup drafted this document to help direct local response. As such, during a HAB, the workgroup recommends the LHA exercise the appropriate actions to protect public health, including posting health advisories, closing water bodies to the public and informing the public to minimize unintentional exposure to harmful algal blooms. State and federal governmental agencies, such as DSHS and TPWD, can provide technical guidance to local partners, as needed. A list of the agencies on the TSCC HAB workgroup, including their contact information, is listed later in this section. Table 5 defines lead roles and assisting roles for agencies in monitoring and responding to HABs. The following are recommended guidance for local and state agencies.

Local Health Authority (LHA)

- The LHA is a physician appointed by the governing body of a municipality or the commissioners court of a county to administer state and local laws relating to public health within an appointing body's jurisdiction.[a]
- See Appendix G for a list of local health departments/LHA.
- In cases where an LHA has limited resources, the LHA should reach out to the Regional Health Authority and DSHS and to local waterbody authorities to request assistance in HAB response.
- Accurately and precisely characterize waters within their jurisdiction through observation and monitoring when a suspected HAB is reported.
- Relay scientific information to the appropriate partners when a bloom is in progress.
- Inform local drinking water providers if a HAB is found to be present in their source supply.
- Determine if a public health advisory is necessary to protect water users in coordination with partners, based on lab analysis of water samples.
- Educate the public on the health effects of cyanobacteria and ways to prevent exposure through various outreach efforts.
- Stay current with federal guidelines and the science of cyanobacteria and HABs.
- Update local health department's website with relevant HAB information.

[a] https://www.dshs.texas.gov/rls/lha/Department-of-State-Health-Services-Appointed-Health-Authority.aspx

- Voluntarily report suspect or confirmed HAB events, suspect, probable or confirmed HAB-associated human or animal cases, and outbreaks to DSHS at EPITOX@dshs.texas.gov or call hotline 1-888-681-0927.
- Optional: Assist DSHS by reporting HAB events to CDC One Health Harmful Algal Bloom System (OHHABS, Appendix J).

Texas Parks and Wildlife Department (TPWD)

- Participate in the TSCC HAB workgroup.
- Investigates fish kills and pollution events that may impact fish and wildlife resources.
- Identify the source and cause of the event.
- Provide guidance to minimize impacts to fish and wildlife resources.
- Notify LHA and TCEQ of possible bloom.

Contact: The link below provides information for regional points of contact.
https://tpwd.texas.gov/landwater/water/environconcerns/kills_and_spills/
Email: le.communications@tpwd.texas.gov
Phone number: (512) 389-4848

Texas Commission on Environmental Quality (TCEQ)

- Participate in the TSCC HAB workgroup.
- Maintain situational awareness of reported HABs.

Contact: Monitoring and Assessment Section
Email: swqm@tceq.texas.gov
Phone number: (512) 239-6682

Texas Department of State Health Services (DSHS)

- Participate in the TSCC HAB workgroup.
- Provide HAB educational materials to LHA and partners.
- Maintain situational awareness of reported HABs.
- Provide consultation on health advisories as needed.
- Inform and share information on HAB events with the Texas Poison Center Network.
- Collect and maintain surveillance on reported animal and human HAB related illnesses.
- Report HAB events on CDC One Health Harmful Algal Bloom System (OHHABS). LHA and other state agencies can assist in reporting to OHHABS (Appendix J).

Contact: Environmental Surveillance and Toxicology Branch (ESTB)
Email: epitox@dshs.texas.gov
Phone number: 1-888-681-0927

Texas Poison Center Network (TPCN)

- Provide medical toxicology support.
- Answer calls from the public to their hotline regarding health concerns or symptoms (1-800-222-1222).
- Share the location of reported HABs to their social media.

Texas Animal Health Commission (TAHC)

- Notify livestock owners when a water body contains a suspected HAB and may be a source of animal drinking water.
- Coordinate, if needed, pet and livestock sampling done by the local accredited veterinarian.

Contact: Olivia Hemby, Emergency Planner
Email: Olivia.Hemby@tahc.texas.gov
Phone number: (512) 719-0778

Contact: Jeff Turner, Director of Emergency Management
Email: jeff.turner@tahc.texas.gov
Phone number: (512) 636-0795

Table 5. Roles and responsibilities for monitoring and responding to harmful algal blooms.

Activity	Lead Role	Assist
Monitor	Local partners monitor water bodies through on-site observations for evidence of HABs	USGS provide guidance on how to monitor for public health purposes and in identifying cyanobacteria
Collect water samples	LHA use scientifically acceptable methods to obtain water samples	Contract Lab, TPWD (when investigating fish kills), and USGS provide guidance on sampling techniques
Analyze samples	LHA contract with laboratories that are qualified to perform the required analyses	TPWD provides a list of laboratories with appropriate analytic capabilities
Investigate fish or wildlife mortalities	TPWD	River Authorities (Appendix H), local municipalities
Investigate human and domestic animal morbidity and mortality	LHA	DSHS
Issue or lift advisories	LHA evaluates data and compares test results to established criteria to determine if an advisory should be issued or lifted	Partners respond to questions about waterbody status
Communicate advisory information	LHA informs the public through advisory news releases, broadcast and print media, a toll-free hotline, website and educational materials	Partners inform constituents of health advisory status through news releases and signage

Communication Plan

In the case of a suspected HAB event, consider issuing a Tier I recreational public health advisory. While waiting for laboratory analysis to determine if a Tier II or Tier III recreational use public health advisory should be issued, it is recommended that communication materials such as social media alerts, press releases, and/or caution signs be posted by an LHA as a precautionary measure, to alert the public of potential health risks associated with recreating in a water body during a suspected HAB.

Public Notification Guidance

The LHA should use several concurrent notification methods in the issuing and lifting of public health advisories. In addition, the LHA should ensure that the HAB has been reported to DSHS. Templates for notifications are available from EPA[a] and examples are provided in Appendices E, F, and I. The recommended methods are as follows:

News Releases: The LHA may issue local press releases which could be reported by local news and print media outlets in the community. These press releases should contain information about the nature and location of the advisory, possible health effects, recommended protective actions and where people can obtain more information. Examples might include Public Notices, Posters, Billboards, Local Newspapers, Radio/TV advertisements, Social Media (see Appendix I).

Website: The LHA should consider posting on their website updated information on the issuing and lifting of HAB advisories in its jurisdiction. The public and others can also access resources for water sampling, response strategy, prevention tips, frequently asked questions, and general information about cyanobacterial HABs.

Hotline: The LHA should consider establishing a toll-free telephone service that provides updated advisory information to the public, which is particularly helpful for individuals who are traveling, or those without Internet access. In addition, Texas Poison Center Network (1-800-222-1222) can provide answers on symptoms related to potential exposures.

[a] **https://www.epa.gov/cyanohabs/communicating-about-cyanobacterial-blooms-and-toxins-recreational-waters**

