Harmful Cyanobacterial Bloom (HCB) Action Plan

for Publicly Accessible Waterbodies in Wyoming

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Summary

The Wyoming Department of Environmental Quality (WDEQ), the Wyoming Department of Health (WDH), the Wyoming Livestock Board (WLB), resource management agencies, and other stakeholders have developed a process to identify potential harmful cyanobacterial blooms (HCBs) in Wyoming surface waters and inform collaborators and the public of the potential health risks when HCBs are present so they can make informed decisions to protect public and animal health. This Action Plan is intended to provide the WDEQ, WDH, WLB, resource management agencies, and other cooperators with procedural guidelines should a HCB be suspected in surface waters in the State of Wyoming. Guidelines include: surveillance and reporting of potential blooms; the process for notifying the public a waterbody may be under investigation due to the potential presence of an HCB; steps for evaluating whether a bloom is likely to contain harmful cyanobacteria; procedures to test cyanobacteria abundance and cyanotoxin concentrations; cyanobacteria cell density and cyanotoxin thresholds for the WDH to issue health advisories; and the process for lifting advisories. The plan also outlines the notification process should a HCB be identified in a public drinking water supply and information on reporting potential HCB-related illnesses. Publicly accessible lakes and reservoirs used for full body contact recreation are the primary focus of this plan because these waterbodies are the most likely to be associated with exposure of people or animals to cyanotoxins or other cyanobacteria-related irritants via water contact, accidental ingestion, or inhalation, however, the plan can also be used for other surface waters where HCBs occur. This plan will be updated as new information becomes available.

For resources and more information on HCBs in Wyoming, including signage, outreach materials, and current and past public health notifications, visit the Wyoming HCB webpage at WyoHCBs.org.

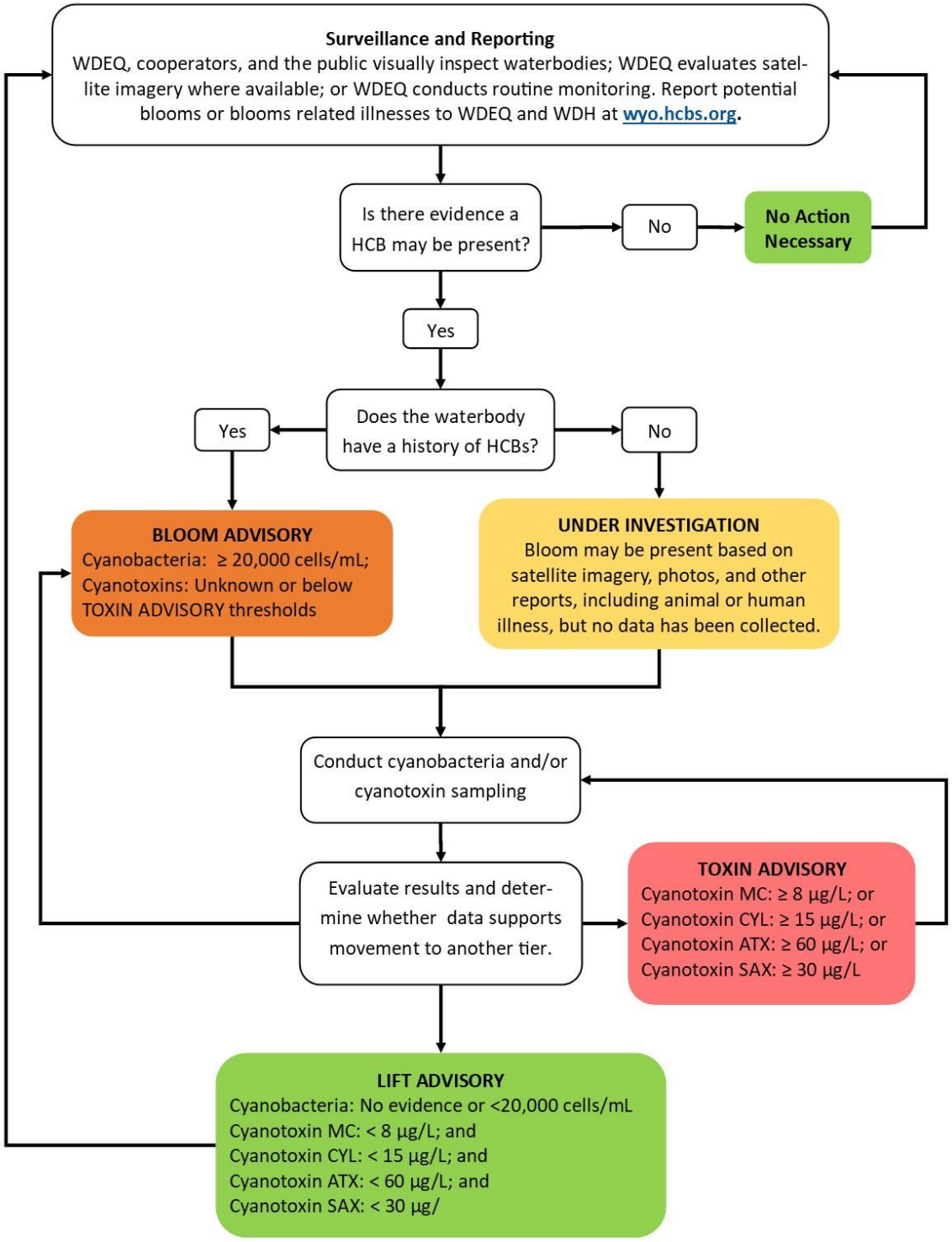

Figure 1. Wyoming's HCB Action Plan Flow Chart.

