Water Quality Monitoring and Source Protection

Dealing with Cyanobacteria: Time to Make a Plan

Guidance for Developing a Harmful Algal Bloom Management and Response Plan

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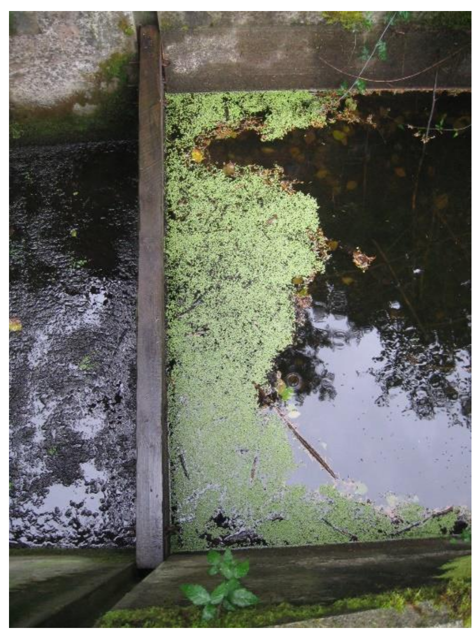

Table of Contents

Glossary ... iv
1.0 Introduction ... 1
What are Cyanobacteria? ... 1
What is a Harmful Algal Bloom? ... 2
What are Cyanobacterial Toxins? ... 2
Microcystins ... 2
Cylindrospermopsin ... 2
Anatoxin-a ... 3
Saxitoxin ... 3
What is a Health Advisory Level (HAL)? ... 3
Health Advisory Levels for Microcystins, Cylindrospermopsin and Anatoxin-a ... 3
Will My Treatment Plant Remove Algae and Cyanotoxins? ... 4
2.0 Vulnerability of Your Surface Water Source to HABs ... 5
3.0 Algal Bloom Management and Response Plan ... 6
3.1 Existing Treatment Processes and Alternative Source Evaluation ... 6
Existing treatment review ... 6
Treatment adjustments in the event of a bloom ... 7
Optimize Existing Treatment and Identify Additional Needs ... 7
3.2 Source Water Observation and Monitoring ... 7
Treatment Plant Performance ... 8
Source Water Observation ... 8
Source Water Monitoring ... 9
Source Water Recreational Advisory ... 9
3.3 Raw and Finished Water Cyanotoxin Monitoring ... 11
Raw Water Monitoring ... 11
Finished Water Monitoring ... 12
Acceptable Analytical Methods ... 13
3.4 Communication and Public Notice ... 14
3.5 Long Term Planning ... 16
4.0 Where to Get Help ... 17
Department of Health-Office of Drinking Water (ODW) ... 17
Department of Health-Office of Environmental Public Health Sciences ... 17
Department of Ecology (Ecology) ... 17

Local Health Jurisdictions 18
US Environmental Protection Agency (EPA) 18
Appendix A.1—Algae and Cyanobacteria Treatment Optimization and Resources 19
Additional Treatment Options for Intracellular Cyanotoxins (Cell Removal) 19
Additional Treatment Options for Extracellular Cyanotoxins 19
Appendix A.2—Washington Waterbodies with Public Water System Intakes and Cyanotoxin Detections 21
Appendix A.3—Impact of Phosphorus on Bloom Risk 22
Appendix B—Cyanobacteria and Associated Toxins They May Produce 23
Appendix C—Cyanotoxin Sample Handling and Details 24
Appendix D—Acceptable Analytical Methods for Cyanotoxin 25
Appendix E—Public Notification/Water Use Advisories for Cyanotoxins in Drinking Water 26
Health Advisory Levels for Microcystins, Cylindrospermopsin, and Anatoxin-a 26
Appendix F—Lab Lists 34
Labs approved for Cyanotoxin analysis by Ecology lab certification program 34
Labs approved for Cyanotoxin analysis by other states' programs 34
EPA Approved Labs for UCMR4 Cyanotoxins 34
Labs for Cyanobacteria identification and enumeration only 35
References 36
Other Resources 37

Washington State Department of HEALTH

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Glossary

Anatoxin-a: Nerve toxin produced by a number of cyanobacteria.

Benthic: relating to or occurring at the bottom of a body of water. Benthic cyanobacteria are attached to substrate or sediment in water bodies. They can occur as large mats or clusters.

Biovolume: The volume of cells in a unit amount of water (mm^3/L). Biovolume is estimated using a digitized microscope to determine the relative abundance of phytoplankton of varying shapes and sizes.

Chlorophyll-a: Photosynthetic green pigment contained in algae and cyanobacteria that is essential for producing energy from light. Can be used to estimate the amount of cyanobacteria in a sample. (See phycocyanin)

Congener: One of a class of compounds with similar structures and similar chemical properties. For example, the class of chemicals called microcystins has over 140 congeners.