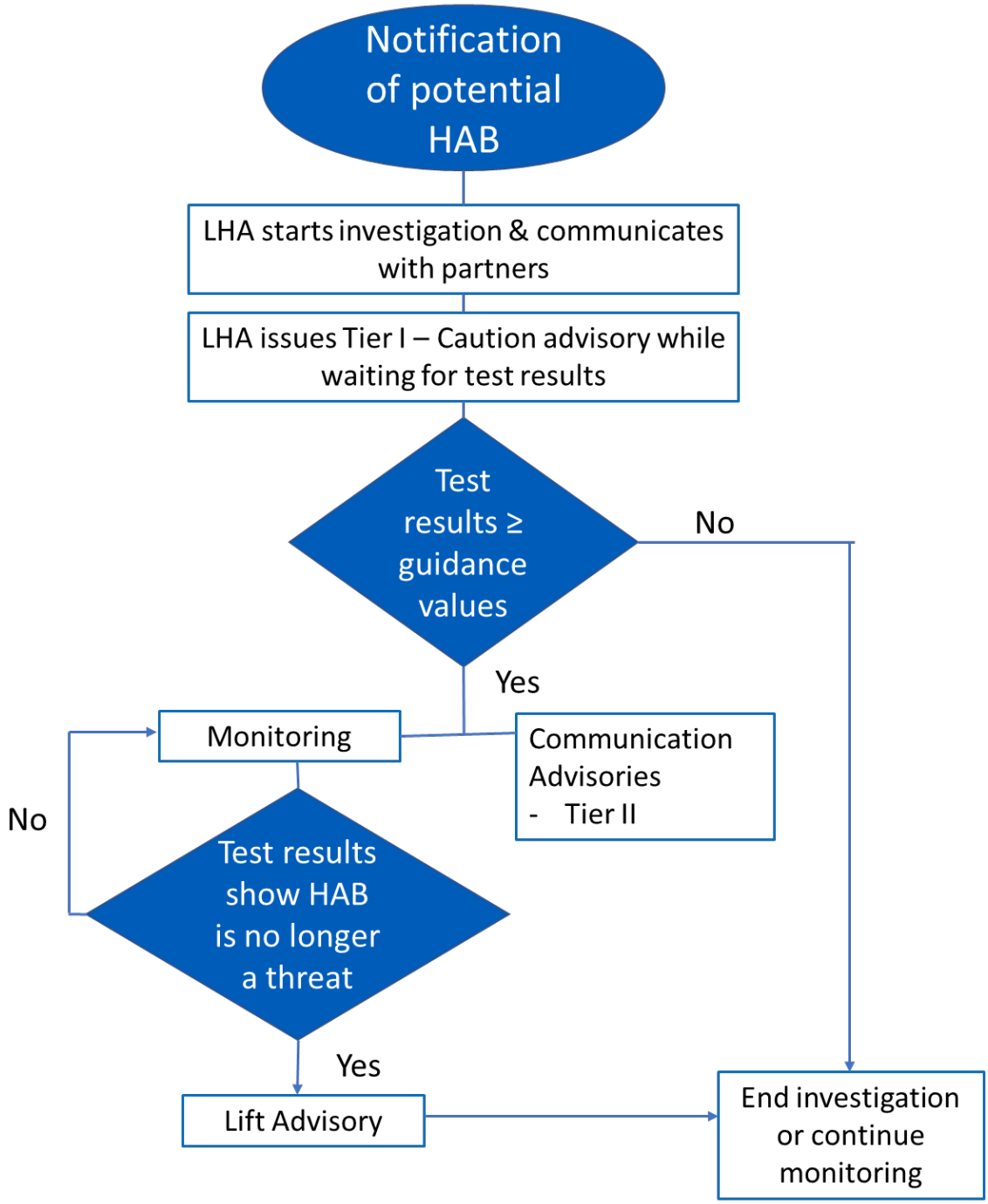


Figure 4. Harmful algal bloom response flowchart.

References

Buratti FM, Manganelli M, Vichi S, Stefanelli M, Scardala S, Testai E. Funari E. 2017. Cyanotoxins: producing organisms, occurrence, toxicity, mechanism of action and human health toxicological risk evaluation. *Archives of Toxicology* 91:1049-1130.

Carlson MP. 2018. Chapter 80, Water Quality and Contaminants. In Gupta RC, *Veterinary Toxicology Basic and Clinical Principles*, 3rd ed, Academic Press, pp 1099-1115.

[CDC] Centers for Disease Control and Prevention. 2017. Harmful Algal Bloom (HAB) – Associated Illness. From https://www.cdc.gov/habs/illness-symptoms-freshwater.html. Accessed 7/15/2021.

[CDC] Centers for Disease Control and Prevention. 2021. One Health Harmful Algal Bloom System (OHHABS) 2021 Data Summary. From https://www.cdc.gov/habs/data/2021-ohhabs-data-summary.html. Accessed 2/1/2024.

Chorus I, Bartram J. 1999. Toxic cyanobacteria in water. A guide to their public health consequences, monitoring and management. E & FN Spon on behalf of the World Health Organization.

Chorus I, Falconer IR, Salas HJ, Bartram J. 2010. Health risks caused by freshwater cyanobacteria in recreational waters. *Journal of Toxicology and Environmental Health, Part B* 3(4):323-347. DOI: 10.1080/109374000436364

Chorus I, Welker M. 2021. Toxic Cyanobacteria in Water, 2nd edition. CRC Press, Boca Raton (FL), on behalf of the World Health Organization, Geneva, CH.

[COA] City of Austin. 2023. Algae. From https://austintexas.gov/page/algae. Accessed 8/2/2023.

[CWB] California Water Boards. 2020. Identifying a Harmful Algal Bloom (HAB). California Water Boards, State Water Resources Control Board.

[CWQMC] California Water Quality Monitoring Council. 2016. California Voluntary Guidance for Response to HABs in Recreational Inland Waters. From https://mywaterquality.ca.gov/habs/resources/habs_response.html#trigger_levels. Accesssed 7/15/2021.

Fawell J.K., Mitchell R.E., Everett D.J., Hill R.E. (1999). "The toxicity of cyanobacterial toxins in the mouse: I Microcystin-LR." Human & Experimental Toxicology 18(3): 162-167.

Gilbert PM, Burkholder JM. 2018. Causes of Harmful Algal Blooms. Harmful Algal Blooms: A Compendium Desk Reference. J. M. B. Sandra E. Shumway, Steve L. Morton, John Wiley & Sons Ltd.

Heinze, R. (1999). "Toxicity of the cyanobacterial toxin microcystin-LR to rats after 28 days intake with the drinking water." Environmental Toxicology and Pharmacology 14(1): 57-60.

Humpage A.R., Falconer I.R. (2002). Oral Toxicity of Cylindrospermopsin: No Observed Adverse Effect Level Determination in Male Swiss Albino Mice. Water Research Australia, Cooperative Research Center for Water Quality and Treatment. Research Report No. 13. from http://www.waterra.com.au/_r6248/media/system/attrib/file/1496/RR%2013%20Oral%20toxicity%20of%20CYN.pdf.

Humpage, A.R., Falconer, I.R. (2003). "Oral toxicity of the cyanobacterial toxin cylindrospermopsin in male Swiss albino mice: determination of no observed adverse effect level for deriving a drinking water guideline value." Environmental Toxicology 18(2): 94-103.

[ITRC] Interstate Technology & Regulatory Council. 2023A. Strategies for Preventing and Managing Harmful Cyanobacterial Blooms (HCB-1). From https://hcb-1.itrcweb.org/. Accessed 9/12/2023.

[ITRC] Interstate Technology & Regulatory Council. 2023B. Strategies for Preventing and Managing Benthic Harmful Cyanobacterial Blooms (HCB-2). From https://hcb-2.itrcweb.org/. Accessed 9/12/2023.

[KDHE] Kansas Department of Health and Environment. 2020. Harmful Algal Blooms, KDHE Agency Response Plan – 2020. From https://www.kdheks.gov/algae-illness/Response_Plan/2020_HAB_Response_Plan_COMPLETE.pdf. Accessed 7/15/2021.

Koreiviene J, Anne O, Kasperoviciene J, Burskyte V. 2014. Cyanotoxin management and human health risk mitigation in recreational waters. *Environmental Monitoring and Assessment* 186:4443-4459.

Lillis J, Ortez A, Teel J. 2012. Blue-Green Algae Response Strategy Summer 2012, Grayson County, Texas Health Department.

Puddick J, van Ginkkel R, Page CD, Murray JS, Greenhough HE, Bowater J, Selwood AI, Wood SA, Prinsep MR, Truman P, Munday R, Finch SC. 2020. Acute toxicity of dihydroanatoxin-a from Microcoleus autumnalis in comparison to anatoxin-a. Chemosphere 263:127937. DOI: 10.1016/j.chemosphere.2020.127937.

Stone D, Bress W. 2007. Addressing public health risks for cyanobacteria in recreational freshwaters: The oregon and vermont framework. *Integrated Environmental Assessment and Management* 3(1):137-143.

Trevino JM, Petersen CB. 2020. Assessment of Field and Laboratory Methods for the Detection and Analyses of Cyanobacteria and Cyanotoxins in Texas Reservoirs. U.S. Geological Survey data release. https://doi.org/10.5066/P9ASYKM7

[USEPA] United States Environmental Protection Agency. 2014. National Beach Guidance and Required Performance Criteria for Grants, EPA-823- B-14-001.