Table 1. Wyoming Harmful Cyanobacterial Bloom Advisory Levels for Recreational Waters.

Notification Level	Human Health Risk	Health Recommendations	Cyanobacteria[1] Abundance	Cyanotoxins[2] (µg/L)				Recommended Action
				MC	CYL	ATX	SAX	
Toxin Advisory	Elevated	Toxins exceed recreational thresholds. Avoid areas in proximity to bloom.	Any	≥ 8	≥ 15	≥ 60	≥ 30	Post signs at waterbody. Add waterbody to WyoHCBs.org webmap. Include waterbody in listserv email. Monitor. Waterbodies will remain under a Toxin Advisory until data supports movement to another tier.
Bloom Advisory	Moderate to Elevated	**Cyanobacteria bloom present. Toxins may be present. Avoid or use caution in areas near bloom.**	**≥ 20,000 cells/mL**	**Unknown or below thresholds.**				**Post signs at waterbody. Add waterbody to WyoHCBs.org webmap. Include waterbody in listserv email. Monitor. Waterbodies will remain under an Bloom Advisory until data supports movement to another tier.**
Under Investigation	Unknown	Cyanobacteria and toxins may be present, but have not been confirmed. Avoid or use caution in areas near bloom.	Bloom may be present based on reports, including animal or human illness, but no other data has been collected.					Add waterbody to WyoHCBs.org webmap. Monitor. Waterbodies will remain **Under Investigation** until data supports movement to another tier.
None	Low	No evidence of blooms or toxins at this time.	No evidence or < 20,000 cells/mL	< 8	< 15	< 60	< 30	No signs or electronic notifications necessary.

[1] For waterbodies with previous history of blooms, cyanobacteria abundance may be determined by: positive jar test and photographs of bloom; photographs of bloom; or detections with satellite imagery. For waterbodies without a previous history of blooms, cyanobacteria abundance should be determined using laboratory identification and enumeration.

[2]MC = Total Microcystins; CYL = Cylindrospermopsin; ATX = Anatoxin-a; SAX = Saxitoxin. Cyanotoxin thresholds represent total concentrations of all congeners. Any of the cyanotoxins can exceed the thresholds for a waterbody to be categorized as under a Health Advisory.

Table 2. Response strategy for HCBs in publicly accessible surface waters in Wyoming.

Step	Responsive Action
Step 1: Surveillance and Reporting	• A public notice will be sent at the beginning of the HCB season with guidance on how to identify HCBs, report HCBs and HCB related illnesses, and health risks associated with HCBs. • WDEQ and/or cooperators should visually inspect publicly accessible lakes and reservoirs (see WyoHCBs.org for photos of Wyoming HCBs). • WDEQ will review satellite imagery, if available, to monitor lakes and reservoirs for HCBs. • Suspected HCBs or possible HCB related illnesses should be report to WDEQ and WDH at WyoHCBs.org. • If a waterbody has signs of a potential HCB, the waterbody will be placed **Under Investigation** on the WyoHCBs.org webmap. When a waterbody is placed **Under Investigation**, resource management agencies and local health authorities may choose to post a HCB signs in the area where the bloom or illness was reported if permanent HCB signs are not in place.
Step 2: Optional Preliminary Screening	• WDEQ or a cooperator can use optional jar and/or stick tests[1] to determine if cyanobacteria are present in a bloom or cyanotoxin field test strips to determine if cyanotoxins are present. • If tests are indicative of cyanobacteria or cyanotoxins, or the waterbody is known to have had a HCB in the past[1], the resource management agency should ensure a HCB sign is posted at the water body and report the bloom to WDEQ.
Step 3: Data Collection and Issuing Advisories	• If a waterbody has a history of HCBs and shows signs of a HCB[3] through reports, satellite imagery, or visual inspection, WDH will issue a **Bloom Advisory,** the waterbody will be included on the HCB webmap, and the public and cooperators will be notified via the HCB listserv. • WDEQ or a cooperator should collect three water samples[1] for laboratory analyses: (1) one sample for cyanobacteria identification and enumeration; (2) one sample for microcystin and cylindrospermopsin analysis; (3) one sample for anatoxin-a analysis. Samples should be collected and shipped per WDEQ Standard Operating Procedures[4]. • If analyses indicate cyanobacteria densities are **≥20,000 cells/mL and cyanotoxin concentrations below thresholds***,* the WDH will issue a **Bloom Advisory**. • If analyses indicate total microcystin concentrations **≥ 8 µg/L,** cylindrospermopsin concentrations **≥ 15µg/L**, anatoxin-a concentrations **≥ 60 µg/L,** or saxitoxin concentrations **≥ 30 µg/L[5],** the WDH will issue a **Toxin Advisory**. • Waterbodies with **Bloom Advisory** or **Toxin Advisory** will be included in the HCB webmap, and the public and cooperators notified be via the HCB listserv. • When the WDH issues an **Advisory**, resource management agencies and local health authorities should coordinate posting of signs if permanent HCB signs are not in place. • WDH may issue a **Closure** at any time during the process based on the threat to public health.
Step 4: Lifting Advisories	• **Advisories** will remain in place until data indicates a bloom has fully dissipated based on satellite imagery, visual evidence, or cyanobacteria density is **< 20,000 cells/mL** and analyzed cyanotoxin concentrations are less than the **Toxin Advisory** levels. • Once WDH lifts an Advisory, the waterbody will be removed from the Current Bloom Advisory or Current Toxin Advisory tab of the WyoHCBs.org webmap and the cooperators and the public will be notified via the HCB listserv. Temporary HCB signs may be removed by resource management agencies and local health authorities. • Once **Advisories** have been lifted for all waterbodies, WDH, WDEQ, and WLB will issue a press release and listserv notice documenting the end of the HCB monitoring season. The press release will advise recreationalists to take appropriate precautions because HCBs may continue to be present in Wyoming surface waters in the cooler months.