[USEPA] United States Environmental Protection Agency. 2016. Method 546: Determination of Total Microcystins and Nodularins in Drinking Water and Ambient Water by Adda Enzyme-Linked Immunosorbent Assay, EPA 815-B-16-011.

[USEPA] United States Environmental Protection Agency. 2017a. Single Laboratory Validated Method for Determination of Cylindrospermopsin and Anatoxin-a in Ambient Freshwaters by Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS), EPA/600/R-17/130.

[USEPA] United States Environmental Protection Agency. 2017b. Single Laboratory Validated Method for Determination of Microcystins and Nodularin in Ambient Freshwaters by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS), EPA/600/R-17/344.

[USEPA] United States Environmental Protection Agency. 2019a. Recommendations for Cyanobacteria and Cyanotoxin Monitoring in Recreational Waters, EPA 823-R-19-001.

[USEPA] United States Environmental Protection Agency. 2019b. Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin. EPA 822-R-19-001.

[USGS] United States Geological Survey. 2017. Cyanobacterial Harmful Algal Blooms and U.S. Geological Survey Science Capabilities. https://doi.org/10.3133/ofr20161174.

[USGS] United States Geological Survey. 2018. Lakes and reservoirs—Guidelines for study design and sampling: U.S. Geological Survey Techniques and Methods, book 9, chap. A10, 48 p. https://doi.org/10.3133/tm9a10.

[WHO] World Health Organization. 1999. Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management, E & FN Spon.

[WHO] World Health Organization. 2003. Guidelines for safe recreational water environments. Volume 1 Coastal and Fresh Waters.

[WHO] World Health Organization. 2020. Cyanobacterial toxins: anatoxin-a and analogues, Background document for development of WHO Guidelines for drinking-water quality and Guidelines for safe recreational water environments.

Wood SA, Kelly LT, Bouma-Gregson K, Humbert JF, Laughinghouse HD, Lazorchak J, McAllister TG, McQueen A, Pokryzywinski K, Puddick J, Quiblier C, Reitz LA, Ryan K G, Vadeboncoeur Y, Zastepa A, Davis TW. 2020. Toxic benthic freshwater cyanobacterial proliferations: Challenges and solutions for enhancing knowledge and improving monitoring and mitigation. *Freshwater Biology* 65(10):1824-1842. https://doi.org/10.1111/fwb.13532

Appendix A

Instructions for Photographing Cyanobacterial HABs

- Suspected cyanobacterial HAB can be reported to state and local health departments with photographs.
- It is important to take photos that clearly tell a story and convey all the information necessary for the event. The guidance below helps to ensure that accurate and helpful photos are taken:
    - Rule of 3 – The image is divided into nine equal parts by two equally-spaced horizontal and vertical lines. Important compositional elements should be placed along these lines or their intersections.
    - Put every photo in perspective – Every close-up should be followed by one or more wider-angle shots that will show the close-up in the context of the rest of the environment. The closer the initial shot the more perspective shots may be needed. For example:
- Habitats and spatial patterns of bloom.
- Context shots (Maybe not every time but always when the broader picture has changed or when it's important to make specific close-ups more valuable.)
    - To document location, take photos of landmarks: road intersections, coastal promontories, stream outlets, shore access locations, lighthouses, etc.
    - Consistent, repetitive photo process – Taking photos in the same order will help to ensure that important photos are not missed and will help keep things organized so it's easier to review photos later. This can be done by:
- Start each new location with panorama shots, where appropriate.
- Always capture your subjects the most zoomed out to the most close-up.
    - Provide scale in the photos.
- 15-cm scales are standard (6 inches). Be sure the scale is labeled.
- If a scale is not available, provide another object (pen, etc.) that can provide perspective in the photo.
- Scales (and quadrat frames) should have intermediate reflectance, not bright white. A bright scale object can cause the camera to underexpose the rest of the photo.
    - Avoid harsh shadows and over exposure – When conditions allow, try to change the perspective of the photo to avoid shadows or over exposure.
    - Review critical photos to ensure that photos are capturing needed information.

- Adjust camera if needed – It is often necessary to adjust camera settings in the field if photos are not coming out well.

Appendix B

Water-Sample Collection

The following procedures are general recommendations developed from the federal guidance documents cited throughout this section. For specific sampling strategies and techniques, consult with the applicable local monitoring entities and laboratories.

Sampling Strategy

Sampling conducted in reaction to bloom events provides information about conditions occurring during the sampling period only and may not capture conditions that represent bloom development or occurrence. Proactive monitoring and sampling before, during, and following bloom events may increase understanding of the environmental conditions associated with bloom events (ITRC 2023A, ITRC 2023B).

Monitoring and sampling objectives should be determined prior to sampling, because they will affect the sampling strategy. In general, three forms of sampling are common—surface, discrete depth, and depth-integrated samples—and vary based on monitoring objectives. In areas where water recreation (such as swimming, water skiing, diving, fishing, and boating) occurs, surface sampling is most commonly used. Surface sampling generally involves collecting a sample from 0.5-1.0 meters below the surface of the water (USGS 2018). If a surface scum is present, sampling should take place directly at the surface, or within the scum layer, to account for maximum potential risk. Additionally, sampling should occur near shorelines, where swimming and recreation are most likely to occur.

Discrete-depth samples are often used when the bloom is known to be at a specific depth, depth profiles are desired, or if monitoring near a drinking water intake (USGS 2018).

Depth-integrated sampling generally takes place when the bloom is evenly mixed throughout the water column (i.e., due to wind mixing), or if the depth of the cyanobacteria community is unknown. Whole-profile samples or integrated photic-zone profiles may be collected (USGS 2018). For integrated photic zone samples, the vertical water column is composited from the surface to the bottom of the photic zone. The bottom of the photic zone is the depth at which 99% of the surface light has been attenuated. This can be determined by using a photosynthetically reactive radiation (PAR) sensor or by estimating the depth of the photic zone by using a Secchi disk (Secchi depth X 2.5).

Regardless of the sampling form chosen, samples may be collected as single grab samples or composite samples. A grab sample is an individual volume of water

taken over a period of time not to exceed 15 minutes. Composite samples are collected by sampling multiple locations and/or depths and combining the samples into one homogenized sample (USGS 2018). Sampling strategy will depend on the monitoring objectives.

For more information on sampling strategy/design, refer to the USGS National Field Manual for the Collection of Water-Quality Data - Lakes and Reservoirs: Guidelines for Study Design and Sampling (USGS 2018).

Sample Collection

Cyanotoxins can adsorb onto plastic containers and degrade in sunlight (USEPA 2014). Therefore, it is best to collect samples in amber glass containers (USEPA 2019a). Samples should be placed on ice and shipped the same day as collection, with analysis taking place within five days of collection (USEPA 2019a). Some samples could require preservatives or several freeze/thaw cycles before analysis. Prior to sampling, consult with the laboratory for sampling/handling instructions that comply with their Quality Assurance Plans (QAPs).

Safety

Take necessary precautions to prevent potential exposure to cyanotoxins while sampling. Wear appropriate personal protective equipment (such as gloves and waders or boots), avoid ingestion of water, and thoroughly wash any areas of exposed skin that contact the water. Thoroughly rinse sampling equipment between water bodies (if sampling more than one) or when sampling is completed (USEPA 2019a).

Appendix C

Benthic Harmful Algal Bloom Sampling

Sampling Strategies

When sampling for plankton blooms, as described in Appendix B, visual inspection and whole water grab samples are often recommended. Because benthic algal proliferations maintain their high toxin concentrations within the cells, sampling the mat material is the best way to characterize cyanotoxin presence. Given the lack of federally recognized guidelines for common benthic cyanotoxins, such as dhATX, state agencies have employed different sampling techniques to yield results that will allow them to make informed decisions on benthic HABs. Below we describe three different methods that can be used for monitoring benthic algal proliferations, as well as different cyanotoxin advisories currently in use by water quality organizations.

SPATT Bag Sampling

Solid phase adsorption toxin tracking device (SPATT) is commonly used to evaluate the presence or absence of dissolved toxins in the water column. SPATT can be used to evaluate many common forms of benthic and planktonic cyanotoxins. SPATT samples are a passive form of sampling, which contain a resin that absorbs cyanotoxins over an extended period of time. SPATT bags are recommended for a long-term monitoring approach. For a complete guide to how to assemble and deploy SPATT bags use: Standard Operating Procedure for Solid Phase Adsorption Toxin Testing (SPATT) Assemblage and Extraction of HAB Toxins. Results from using SPATT bags can be impacted by a variety of factors such as time of deployment, flow, and turbidity. Therefore, SPATT is often used as a detect/non-detect option for monitoring cyanotoxins in a system.

Benthic Disturbance Sampling

Recreation threshold values exist to protect people and pets that engage in recreational activity in natural bodies of water. Due to the nature of benthic HABs, toxins may be concentrated within mat material found on the shoreline or attached to the benthos. To accurately capture risk associated with recreating on or near benthic algal proliferations, the benthic disturbance sample method can be used. The benthic disturbance method aims to capture the worst-case recreation scenario which involves a recreator disturbing a benthic colony, lysing cells, and therefore releasing toxins from the mat material into the water column. Once toxins are in the water column, recreation and drinking water threshold values can be applied. Below is an example of a benthic disturbance sampling protocol modified from the one currently in use by Zion National Park.

Disturbance grab samples:

1. Put on nitrile gloves.
2. Only collect grab samples after all other measurements and water quality parameters have been taken.
3. Retrieve the SPATT samplers before taking the benthic disturbance grab samples if using SPATT.
4. Wash bucket three times in stream/river water.
5. Take the benthic disturbance sample in area of highest visible cyanobacteria concentration near
6. Step in roughly 1 square meter area for 5 seconds. Scoop water from disturbed area with 2.5-gallon bucket, attempting to capture any dislodged mats and disturbed sediments.
7. Water toxin grab sample: Dip the 500-mL amber glass bottle into the bucket and fill HALF FULL. Place sample on ice.
8. Wash off bucket in stream water. Remove and wash off boots/waders. Wash hands using soap and water bottle.
9. Submit sample for toxin analysis.

Benthic Mat Sampling

While toxins contained in mat material can be released via benthic disturbance, they can also be ingested by canines which can release toxins into their digestive system. Dogs becoming ill or dying from mat consumption is often the first sign that toxic benthic algal proliferations may be present. California. Oregon, Indiana and Pennsylvania have standards for how much of each toxin can be consumed within mat material (Table A3) and these numbers can be used to inform water closures. Benthic mats can detach from the benthos and float to the surface; wind and wave action can push these mats towards the shoreline where they can be interacted with by humans, dogs, and cattle. Sampling of benthic mat material is recommended in areas of high-recreation potential, especially if dogs are frequently found along the shore. Benthic mat sampling can be conducted routinely, or as a response to a HAB related illness or death. The following is an example of a protocol that can be used while investigating a site that is potentially experiencing a benthic cyanobacterial bloom.

1. Visually investigate site, look for visible blooms, mat proliferations, floating blobs or mats with bubbles, or dead fish/birds near the site.

2. Take photos of the site before sample collection. Pay attention to capture any mats, or brightly colored patches of water.

3. Collect water quality parameters using a sonde; temperature, DO, pH, chlorophyll, salinity, conductivity and phycocyanin if probe available.

4. Optional: collect a nutrient sample (water column and sediment).

5. Optional: use 50 mL conical tube to collect turbidity sample, or use a secchi disk to determine water clarity. This information can be especially useful for benthic cyanobacteria blooms.

6. Collect water sample in an amber bottle (250 mL at minimum) from the site, place on ice.

7. Collect a composite algal material sample (250 mL minimum) in an amber bottle, place on ice.

8. Ship algal material and whole water samples overnight to a laboratory capable of processing them. See Appendix D.

9. Optional: Consider ordering a species screening, known as a potential toxigenic cyanobacteria screening, to determine which species of cyanobacteria may be present in your algal sample. Based on the results of this test, the lab can narrow down which cyanotoxins to test for. This can potentially save money

on unnecessary testing or identify species that require specific tests to detect their cyanotoxins.

10. Order toxin testing on algal material and whole water samples.

Examples:

Zion National Park uses a combination of SPATT, visual inspection, and benthic disturbance sampling to make informed decisions about recreation in the park.

Table A 1. ZION Benthic HCB Recreational Advisory Decision Criteria (ITRC 2023b). Example of how different methods are used to drive Decision Criteria for Waterbody Advisories during Harmful Cyanobacteria Blooms in Zion National Park

Advisory	Permitted Activities	Human Health Risk	Presence of Toxigenic Cyanobacteria Species[a]	Benthic Disturbance Sample	8 to 10-day SPATT
Danger Advisory (avoid all contact with the water, never drink the water)	Permitted waterbody-related activities allowed; language in the permits indicating Danger	Potential for acute poisoning Potential for long-term illness Short term effects (e.g., skin and eye irritation, nausea, vomiting, diarrhea)	Based on Benthic Disturbance Sample	Greater than 90 µg/L of anatoxin-a	
Warning Advisory (avoid primary contact recreation,	Permitted waterbody-related activities allowed; language in the permits indicating Warning	Potential for long-term illness Short term effects (e.g., skin and eye irritation, nausea, vomiting, diarrhea)	Based on Benthic Disturbance Sample	Less than 90 µg/L but greater than 15 µg/L of anatoxin-a	Detection anatoxin-a

[a] Based on 1. Visual inspection (25 meters upstream/downstream of the SPATT site) 2. Taxonomic analysis 3. Found anywhere in the waterbody

never drink the water)					
Health Watch (avoid primary contact recreation, never drink the water)	Permitted waterbody-related activities allowed, permanent language indicating risk	Unknown	Toxigenic cyanobacteria present	OR Detection of anatoxin-a but less than 15 µg/L	Non-detect anatoxin-a

Table A 2. Alert-level framework for benthic cyanobacteria (adapted from Ministry for the Environment and Ministry for Health 2009) for New Zealand. [a]

Alert Level*	Actions
Surveillance (green mode) **Up to 20% coverage** of potentially toxigenic cyanobacteria attached to substrate.**	Undertake fortnightly surveys between spring and autumn at representative locations in the water body where known mat proliferations occur and where there is recreational use.
Alert (amber mode) **20–50% coverage of potentially toxigenic cyanobacteria attached to substrate.**	• Notify the public health unit. • Increase sampling to weekly. • Recommend erecting an information sign that provides the public with information on the appearance of mats and the potential risks. • Consider increasing the number of survey sites to enable risks to recreational users to be more accurately assessed. If toxigenic cyanobacteria dominate the samples, testing for cyanotoxins is advised. If cyanotoxins are detected in mats or water samples, consult the testing laboratory to determine whether levels are hazardous.
Action (red mode)	• Immediately notify the public health unit. • If potentially toxic taxa are present, then consider testing samples for cyanotoxins.

[a] Ministry for the Environment and Ministry of Health. 2009. New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters – Interim Guidelines. Prepared for the Ministry for the Environment and the Ministry of Health by S.A. Wood, D.P. Hamilton, W.J. Paul, K.A. Safi and W.M. Williamson. **https://environment.govt.nz/assets/Publications/Files/nz-guidelines-cyanobacteria-recreational-fresh-waters.pdf**

>50% coverage of potentially toxigenic cyanobacteria attached to substrate	Notify the public of the potential health risks.