[3] For waterbodies with previous history of blooms, HCB presence can be determined by: positive jar test and photographs of bloom; photographs of bloom; or detections with satellite imagery. For waterbodies without a previous history of blooms, cyanobacteria abundance should be determined using laboratory identification and enumeration.

[4] See WyoHCBs.org for resources for management agencies, including signs, sampling procedures, information on publicly accessible lakes and reservoirs (e.g., contact information, past HCB occurrence, use as a public water supply, etc.).

[5] Saxitoxin is not routinely collected and analyzed by WDEQ.

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Definitions

Anatoxin-a	A cyanotoxin that primarily affects the central nervous system. Common cyanobacteria in Wyoming that produces anatoxin-a are *Anabaena, Aphanizomenon, Cylindrospermopsis, Microcystis* and *Phormidium.*
Benthic Cyanobacteria	Cyanobacteria that attach to rocks, sediment and macrophytes located on the bottom of a waterbody.
Cooperator	An entity or agency working jointly with the Wyoming Department of Environmental Quality, Wyoming Department of Health, and Wyoming Livestock Board to achieve Action Plan objectives. Cooperators include, but are not limited to, Resource Management Agencies and Local County Coordinators.
Cyanobacteria	A phylum of bacteria that obtain their energy from photosynthesis. Cyanobacteria are often referred to as *blue-green algae*, however they are taxonomically distinct from true algae. Cyanobacteria are commonly found in phytoplankton communities, but can also colonize benthic substrates and macrophytes.
Cyanotoxins	Toxins produced by cyanobacteria. Contact, ingestion, and inhalation of these toxins can cause serious health impacts to humans, pets, livestock, wildlife, and aquatic life.
Cylindrospermopsin	A cyanotoxin that primarily affects the liver. Common cyanobacteria in Wyoming that produce cylindrospermopsin are *Anabaena, Aphanizomenon, Cylindrospermopsis,* and *Lyngbya*.
Harmful Cyanobacterial Bloom (HCB)	A highly dense concentration of cyanobacteria where there is an elevated risk to human or animal health due to cyanotoxin production or other cyanobacteria-related effects. Also referred to as a harmful algal bloom (HAB).
Local County Coordinators	Local government coordinators responsible for preparing and protecting the public against problems that occur within their county.
Microcystin	A cyanotoxin that primarily affects the liver. Microcystin is a common toxin (more than 100 congeners) with the most widely available toxicological data. Common cyanobacteria in Wyoming that produce microcystin are *Anabaena*, *Aphanizomenon, Aphanocapsa*, *Gloeotrichia, Microcystis*, and *Pseudanabaena*.
Phytoplankton	Small photosynthetic organisms suspended in the water column. Phytoplankton communities commonly include cyanobacteria and algae.

Publicly Accessible Lakes or Reservoirs	Those lakes and reservoirs occurring on public or private land that can be used, entered and reached by the public without the permission of the land owner or resource management agency.
Resource Management Agency	Agency that manages a publicly accessible lake or reservoir, such as the Wyoming Game and Fish Department, Wyoming State Parks, United States Forest Service, Bureau of Land Management, Bureau of Reclamation and the United States Fish and Wildlife Service.
Saxitoxin	A cyanotoxin that primarily affects the central nervous system. Common cyanobacteria in Wyoming that produce saxitoxin are *Anabaena, Aphanizomenon, Cylindrospermopsis* and *Lyngbya.*
Scum	A cyanobacterial bloom that densely accumulates at the water surface, producing a visible layer or colony.

Introduction

Purpose

The Wyoming Department of Environmental Quality (WDEQ), the Wyoming Department of Health (WDH), the Wyoming Livestock Board (WLB), resource management agencies, and other stakeholders have developed a Harmful Cyanobacteria Bloom (HCB) Program for Wyoming to inform collaborators and the public when HCBs may be present in Wyoming surface waters so they can make informed decisions to protect public and animal health. This Action Plan is intended to provide the WDEQ, WDH, WLB, resource management agencies, and other cooperators with procedural guidelines should a harmful cyanobacterial bloom (HCB) be suspected in surface waters in the State of Wyoming. Guidelines include: surveillance and reporting of potential blooms; the process for notifying the public a waterbody may be under investigation due to the potential presence of an HCB; steps for evaluating whether a bloom is likely to contain harmful cyanobacteria; procedures to test for cyanobacteria abundance and cyanotoxin concentrations; cyanobacteria cell density and cyanotoxin thresholds for the WDH to issue health advisories; and the process for lifting advisories. The plan also outlines the process should a HCB be identified in a public drinking water supply and information on reporting potential HCB-related illnesses. Publicly accessible lakes and reservoirs used for full body contact recreation are the primary focus of this plan because these waterbodies are the most likely to be associated with exposure of people or animals to cyanotoxins or other cyanobacteria-related irritants via water contact, accidental ingestion, or inhalation, however, the plan can also be used for other surface waters where HCBs occur. This plan will be updated as new information becomes available.