Table A 3. U.S. state derived threshold values for water and mat consumption by cattle and canine (ITRC 2023b)

Type	State	Animal and water use	Microcystin	Anatoxin-a	Saxitoxin	Cylindro-spermopsin
Whole water or benthic disturbance	California (OEHHA 2012)	Dog, subchronic water intake	2 µg/L	100 µg/L	—	10 µg/L
	California (OEHHA 2012)	Cattle, subchronic water intake	0.9 µg/L	40 µg/L	—	5 µg/L
	Indiana (IN DEM 2021)	Dog recreational	0.8 µg/L	Any detection	Any detection	1.0 µg/L
	Oregon (OR HA 2019a)	Dog recreational	0.2 µg/L	0.4 µg/L	0.02 µg/L	0.4 µg/L
	Pennsylvania (PA DEP 2017)	Dog, non-specified	0.2 µg/L	0.6 µg/L	3 µg/L	0.2 µg/L
	OEHHA 2012	Dog, acute	0.5 mg/kg	0.3 mg/kg	—	0.5 mg/kg

Mat material threshold values	OEHHA 2012	Dog, subchronic	0.01 mg/kg	0.3 mg/kg	—	0.04 mg/kg
	OEHHA 2012	Cattle, acute	5 mg/kg	3 mg/kg	—	5 mg/kg
	OEHHA 2012	Cattle, subchonic	0.1 mg/kg	3 mg/kg	—	0.4 mg/kg

References:

IN DEM. 2021. "Indiana Reservoir and Lake Sampling Update." Indiana Department of Environmental Management. https://www.in.gov/idem/algae/indiana-reservoir-and-lake-sampling-update/

Ministry for the Environment and Ministry for Health 2009

PA DEP. 2017. "Lake Erie harmful algal bloom monitoring and response strategy." Pennsylvania Department of Environmental Protection. **https://seagrant.psu.edu/file/1767/download?token=dS2eHdTS**

OEHHA. 2012. "Toxicological Summary and Suggested Action Levels to Reduce Potential Adverse Health Effects of Six Cyanotoxins." Sacramento, CA: California Environmental Protection Agency, Office of Environmental Health Hazard Assessment **https://oehha.ca.gov/media/downloads/fish/document/cyanotoxins053112.pdf**

OR HA. 2019. "Oregon Harmful Algae Bloom Surveillance (HABS) Program Recreational Use Public Health Advisory Guidelines Cyanobacterial Blooms in Freshwater Bodies." Oregon Health Authority. Center for Health Protection

Appendix D

Table A 4. Laboratories available for sample analysis. Cyanobacterial taxa are identified and quantified using microscopy. Toxin concentrations are quantified using liquid chromatography tandem mass spectrometry (LC-MS/MS) and enzyme-linked immunosorbent assay (ELISA) methods.

Laboratory	Taxonomic Identification	Enumeration	Toxin Analysis: Water	Toxin Analysis: Tissue
Texas A&M University Corpus Christi Center for Coastal Studies, Plankton Lab	Yes	Yes	LC-MS/MS, ELISA	LC-MS/MS, ELISA
University of Texas Marine Science Institute, Liu Lab			LC-MS/MS	
Baylor University Center for Reservoir and Aquatic System Research	Yes	Yes	LC-MS/MS	LC-MS/MS
University of Texas at Austin Center for Systems and Synthetic Biology	Yes	Yes	LC-MS/MS	LC-MS/MS
BSA Environmental Services, Inc	Yes	Yes	ELISA	ELISA
Green Water Laboratories	Yes	Yes	LC-MS/MS, ELISA	LC-MS/MS, ELISA

Contact Information for Cyanobacterial Analysis

University of Texas-Marine Science Institute, Liu Lab

- Address: 750 Channel View Drive, Port Aransas, Texas, 78373.
- Point of Contact: Dr. Zhanfei Liu, zhanfei.liu@utexas.edu**,** 361-749-6711.

- Analytical Method: Solid phase extraction, Tandem mass spectrometry (LC-MS/MS)

Texas A&M University-Corpus Christi, Center for Coastal Studies-Plankton Lab

- Address: 6300 Ocean Drive, Unit 5866, Corpus Christi, TX 78412
- Point of Contact: Dr. Paul Zimba, paul.zimba@tamucc.edu, 361-825-2768
- Enumeration Method: Pigments, light microscope, fluorescence, inverted and upright scopes
- Analytical Method: Elisa and HPLC-MS/MS

Baylor University, Center for Reservoir and Aquatic Systems Research

- **Address:** One Bear Place #97178, Waco, TX 76798
- **Point of Contact:** Dr. Thad Scott, Thad_Scott@baylor.edu, 254-710-2147
- **Enumeration Method:** Compound microscopy
- **Analytical Method:** Liquid Chromatography Mass Spectrometry by Isotope Dilution

- **Address:** One Bear Place #97178, Waco, TX 76798
- **Point of Contact:** Dr. Bryan Brooks, bryan_brooks@baylor.edu
- **Analytical Method:** Agilent LC-MSMS for targeted HAB analysis; Thermo Fisher Q-Exactive Focus Orbitrap LC-MSMS for nontargeted HAB analysis

The University of Texas at Austin, Center for Systems and Synthetic Biology

- **Address:** 204 W. 25th BIO 316, Austin, TX 78712
- **Point of Contact:** Dr. Schonna Manning**,** schonna.manning@utexas.edu**,** 512-922-1190 (cell)
- **Analytical Method:** High-resolution HPLC-MS for biomass and water analyses.

BSA Environmental Services, Inc.

- Address: 23400 Mercantile Rd., Suite 8, Beachwood, OH 44122
- Point of Contact: Dr. John Beaver, j.beaver@bsaenv.com, 216-765-0582
- Enumeration Method: BSA offers speciation, enumeration, and biovolume estimation of phytoplankton, including toxin producing algal species, utilizing standard Utermöhl microscopic method. $150 up depending upon the SOW/counting standards.

Green Water Laboratories

- Address: 205 Zeagler Drive Suite 302, Palatka, FL 32177
- Point of Contact: Dr. Mark Aubel or Amanda Foss, info@greenwaterlab.com**,** 886-328-0882
- Enumeration Method: Potentially toxigenic cyanobacteria screening, algal identification, enumeration, and biovolume calculation.

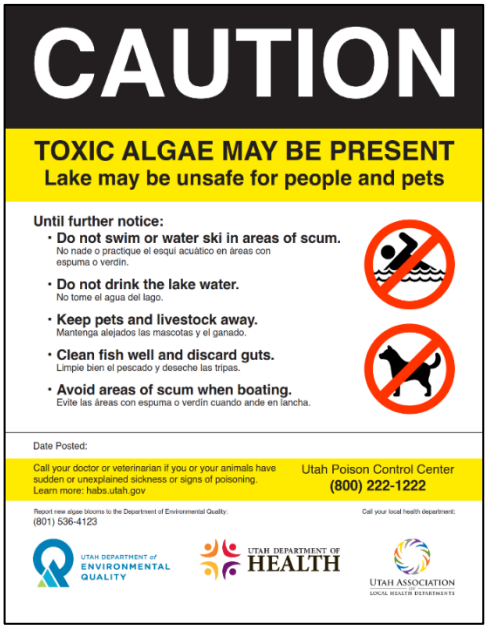
- Analytical Method: Molecular / genetic analysis (rt qPCR), Toxin analysis for targeted groups including anatoxins (ELISA and LC-MS/MS).

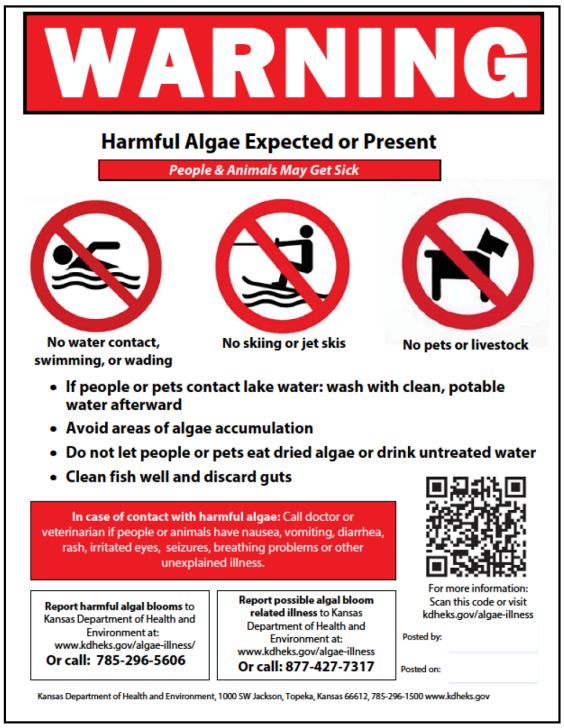
Appendix E

Example of Signs

Signs should have Poison Control and Local Health Authority contact number. Posters, reference cards and fact sheets are available to download from the CDC (https://www.cdc.gov/habs/materials/index.html), Utah (https://deq.utah.gov/water-quality/signage-harmful-algal-blooms), and Texas.

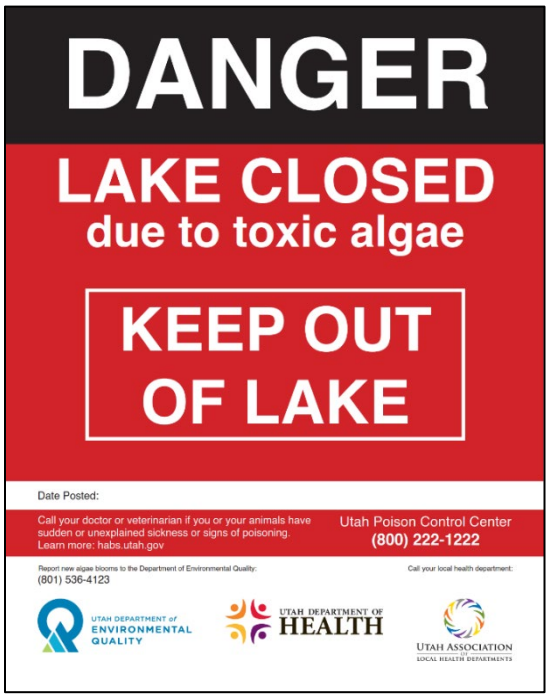
Below are examples of Caution, Warning, and Danger signs.




WARNING
Harmful Algae Expected or Present
People & Animals May Get Sick
No water contact, swimming, or wading
No skiing or jet skis
No pets or livestock
• If people or pets contact lake water: wash with clean, potable water afterward
• Avoid areas of algae accumulation
• Do not let people or pets eat dried algae or drink untreated water
• Clean fish well and discard guts
In case of contact with harmful algae: Call doctor or veterinarian if people or animals have nausea, vomiting, diarrhea, rash, irritated eyes, seizures, breathing problems or other unexplained illness.
For more information: Scan this code or visit kdheks.gov/algae-illness
Report harmful algal blooms to Kansas Department of Health and Environment at: www.kdheks.gov/algae-illness/ Or call: 785-296-5606
Report possible algal bloom related illness to Kansas Department of Health and Environment at: www.kdheks.gov/algae-illness Or call: 877-427-7317
Posted by:
Posted on:
Kansas Department of Health and Environment, 1000 SW Jackson, Topeka, Kansas 66612, 785-296-1500 www.kdheks.gov


WARNING
TOXIC ALGAE PRESENT
Lake unsafe for people and pets
Until further notice:
• Do not swim or water ski
No nade o practique el esqui acuático.
• Do not drink the lake water.
No tome el agua del lago.
• Keep pets and livestock away.
Mantenga alejados las mascotas y el ganado.
• Clean fish well and discard guts.
Limpie bien el pescado y deseche las tripas.
• Avoid areas of scum when boating.
Evite las áreas con espuma o verdín cuando ande en lancha.
Date Posted:
Call your doctor or veterinarian if you or your animals have sudden or unexplained sickness or signs of poisoning.
Learn more: habs.utah.gov
Utah Poison Control Center
(800) 222-1222
Report new algae blooms to the Department of Environmental Quality:
(801) 536-4123
Call your local health department:
UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
UTAH DEPARTMENT OF HEALTH
UTAH ASSOCIATION LOCAL HEALTH DEPARTMENTS


WARNING
TOXIC ALGAE PRESENT
Water is unsafe for people and animals
Until further notice:
• Do not swim, wade or jet ski
• Do not drink the water
• Keep pets and livestock away
• Clean fish well and discard guts
• Avoid areas of scum
In case of contact with harmful algae: Call your doctor or veterinarian if you or your animals have sudden or unexplained sickness or signs of poisoning.
Date Posted:
Local Health Department/Authority Contact Information
Texas Poison Control Center
1-800-222-1222



Example Benthic Algal Mat Signs

Signs with information specific to benthic algal mats should be included for blooms that involve benthic algal mats. Below are example signs from California Health

Department.
(https://mywaterquality.ca.gov/habs/resources/benthic_posting_guidance.html)

CHECK FOR ALGAE

Toxic algal mats may be present in this water

Mats can be attached to the bottom, detached and floating, or washed up on shore

If you see algal mats:

Do NOT let children or adults touch, eat, or swallow any algal mats.

Do NOT let dogs eat algal mats or drink from the water.

Call your doctor or veterinarian if you or your pet get sick after contacting or ingesting algae. For more information on toxic algae visit: **mywaterquality.ca.gov/habs**
For local information, contact:

TOXIC ALGAE ALERT

Toxic algal mats ARE present in this water

Mats can be attached to the bottom, detached and floating, or washed up on shore

Do NOT let children or adults touch, eat, or swallow any algal mats.

Do NOT let dogs eat algal mats or drink from the water.

Common examples

Call your doctor or veterinarian immediately if you or your pet get sick after contacting or ingesting algae. For more information on toxic algae visit: **mywaterquality.ca.gov/habs**

For local information, contact:

Date posted:

Appendix F

Example of Animal Safety Alert

Cyanobacterial Blooms and Animals

Cyanobacterial blooms can be deadly for pets and livestock.

When in doubt, keep animals out!

Cyanobacteria (also called blue-green algae) are microscopic organisms that can be found naturally in all types of water (fresh; marine; or a combination, which is also called brackish). Sometimes cyanobacteria rapidly grow out of control, or bloom. Cyanobacterial blooms are most commonly found in fresh water, such as lakes, rivers, and streams. Cyanobacteria can produce toxins (poisons), which can cause serious illness in animals.

Signs of a cyanobacterial bloom

Foam, scum, mats, or paint-like streaks on the water's surface.

Different colors like green, blue, red, or brown.

As the bloom dies off, it may **smell like rotting plants**.

Cyanobacteria **bloom more often in summer and fall**, but can bloom anytime.

You cannot tell if a cyanobacterial bloom is toxic or not just by looking at it.

Protect your pets and livestock

- Keep pets and livestock away from the water if you see signs of cyanobacteria.
- Do not let your animals drink, swim in, or eat near discolored or scummy water.
- Keep animals from licking their fur, eating dead fish or other animals found near the bloom, or eating mats of cyanobacteria.

Pets and livestock can get very sick and die within hours to days after swallowing toxins made by cyanobacterial blooms.

If your pets or livestock are exposed to a bloom

- **Immediately wash them** with clean water so they don't lick cyanobacteria off their fur.
- **Call a veterinarian** if your animal shows any of these signs
  - » Loss of energy
  - » Loss of appetite
  - » Vomiting
  - » Stumbling and falling
  - » Foaming at the mouth
  - » Diarrhea
  - » Convulsions
  - » Excessive drooling
  - » Tremors and seizures
  - » Any unexplained sickness that occurs within a day or so after being in contact with water

Call **Poison Control** at **1-800-222-1222** if you have questions about cyanobacterial toxin poisoning.

Call the **ASPCA Animal Poison Control Center** at **1-888-426-4435** or the **Pet Poison Helpline** at **1-855-764-7661** if you have questions about your pet or livestock. (Note: There is a fee for these calls.)