Background

HCBs are dense concentrations of cyanobacteria that have serious health consequences for humans, pets, and livestock through contact, ingestion, and/or inhalation of cyanotoxins or other cyanobacteria-related irritants. Other consequences of HCBs include: food web alterations and ecological dead zones (e.g., fish kills); ecotourism and property value losses; and negative impacts to drinking water supplies, agriculture, and wildlife (Carmichael, 1992; Fawell et al., 1993; WHO, 1999). Cyanobacteria are commonly referred to as blue-green algae since they appear and function similar to algae, yet they are taxonomically distinct from true algae. HCBs are therefore also referred to as *harmful algal blooms* or *HABs*.

Under normal conditions, cyanobacteria are present in the water column or attached to substrates at low levels. When blooms occur, cyanobacteria become visibly abundant, typically forming dense colonies on the water surface (i.e., scums) and may make the water green to bluish-green in appearance. Other cyanobacteria blooms may occur deeper in the water column (e.g., *Planktothrix rubscens*), may appear brownish-green like turbid water (e.g., *Cylindrospermopsis* spp.) or may attach to rocks, sediment or plants on bottom of a water body (e.g., benthic cyanobacteria such as *Phormidium* spp.) (USGS, 2008).

Cyanotoxins produced by cyanobacteria generally affect the body through three exposure pathways: the central nervous system, digestive system, and renal system through ingestion; the respiratory system through inhalation; and the skin, eyes, nose, mouth, and throat through direct contact. Health effects of toxin exposure may include nausea, fatigue, shortness of breath, coughing, disorientation, rashes, blisters, itching, numbness, burning, headache, fever, abdominal pain, vomiting, diarrhea, pneumonia, inflammation of the liver, and impaired kidney function. Effects may occur within minutes to days after exposure. In extreme cases, cyanotoxins may lead to pet or livestock death. Currently, there are no known antidotes for cyanotoxins (Carmichael, 1992; Fawell et al., 1993; WHO, 1999). Health effects may also be linked to

cyanobacteria cells and associated irritants, though these sources and their mode of action remain unclear (USEPA 2019).

The type of cyanotoxins present in a water body depends on the species/genera of cyanobacteria, though some species/genera are capable of producing multiple types of toxins. Moreover, toxigenic cyanobacteria, or those with genes that allow for cyanotoxin production, may only produce cyanotoxins under certain environmental conditions. Toxigenic cyanobacteria that dominate blooms in Wyoming's publicly accessible reservoirs and the cyanotoxins they produce are listed in Table 3. These cyanotoxins are categorized by their primary mode of action: dermatoxins (i.e., skin irritants), hepatotoxins (i.e., affect liver function), and neurotoxins (i.e., affect central nervous system). Sampling in Wyoming currently targets three cyanotoxins: microcystins, cylindrospermopsin, and anatoxin-a. These cyanotoxins are the most common cyanotoxins and have the most available information regarding their health effects.

Table 3. Common cyanobacteria in Wyoming lakes and reservoirs and their associated cyanotoxins.

Cyanobacteria Genera	**Dermatoxins**			**Hepatotoxins**			**Neurotoxins**			
	APL	**LPS**	**LYN**	**CYL**	**MC**	**NOD**	**ATX**	**BMAA**	**NEO**	**SAX**
Dolichospermum (Anabaena)		X		X	X		X	X	X	X
Aphanizomenon		X		X	X		X	X	X	X
Aphanocapsa		X			X					
Cylindrospermopsis		X		X			X			X
Gloeotrichia		X			X					
Lyngbya	X	X	X	X				X		X
Microcystis		X			X		X	X		
Nodularia		X				X		X		
Nostoc		X			X					
Oscillatoria (Planktothrix)	X	X			X		X			
Phormidium		X					X			
Planktolyngbya		X								
Pseudanabaena		X			X					

Data provided in this table are largely based on results documented in USGS (2008), WHO (1999), EPA website.
Toxin abbreviations are as follows: APL, aplysiatoxins; LPS, lipopolysaccharides; LYN, lyngbyatoxin-a; CYL, cylindrospermopsins; MC, microcystins; NOD, nodularins; ATX, anatoxins; BMAA, β-N-methylamino-L-alanine; NEO, neosaxitoxins; SAX, saxitoxins.

When released from cyanobacteria cells, cyanotoxins are colorless and may remain in the water column after a bloom has dissipated. Studies have shown cyanotoxins persisting anywhere from five days to several months in water and up to six months in dry scum (USEPA 2019). The rate at which cyanotoxins are removed depends on environmental factors such as water pH and temperature, ultraviolet degradation, the presence of particulate matter, water depth and bacterial breakdown (USGS 2008, USEPA 2019). Studies have also shown that certain strains of microcystin can remain in sediments for months or, conversely, bypass sediments and enter groundwater. Cyanotoxins and cyanobacteria can also flow downstream from lakes and reservoirs for indeterminate long distances (USEPA 2019).

Many factors including excess nutrients, sunlight, wind, flow and temperature contribute to the formation of HCBs. Although blooms can occur at any time, they are more likely to occur in late summer and early fall when reservoir temperatures warm, water levels stabilize, nutrients are assimilated, and phytoplankton productivity increases. Blooms may occur in some reservoirs following turn-over when nutrients are

released from the bottom of a reservoir as cooler water is brought toward the surface. Shallow reservoirs, those with long residence times, or those with elevated concentrations of nutrients have an increased likelihood of blooms.