Report cyanobacterial blooms or illnesses to your health department online or by phone.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

Learn more about cyanobacterial blooms: **www.cdc.gov/habs**

PubNo.300861 CS 319419-A

https://www.cdc.gov/habs/pdf/algal_bloom_poster.pdf

Appendix G

Local Public Health Organizations

For a list of Local Public Health Organizations see **https://dshs.texas.gov/regions/lhds.shtm.**

Public Health Regions

PUBLIC HEALTH REGION 1 - Lubbock **Scott Milton, MD,** Regional Medical Director Kelly Northcott, Deputy Regional Director **Regional Headquarters:** 6302 Iola Ave, Lubbock, Texas 79424, Mail Code 1899 Phone: (806) 744-3577 FAX: (806) 783-6435 **Map to Region 1 office** **Web site**	
PUBLIC HEALTH REGION 2/3 - Arlington **Aurelia Schmalsteig, MD,** Regional Medical Director Becky Earlie-Royer, PhD, MPH, CHES, Deputy Regional Director **Regional Headquarters:** 1301 South Bowen Road, Suite 200, Arlington, Texas 76013, Mail Code 1905 Phone: (817) 264-4500 FAX: (817) 264-4506 TDD: (817) 264-4505 **Map to Region 2/3 office** **Web site**	
PUBLIC HEALTH REGION 4/5 - Tyler **Sharon Huff, MD, MS,** Regional Medical Director Caleb Rackely, LCSW, Deputy Regional Director **Regional Headquarters:** 2521 West Front Street, Tyler, Texas 75702, Mail Code 1901 Phone: (903) 595-3585 FAX: (903) 593-4187 **Map to Region 4/5 North office** **Web site**	
PUBLIC HEALTH REGION 6/5 - Houston **Carlos Plasencia, MD, MSPH,** Regional Medical Director Greta Etnyre, MS, RD, REHS/RS, Deputy Regional Director **Regional Headquarters:** 5425 Polk, Suite J, Houston, Texas 77023, Mail Code 1906 Phone: (713) 767-3000 FAX: (713) 767-3049 **Map to Region 6/5 South office** **Web site**	

PUBLIC HEALTH REGION 7 - Temple **Sharon Melville, MD, MPH,** Regional Medical Director Carol Davis, MSPH, CPH, Deputy Regional Director **Regional Headquarters:** 2408 South 37th Street, Temple, Texas 76504, Mail Code 1902 Phone: (254) 778-6744 FAX: (254) 778-4066 **Map to Region 7 office** **Web site**	
PUBLIC HEALTH REGION 8 - San Antonio **Lillian Ringsdorf, MD, MPH,** Regional Medical Director Gale Morrow, MPH, MCHES. Deputy Regional Director **Regional Headquarters:** 7430 Louis Pasteur Drive, San Antonio, Texas 78229, Mail Code 5716 Phone: (210) 949-2000 FAX: (210) 949-2015 **Map to Region 8 office** **Web site**	
PUBLIC HEALTH REGION 9/10 - El Paso (Vacant) Regional Medical Director Art Alvarado, RS, MPH., Deputy Regional Director **Regional Headquarters:** 401 East Franklin, Suite 210, El Paso, Texas 79901, Mail Code 1903 Phone: (915) 834-7675 FAX: (915) 834-7799 **Map to Region 9/10 office** **Web site**	
PUBLIC HEALTH REGION 11 - Harlingen **Emilie Prot, DO, MPH,** Regional Medical Director Sylvia Hobbs, Deputy Regional Director **Regional Headquarters:** 601 West Sesame Drive, Harlingen, Texas 78550, Mail Code 1907 Phone: (956) 423-0130 FAX: (956) 444-3298 **Map to Region 11 office** **Web site**	

Appendix H

Texas River Authorities

https://tpwd.texas.gov/landwater/water/habitats/rivers/authorities.phtml

Location	River Authority	Website
	Angelina-Neches River Authority	**https://www.anra.org/**
	Bandera County River Authority	**http://www.bcragd.org/**
	Brazos River Authority	**https://www.brazos.org/**
	Guadalupe-Blanco River Authority	**https://www.gbra.org/**
	Lavaca-Navidad River Authority	**http://www.lnra.org/**
	Lower Colorado River Authority	**http://www.lcra.org/**
	Lower Neches River Authority	**https://lnva.dst.tx.us/**

	Nueces River Authority	**http://www.nueces-ra.org/**
	Red River Authority	**http://www.rra.texas.gov/**
	Sabine River Authority	**https://www.sratx.org/**
	San Antonio River Authority	**https://www.sariverauthority.org/**
	San Jacinto River Authority	**https://www.sjra.net/**
	Trinity River Authority	**http://www.trinityra.org/**
	Upper Colorado River Authority	**https://www.ucratx.org/**
	Upper Guadalupe River Authority	**http://www.ugra.org/**

Appendix I

Examples of Communication Materials

Press Release

CITY OF AUSTIN

FOR IMMEDIATE RELEASE
Release Date: Aug. 05, 2019
Contact: Communications and Public Information Office 512-974-2220 Email

---

Owners strongly advised to keep pets out of Lady Bird Lake.
The City of Austin is advising pet owners to not allow pets to swim in or drink water from Lady Bird Lake after being notified that two dogs have died after swimming in the lake. The City cannot confirm the cause of either death.

On Sunday, City of Austin scientists investigating the water quality noted the presence of clumps of algae in Lady Bird Lake. Preliminary results indicate the algae is a type of blue green algae of the genus Oscillatoria. This type of algae can release a neurotoxin. The neurotoxin in this type of algae can be harmful to pets and people if a sufficient quantity of water or algae is ingested.

The algae is especially prevalent near Red Bud Isle, covering up to 40% of the water surface in that area. It also tends to be more abundant near shorelines and in areas with low water flow. The situation is evolving. We have not seen any impacts to aquatic species at this time.

There have been blue-green algae blooms in Austin in previous years, but we have not been aware of any effects from neurotoxins. Algae tends to be more prevalent in late summer and early fall and when flows are low.

Austin Water regularly looks at algae levels on Lake Austin and Lake Travis and has not seen levels of concern for drinking water. Austin Water does not use Lady Bird Lake as a source for drinking water.

The current algae bloom appears to be confined to algae growing on the bottom of the lake and then floating in clumps to the surface. Scientists have taken samples of both the algae and the water near the algae in Lady Bird Lake. Results from the analysis for the actual presence of the toxin should be available early next week.

Dogs who ingest water contaminated with this toxin could have a number of symptoms. On the severe end, it could result in respiratory paralysis and death. Look for these signs in your pet within minutes to hours of exposure:

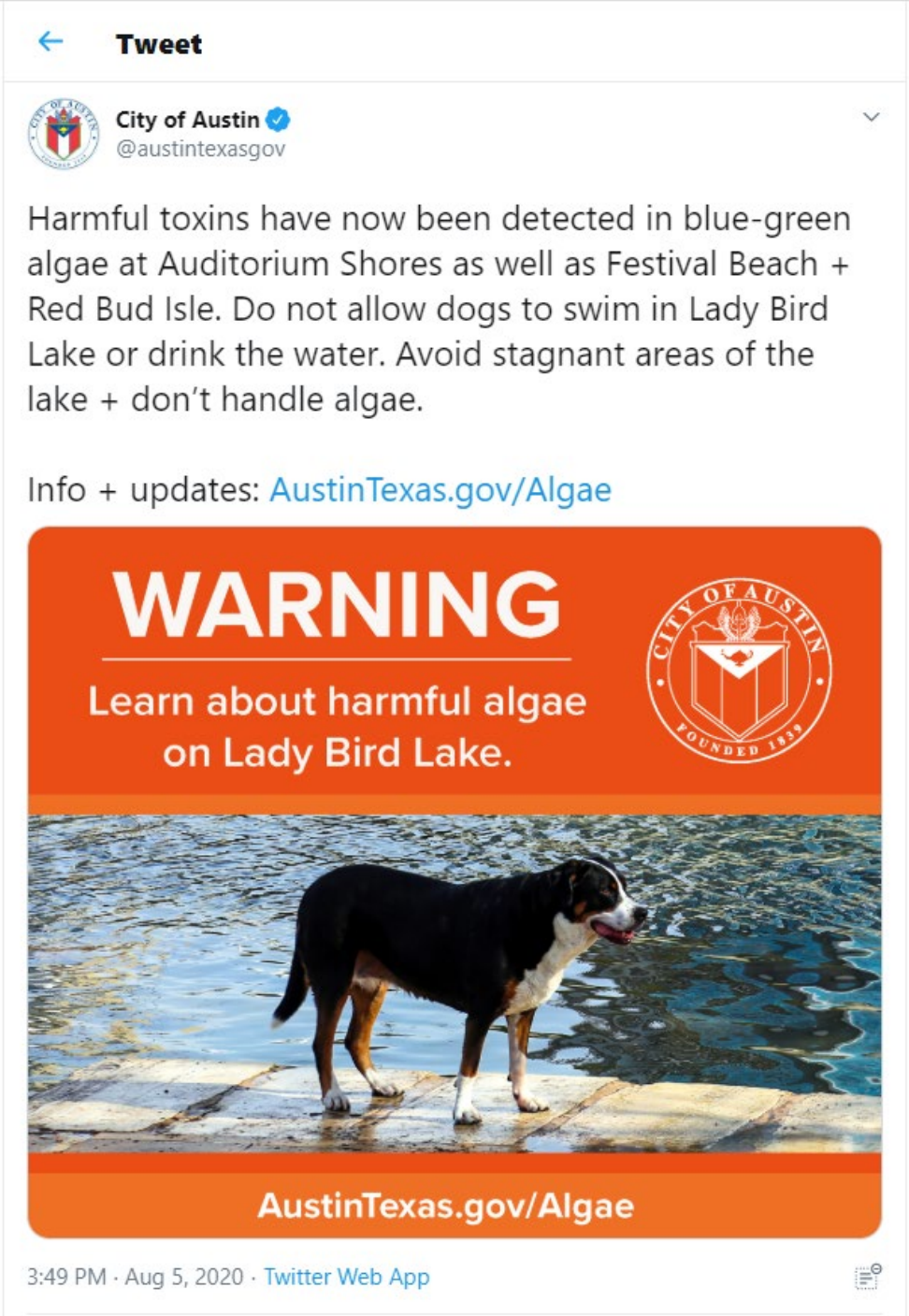
- Excessive drooling, vomiting, diarrhea
- Foaming at the mouth
- Jaundice, hepatomegaly
- Blood in urine or dark urine
- Stumbling
- Loss of appetite
- Photosensitization in recovering animals
- Abdominal tenderness
- Progression of muscle twitches
- Respiratory paralysis