Health Advisory Levels

The objective of this plan is to identify cyanobacteria and cyanotoxin thresholds that will be used to inform the public and cooperators of the health risks that may be present in waterbodies based on the presence of a cyanobacteria bloom, and the presence of cyanotoxin concentrations that exceed recreational thresholds (see Table 1). The plan uses cyanobacteria abundance and ambient concentrations of the cyanotoxins anatoxin-a, microcystin, cylindrospermopsin, and saxitoxin, as these are currently the most reliable methods of determining potential health risks. Cyanobacteria abundance and cyanotoxin concentration thresholds are used to identify risks to human health as low for no notifications necessary, moderate to elevated for a BLOOM ADVISORY, and elevated for TOXIN ADVISORY (see Table 1). Waterbodies where blooms have been reported, including bloom related illnesses, but cyanobacteria and cyanotoxin samples have not yet been analyzed are placed UNDER INVESTIGATION to notify the public that there may be potential health risks associated with the waterbody. This information can then be used by the public and cooperators to take appropriate precautions to protect the health of people and animals. Such actions may include, but are not limited to, avoiding areas with blooms, cleaning fish properly, conducting additional monitoring at public water supplies, etc.

Because the extent of a HCB may change rapidly or may move from one area of a reservoir to another, an ADVISORY will apply to an entire reservoir unless otherwise noted. An ADVISORY for a lake or reservoir should not, however, be interpreted as a closure since many areas of waterbody may not be impacted by a HCB.

Cyanotoxin Thresholds

In May 2019, the US Environmental Protection Agency (EPA) released *Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin* that states can consider for inclusion as water quality criteria for the protection of primary contact recreation and/or for issuing public health advisories. The recommended cyanotoxin thresholds are **8 µg/L total microcystins** and **15 µg/L cylindrospermopsin.** These recommendations are based on incidental ingestion by children while swimming since children represent the most vulnerable age group due to their extended periods of water play as well as the quantity of water they ingest. The recommendations were derived from peer-reviewed scientific literature and criteria methodologies in EPA's Exposure Factors Handbook. Thresholds were only developed for microcystin and cylindrospermopsin since these toxins have the most available toxicological data and EPA has not released recommended criteria for any other cyanotoxins. It is important to note that these values may not be appropriate for domestic animals or livestock.

In February 2021, the World Health Organization (WHO) released *Toxic Cyanobacteria in Water – Second Edition; A Guide to Their Public Health Consequences, Monitoring, and Management.* The WHO identified recreational health-based reference values (HBRV) and guideline values (GV) for cyanotoxin exposure to protect the health of vulnerable populations, including children. The WHO encourages regulators to adopt these values as thresholds to protect public health in waterbodies used for recreation. The **saxitoxin**

recreational GV is **30 µg/L** and was calculated considering the amount of toxin that can be ingested daily over a lifetime without health risks, the high incidental water consumption of children recreating in waterbodies, and the bodyweight of a child. The **anatoxin-a** recreational HBRV is **60 µg/L**. The WHO concluded that there are not enough long-term studies to develop a long term anatoxin-a GV, but derived the anatoxin-a short term, recreational HBRV from studies conducted in the 1980s and 1990s demonstrating acute exposure of anatoxin-a in animals. This reference value also accounts for the high total exposure of children, and body weight of a child.

Cyanobacteria Thresholds

This plan also identifies potentially harmful densities of cyanobacteria since all cyanobacteria do not produce microcystin, cylindrospermopsin, anatoxin-a, and saxitoxin, and there may be risks associated with direct contact to cyanobacteria cells (USEPA 2019). In addition, cyanobacteria may transition from not producing cyanotoxins to producing cyanotoxins and cyanobacteria are capable of producing different toxins at different times, some of which may not be documented (Otten and Paerl 2015). For these reasons, Wyoming recreational use thresholds also include a **20,000 cells/mL cyanobacteria** cell density component. The cell density threshold was selected after reviewing scientific studies utilized by other state agencies and health organizations (Graham et al., 2009; Farrer et al., 2015). The cell density threshold is consistent with World Health Organization (WHO 1999) guidelines and represents the level at which acute health effects transition from low to moderate risk (Table 4). Based on the recurring nature of HCBs in many waterbodies, for waterbodies with a previous history of HCBs, evidence of a bloom by positive jar tests and photographs of a bloom; photographs of a bloom; or detections with satellite imagery will be used as evidence that cell densities exceed 20,000 cells/mL. For waterbodies without a previous history of HCBs, cell densities will be determined via identification and enumeration.

Table 4. World Health Organization guidelines for cyanobacterial bloom characterization.

Acute Health Effects	Cyanobacteria (cells/mL)
Low	< 20,000
Moderate	20,000 to 100,000
High	100,000 to 10,000,000
Very High	> 10,000,000

*Microcystin-LR is commonly used to represent microcystin congeners due to widely available data and known toxicity

Additional Thresholds

In circumstances where a cyanobacterial bloom poses a potential health risk due to cyanotoxins other than anatoxin-a, microcystin, cylindrospermopsin, and saxitoxin, WDH will determine an appropriate threshold for issuing a public health notification, if necessary. WDH may also issue public health notifications based on other bloom conditions that pose health risks to people such as pet or livestock deaths. Thresholds included in this plan will be updated as more cyanobacteria and toxin data are collected in Wyoming's publicly accessible lakes and reservoirs and new scientific information becomes available.

Lake and reservoir CLOSURES do not have an established cyanobacteria or cyanotoxin threshold. According to Wyoming Statute (WS) § 35-1-240, WDH may issue a public beach or water body CLOSURE at any step of the process based on the threat to public health. Actual or potential cyanotoxin and cyanobacteria-related illnesses will be considered as part of this assessment. WDH will determine the location and extent of a CLOSURE by evaluating the threat to public health or where actual or potential cyanotoxin and

cyanobacteria-related illnesses have been documented. WDH will follow usual processes and policies in place for mitigating public health threats, which may include notification of local officials, state agencies, the public, the media, and healthcare providers.

Response Strategy

The following procedures have been developed by the WDEQ, WDH, and WLB for notifying the public about recreation risks in surface waters associated with HCBs. Wyoming's HCB response strategy is based on four steps 1) Surveillance and Reporting; 2) Optional Preliminary Screening; 3) Data Collection and Issuing Advisories; and 4) Lifting Advisories (see Table 2).

Step 1: Surveillance and Reporting

WDEQ, WDH and WLB will issue a press release at the beginning of the HCB season to remind the public of the upcoming season, the health risks associated with HCBs, and how to identify and report HCBs and HCB related illnesses.

HCBs may appear blue, green, yellow, white and/or brown in color and look like scums, clumps, floating mats, small grass clippings and/or spilled paint (USGS, 2008). These accumulations may be present at the water surface, evenly throughout the water column, at specific depths within the water column, attached to aquatic plants, or attached to the bottom of a water body. See WyoHCBs.org for photographs of cyanobacterial blooms in Wyoming. A helpful US Geological Survey Field and Laboratory Guide for identifying toxin-producing cyanobacteria is provided at the following link: https://pubs.er.usgs.gov/publication/ofr20151164.

Water bodies with heavy recreational use, particularly those with swimming beaches or those that are frequently used for swimming and similar water contact activities, should be visually inspected approximately weekly during the summer recreation season (approximately May through October) or routinely monitored during the HCB season (approximately mid-July through October). Visual inspection should generally occur through observations by resource management agencies (e.g., Wyoming State Parks, Historic Sites & Trails; National Park Service; Wyoming Game and Fish Department; United States Forest Service; Bureau of Land Management; Bureau of Reclamation; United States Fish and Wildlife Service) as well as WDEQ, municipalities, and other cooperators. Observations of potential HCBs will also rely on public reporting by recreational users. Overall, management agencies and other cooperators are encouraged to work with WDEQ, WDH and WLB to educate staff, recreationalists and agricultural producers of cyanobacterial blooms, their potential health risks, and how to report suspected HCBs.

Resource constraints may limit the number of lakes and reservoirs that can be inspected by resource management agencies on a routine basis and the public may not consistently report suspected blooms. As such, WDEQ will use Cyanobacteria Assessment Network (CyAN) satellite imagery that detects HCBs due to the unique spectral signature of cyanobacteria. For lakes and reservoirs to be considered resolvable by CyAN, they must meet a minimum size requirement (>900 meters). This results in 40 lakes and reservoirs that can be monitored remotely by WDEQ. WDEQ will analyze imagery for these water bodies using screening metrics that determine the areal extent of blooms, cyanobacteria cell density and bloom persistence over time. WDEQ may also use CyAN imagery and other remote sensing platforms to determine if smaller lakes and reservoirs should be investigated.

A table of some publicly accessible recreational lakes and reservoirs is included in the resources section of the WyoHCBs.org webpage. The table details which water bodies are resolvable by CyAN and also contains recreational activities for lakes or reservoirs, the name and contact number of the entity that manages the water body, whether cyanobacterial blooms have been documented in the reservoir, and whether drinking water intakes are located in or downstream of the water body. This table serves as an information source should a suspected HCB occur in one of these lakes or reservoirs and should not be considered comprehensive. The table will be updated periodically as new information becomes available.

In the event of a suspected HCB, observers should report the bloom to WDEQ using the *Report a Spill* hotline at WyoSpills.org or call 307-777-7501. If reporting online, observers are encouraged to provide contact information and photographs of suspected blooms so WDEQ may contact complainants and conduct a preliminary evaluation. It is recommended that observers avoid contact with blooms until they are deemed safe. If observers believe that they may be experiencing adverse health effects after contact with a bloom, they should contact a health care provider and report the illness to the Wyoming Department of Health via WyoHCBs.org webpage.

General information on HCB health risks can be found at: https://www.cdc.gov/habs/ and additional information on HCB health risks can be found at: https://health.wyo.gov/publichealth/infectious-disease-epidemiology-unit/disease/harmful-algal-blooms/.

If a potential HCB or HCB related illness is reported to WDH or WDEQ and an initial evaluation determines the report to be credible, the waterbody will be placed **UNDER INVESTIGATION** on the WyoHCBs.org webmap. Waterbodies placed **UNDER INVESTIGATION** to notify the public that HCBs and associated health risks may be present in waterbody, however, additional data needs to be collected to determine potential health risks. Resource management agencies or local health authorities may choose to post a temporary HCB sign to inform recreationalists of potential health risks in the area where the bloom or illness was reported. HCB signage can be found at WyoHCBs.org.

Step 2: Optional Preliminary Screening

Field tests are optional but may provide preliminary information on the potential health risks of a suspected HCB as well as the type of laboratory analysis that should be conducted. Once reported to WDEQ, suspected HCBs can be evaluated by WDEQ or a cooperator using jar and/or stick tests to determine whether cyanobacteria are present (see resources at WyoHCBs.org for procedure). WDEQ or a cooperator can also use field test strips (e.g., Abraxis Strip Test®) to test for cyanotoxins such as microcystins. Samplers should follow test strip protocols provided in their purchased test kit.