Until we have more information, we strongly advise that pets stay out of the water. At this time, we have no reason to believe that boating is unsafe. However, people should not be swimming in Lady Bird Lake. It is illegal. When out on the lake, people should take care to avoid ingesting water or coming into direct contact with the algae. The degree of risk to human exposure, such as through accidental swallowing of lake water, cannot be known until the tests results are available and analyzed.

###

https://www.austintexas.gov/news/officials-advise-keeping-pets-out-lady-bird-lake

Social Media



https://twitter.com/austintexasgov/status/1291114139302211585?lang=en

Appendix J

The One Health Harmful Algal Bloom System (OHHABS)

The One Health Harmful Algal Bloom System (OHHABS) is a voluntary HAB reporting and tracking tool launched by the CDC in 2016. OHHABS collects information on HAB events and any associated human and animal illnesses within the U.S. Creating a national database tracking HABs and their impacts is important for developing the science of understanding HABs and addressing them with mitigation and prevention strategies.

U.S. state and territory health departments report information on HABs and human and animal illnesses to OHHABS through an online portal. State health departments can recruit other state agencies and partners to assist with reporting. PDF forms are available for agencies and partners to fill out and send to the reporting health department.

OHHABS Reporting in Texas

Texas DSHS is responsible for submitting reports to OHHABS for Texas. Other agencies and partners are encouraged to assist this process by filling out PDF reporting forms on any HAB events and associated human and animal illnesses they are responding to and sending them to EPITOX@dshs.texas.gov.

There are three types of forms for OHHABS reports:

1. Environmental – Form, Guidance
2. Human illness – Form, Guidance
3. Animal illness – Form, Guidance

The minimum information for reporting is the date of the HAB event and the waterbody location. When human or animal forms are submitted an environmental report is automatically generated. Table A2 summarizes the information that OHHABS collects in reports.

Table A5. Types of data collected for OHHABS reports for environmental, human, and animal forms. Table from CDC: https://www.cdc.gov/habs/pdf/overview-slides-nors-ohhabs.pptx.

Form Type	Types of Data Collected
Environmental Form	• Location of the HAB event • Observed water body characteristics • Advisories and health warnings • Laboratory testing – event sample testing • Pathogens or toxins detected • Other data systems that contain associated information • Seafood catch or harvest location for HAB-associated foodborne illnesses
Human Form	• General case information (e.g., sex, age in years) • Exposures (e.g., activities, duration) • Signs and symptoms of illness • Medical and health history • Clinical testing • Pathogens or toxins detected in clinical samples
Animal Form	• General case information (e.g., type of animal, single/group of animals) • Exposures (e.g. activities, duration) • Signs of illness • Health information (e.g., veterinary treatment) • Clinical testing • Pathogen or toxins detected in clinical samples

HAB Event and Case definitions

OHHABS uses standardized definitions to characterize HAB Events as Suspect or Confirmed and characterize human and animal cases as Suspect, Probable, or Confirmed. These characterizations depend on the level of evidence and data available. See HAB Case and Event Definitions Table (https://www.cdc.gov/habs/pdf/ohhabs-case-and-event-definitions-table-508.pdf) on the OHHABS website.

OHHABS Resources

- OHHABS website (https://www.cdc.gov/habs/ohhabs.html)
- PDF forms and reporting guidance (https://www.cdc.gov/habs/using-ohhabs.html)
- CDC publication on OHHABS data from 2016-2018 (https://www.cdc.gov/mmwr/volumes/69/wr/mm6950a2.htm?s_cid=mm6950a2_w)

Appendix K

Threshold Value Selection

Cyanobacterial Cell Density

The basis for cyanobacterial cell density thresholds is WHO (2003), where 20,000 – 100,000 cells/ml of cyanobacteria was associated with moderate probability of acute health effects and >100,000 cells/ml was associated with a high probability of acute health effects. WHO (2003) used epidemiological studies from Chorus and Bartram (1999) to distinguish mild skin irritation effects (<20,000 cells/ml) from microcystin caused liver damage (>20,000 cells/ml). At 100,000 cells/ml the formation of scums or mats is more likely, which carry the danger of exposure to very high concentrations of cyanobacterial cells and associated toxins.

However, there are many uncertainties and high variability in linking cell density to health effects due to differing cyanobacterial species, how much if any toxin is produced, differing potencies of toxins, differing health effects, and potential co-occurrences with pathogens, etc. Because of these uncertainties it is also recommended to analyze toxin concentrations.

Total Microcystins

The basis for the Tier II Warning threshold value for microcystins is USEPA (2019b), where 8 µg/L microsystins is the recommended magnitude for application as either a 10-day recreational water quality criterion or a swimming advisory threshold. This value was calculated based on liver damage to rats in a 28-day study (Heinze 1999).

Cylindrospermopsin

The basis for the Tier II Warning threshold value for cylindrospermopsin is USEPA (2019b) where 15 µg/L cylindrospermopsin is the recommended magnitude for application as either a 10-day recreational water quality criterion or a swimming advisory threshold. This value was calculated based on kidney damage to mice in an 11-week study (Humpage and Falconer 2002, 2003).

Anatoxin-a

The Tier II Warning / Danger threshold for anatoxin-a is triggered if anatoxin-a is detected in algal mat material or in water above the Tier II threshold. This is a protective approach based on the nature of benthic cyanobacterial mats associated with anatoxin-a in Texas. There have been high concentrations of anatoxin-a, and other anatoxins, such the more toxic dihydroanatoxin-a, in cyanobacterial benthic mats but low concentrations in the surrounding water (Puddick et al. 2020). The

toxins are concentrated in pieces of benthic mat that separate from the underwater mass and float to the surface or accumulate at shores. Therefore, if any anatoxin-a is present in the algal material a Tier II Warning advisory is appropriate due to the possible presence of dangerous accumulations of toxins in algal mat material.

The basis for the Tier II water threshold for anatoxin-a is WHO (2020), where 60 µg/L is the provisional recreational water health-based reference value for anatoxin-a. This value was calculated based on acute lethal toxicity to mice (Fawell et al. 1999). Due to the lack of available studies in the scientific literature and uncertainties within the few available studies, the value from WHO (2020) is considered a temporary and protective value.

Toxic Substances Coordinating Committee
Harmful Algal Workgroup