Samples for optional screening tests should be collected from the densest portion of a bloom in areas where the public comes into contact with the water (e.g., boat ramps, swimming beaches, etc.). If tests indicate that cyanobacteria or cyanotoxins are present and a permanent HCB sign is not already in place, the resource management agency may choose to post a temporary HCB sign to inform recreationalists of potential health risks. The HCB sign may also be posted prior to screening if the reservoir has a history of reoccurring HCBs or the bloom shows signs of worsening. HCB signage can be found at WyoHCBs.org and should be posted at heavily-used locations around the lake or reservoir. More information regarding permanent signs can be found in *Step 3: Data Collection and Issuing Advisories.*

Step 3: Data Collection and Issuing Advisories

If preliminary screening (i.e., reports, satellite imagery, or visual inspections), suggests that a HCB is present in a waterbody with a prior history of HCBs, the WDH will issue a **BLOOM ADVISORY** for the waterbody.

Once a waterbody has been placed **UNDER INVESTIGATION** or WDH has issued a **BLOOM ADVISORY**, additional samples should be collected to determine whether it is appropriate to move the waterbody to another tier. In most circumstances, when blooms are present, WDEQ or a cooperator should collect three samples for laboratory analysis: one sample for cyanobacteria identification and enumeration; one sample for microcystin and cylindrospermopsin analysis; and one sample for anatoxin-a analysis. If resources are limited, cyanobacteria identification and enumeration samples can be reserved for waterbodies with no prior history of HCBs, so the presence of a cyanobacteria bloom can be documented.

Similar to optional screening tests, samples should be collected from the densest portion of a bloom in areas where the public regularly comes into contact with the water. Additional information on sampling protocols can be found in WDEQ's Standard Operating Procedures, *Harmful Cyanobacterial Blooms: Cyanobacteria Collection (Lentic)* and *Harmful Cyanobacterial Blooms: Cyanotoxin Collection (Lentic)* (see WyoHCBs.org). Samplers should follow all health and safety procedures included in these documents.

Cyanobacteria samples will be shipped to WDEQ's contract laboratory for cyanobacteria identification and enumeration. WDEQ will send cyanotoxin samples to the State of Wyoming Water Quality Lab in Cheyenne, Wyoming, for analysis using enzyme-linked immunosorbent assay (ELISA). WDEQ does not provide analytical support for private water bodies unless there is a public health concern associated with the waterbody. If other entities are interested in having samples analyzed, a list of common laboratories that analyze cyanobacteria and cyanotoxins can be found on EPA's website: https://www.epa.gov/cyanohabs/laboratories-analyze-cyanobacteria-and-cyanotoxins.

No advisory is necessary if analyses reveal cyanobacteria density **< 20,000 cells/mL**, total microcystin **< 8 µg/L**, cylindrospermopsin **< 15 µg/L**, anatoxin-a **< 30 µg/L**, and saxitoxin **< 60 µg/L.**

WDH will retain a **BLOOM ADVISORY** or issue a new **BLOOM ADIVSORY** if analyses reveal cyanobacteria density is **> 20,000 cells/mL** and cyanotoxin levels are below Wyoming's HCB Toxin Advisory levels for recreational waters. WDH will issue a **TOXIN ADVISORY** if microcystin concentrations are **≥ 8 µg/L**, cylindrospermopsin concentrations are **≥ 15 µg/L**, anatoxin-a concentrations are **≥ 60 µg/L,** or saxitoxin concentrations are **≥ 30 µg/L**. If any cyanotoxins other than microcystin, cylindrospermopsin, anatoxin-a, or saxitoxin are detected, or any other conditions such as human or animal illnesses are linked to the bloom, WDH will determine whether to issue a **BLOOM ADVISORY**, **TOXIN ADVISORY**, or other public health notification.

Once the WDH issues a **BLOOM ADVISORY** or a **TOXIN ADVISORY**, the public health notification process includes (1) updating Wyoming's HCB webmap; (2) sending notification via Wyoming's HCB listserv; (3) posting signs at the waterbody; and (4) additional public outreach via press releases or social media. All past and current notifications will be available on WyoHCBs.org. WDEQ encourages cooperators and recreationalists to visit the webpage for the most up-to-date information.

Additional cooperator notification, typically via the HCB listserv, will include: (1) WDH notification to local health authorities of common cyanobacteria and cyanotoxin-related symptoms; (2) WDEQ notification to

EPA if a water intake is located on or downstream of the waterbody impacted by a HCB; (3) WDEQ notification to local county coordinators so appropriate action can be taken in their respective county; (4) WDEQ notification to the U.S. Fish and Wildlife Service (USFWS) and the Wyoming Game and Fish Department (WGFD) due to potential HCB related impacts to migratory birds, eagles, fisheries, and other wildlife; and (5) WDEQ notification to water quality agencies of adjacent states and/or tribes when a public health notification has been issued for a publicly accessible waterbody that occurs both in the State of Wyoming and in the adjacent state or tribal territory.

Permanent signs with advice on how to identify HCBs and avoid potential health risks, and inform the public to visit WyoHCBs.org for additional information, may already be installed at some waterbodies. If permanent HCB signs are not already in place or additional signs are warranted, such as when a **TOXIN ADVISORY** is issued, WDH will coordinate posting of temporary signage by resource management agencies, local health authorities, and/or local country coordinators. Permanent and temporary signs will utilize the templates found at WyoHCBs.org. For waterbodies with a **BLOOM ADVISORY**, signs should be posted around the entire waterbody since blooms may form, reform and move to different areas at any given time. Permanent and temporary signs should be posted at heavily trafficked locations, including boat ramps, swimming beaches, fee canisters, park entrances, etc., so they can be easily seen by recreationists. For waterbodies with a **TOXIN ADVISORY**, signs may be posted in the area where toxin concentrations exceed recreational thresholds so that they can be easily seen by recreationists.

WyoHCBs.org includes an example press release with health effects language and use restrictions, should a cooperator choose to conduct additional public notifications. Press releases should not be used without approval from each agency's public information officer or communication coordinator.

Once a BLOOM ADVISORY or TOXIN ADVISORY has been issued for a waterbody, WDEQ and resource management agencies will continue to monitor the location, extent, and severity of HCBs to provide the most up to date information to recreationists. In circumstances where data indicates a waterbody should be moved to another tier, the public health notification (webmap, listserv notice, etc.) will be updated accordingly. Resource management agencies should also ensure that any human illnesses or animal deaths have been reported to the WDH and continue to coordinate with public water supplies, if applicable. Resource management agencies are encouraged to coordinate with WDEQ if additional cyanobacteria or cyanotoxin samples are to be collected to monitor an ongoing HCB.

Step 4: Lifting Advisories

Advisories will remain in place until a bloom has fully dissipated **and** cyanotoxin concentrations are below the **TOXIN ADVISORY** thresholds. For visual confirmation that a bloom has dissipated, resource management agencies should provide visual evidence such as photographs or videos to WDEQ. WDEQ will evaluate the evidence as well as satellite imagery provided by CyAN, if available. If both visual evidence and satellite imagery indicate that cyanobacteria are not present, WDEQ will conduct cyanotoxin sampling to confirm safe levels. Once confirmed the WDH will lift the **ADVISORY**, the waterbody will be removed from the Current Bloom Advisory or Current Toxin Advisory tab on the WyoHCBs.org webmap, and cooperators and the public will be notified via the HCB listserv. Once all ADVISORIES are lifted, temporary signs may be removed by resource management agencies, local health authorities, and/or local country coordinators.

Resource management agencies should continue to observe the waterbody and report new cyanobacterial blooms if they appear.

Once ADVISORIES have been lifted for all waterbodies, WDH, WDEQ, and WLB will issue a press release and listserv notice documenting the end of the HCB monitoring season. The release will notify the public that undocumented HCBs may continue to be present in Wyoming surface waters in the cooler months, and that recreationists, including waterfowl hunters and ice fisherman, should continue to avoid HCBs due to the potential health risks.

Public Outreach

The WDEQ, WDH, WLB and cooperating agencies should work to inform the public of the adverse health effects associated with HCBs and how to identify and report a suspected bloom. A HCB flyer, frequently asked questions (FAQs), photo gallery, webinar presentation, and video for public dissemination can be found in the resources section of the WyoHCBs.org webpage. In the event of a public health notification or closure, WDEQ, WDH, WLB, and cooperating agencies should coordinate to ensure that information is disseminated via signs, press releases, videos, websites, social media, and other public forums.

Public Water Supplies

When cyanobacterial blooms are suspected within or in close proximity to public water supply source waters, including either surface waters or groundwater under the influence of surface water, WDEQ will notify EPA so that they can coordinate appropriate next steps with public water supply utilities. Particular attention will be paid in circumstances where cyanotoxin levels exceed the drinking water thresholds included in Table 5. The children and adult drinking water thresholds correspond with EPA's Ten-Day Health Advisories for microcystin and cylindrospermopsin and represent concentrations at which adverse health effects are anticipated (USEPA 2015a, USEPA 2015b).

Once notified, public water supplies, EPA, and WDH will determine appropriate next steps, including initiating their own sampling to ensure public safety (see EPA's drinking water response strategy on WyoHCBs.org). WDH may issue a Do Not Drink and Do Not Boil order when finished drinking water exceeds cyanotoxin thresholds. A Do Not Boil order is necessary since boiling will not remove cyanotoxins and may actually increase toxin levels by lysing cyanobacteria cells. These orders should not be lifted until sampling results indicate that cyanotoxins have fallen and will remain below the drinking water thresholds.

Table 5. Wyoming drinking water thresholds for cyanotoxin concentrations.

Threshold	Threshold Value	Responsive Action
Drinking Water	≥ 0.3 µg/L Microcystin[1] (children and vulnerable populations[2]) ≥ 1.6 µg/L Microcystin[1] (adults)	**Do Not Drink / Do Not Boil**
	≥ 0.7 µg/L Cylindrospermopsin (children and vulnerable populations[2]) ≥ 3.0 µg/L Cylindrospermopsin (adults)	

[1] Microcystin thresholds (µg/L) are to be applied to total concentrations of all congeners of those toxins.

[2] Vulnerable populations include pregnant women, nursing mothers, those with pre-existing liver conditions, those receiving dialysis treatment, the elderly and other sensitive populations.

Illness Reporting and Tracking

The WDH has created an online illness form for members of the public, physicians, veterinarians, and others to report potential bloom related illnesses in people and animals. The WDH will review the information, relay illness reports to WDEQ so follow-up monitoring can occur, and report applicable cases of human and animal illnesses to the United States Center for Disease Control and Prevention's One Health Harmful Algal Bloom System (OHHABS). OHHABS is a collaborative network between state and federal partners and provides: electronic reporting by state and local health departments via the National Outbreak Reporting System (NORS); case studies of HCB-related illness surveillance; and support from the Great Lakes Restoration Initiative that uses OHHABS data to inform their restoration objectives. More information and resources can be found at the OHHABS website.

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