Cyanobacteria: Type of bacteria with qualities similar to algae and other plants. They are phototrophic and occur naturally in freshwater lakes, ponds, and river impoundments.

Cyanotoxins: Chemical compounds produced by some species of cyanobacteria that pose serious public health risks if found in drinking water sources.

Cylindrospermopsin: Liver toxin produced by a number of cyanobacteria.

Detection: A result greater than or equal to the laboratory method reporting limit (MRL).

Diatoms: Single-celled algae. Most diatoms are photosynthetic.

ELISA: Enzyme linked immunosorbent assay (ELISA) is a three step method of cyanotoxin analysis commonly used to detect total microcystins, cylindrospermopsin and anatoxin-a. It is more rapid and less expensive than LC/MS/MS. It is not congener specific and can produce a false positive result in the presence of degraded cyanotoxin.

Eutrophic: Rich in nutrients supporting a dense plant population, especially algae.

Extracellular: Located or occurring outside of the cell or cells.

Fluorescence: Property of chlorophyll-a and phycocyanin in which they absorb light at a shorter wavelength and re-emit light at a longer wavelength.

Genus: Taxonomic category used in biology that ranks above species and below family.

Geosmin: Naturally occurring compound produced by cyanobacteria and other bacteria. It gives water an earthy or musty smell and is a frequent source of taste and odor complaints.

HAB: Harmful algal bloom.

Intracellular: Located or occurring inside of the cell or cells.

LC/MS/MS: Liquid chromatography with tandem mass spectrometer, also called "LC tandem mass spec." Sample is first run through a chromatography column that separates the constituents by time. Then the column effluent is run through a mass spectrometer that separates the constituents by mass and fragmentation pattern. Available for cylindrospermopsin, anatoxin-a, saxitoxin, and some (but not all) microcystin congeners (EPA Method 544).

Lyse: To rupture an organism's cell wall, releasing any toxins that may be present inside the cell.

MIB: Two-methylisoborneol (MIB), a naturally occurring compound produced by cyanobacteria and other bacteria. It gives water an earthy or musty smell and is a frequent source of taste and odor complaints.

Microcystins: Liver toxins produced by a number of cyanobacteria. Total microcystins are the sum of all the variants/congeners of the cyanotoxin microcystin.

NOM: Natural organic matter.

Oligotrophic: Low in plant nutrients and usually containing abundant dissolved oxygen.

Oxidant: A chemical that has the ability to oxidize other substances by accepting their electrons. Common oxidants in water treatment are chlorine, chlorine dioxide, ozone and potassium permanganate.

Photosynthetic: Relating to the process by which organisms use sunlight to synthesize nutrients from carbon dioxide and water.

Phototroph: An organism that obtains energy from sunlight to synthesize organic compounds for nutrition.

Phycocyanin: (Fī-kō-ˈ**sī**-ə-nən) a blue photosynthetic pigment contained in cyanobacteria, but not algae. Can be used to estimate the amount of cyanobacteria in a sample.

Phytoplankton: (Fī-tō-**plank**-tən) microscopic photosynthetic organisms that live in watery environments, both salty and fresh. This includes cyanobacteria as well as photosynthetic diatoms and other microscopic algae.

Pre-oxidation: In water treatment, to add an oxidant before other processes, usually filtration.

qPCR: Quantitative polymerase chain reaction. A technology used to target a genetic sequence associated with a specific cyanotoxin and quantify the presence of those genes in a sample. Used to assess the potential for cyanotoxin production.

Saxitoxins: Nerve toxins produced by a number of cyanobacteria.

SUVA: Specific ultraviolet adsorption is the absorbance of ultraviolet light in a water sample at a specific wavelength. It is used to characterize natural organic matter (NOM) in a water sample and to determine disinfection by-product (DBP) formation potential.

1.0 Introduction

In August 2014, a cyanobacteria bloom in Lake Erie resulted in a “do not drink” advisory for nearly 500,000 people in and around Toledo, Ohio (Carpenter, 2020). A bloom in the drinking water source for Salem, Oregon led to a similar advisory in 2018 (Salem, 2018). Three years later, following an exceptionally hot summer, cyanotoxins were detected for the first time in the Columbia River in Washington State at three separate utilities’ source water intakes. The cyanotoxins persisted for nearly three months. Cyanobacteria are being detected more frequently and in more locations around the planet. Changing environmental conditions means that historical absence of cyanobacteria or harmful algal blooms (HABs) in our surface water sources is no longer an indicator that HABs will not impact a particular water source.

HABs are a potential source of contamination for all surface water sources in Washington. Toxins produced by cyanobacteria found in source water or released from cyanobacterial cells through treatment processes can harm people. By damaging the liver, nervous system, skin, and gastrointestinal systems cyanotoxins can cause paralysis, organ damage, heart failure, and death.

In addition to potential public health risks of cyanobacteria, any source water algal bloom can cause:

- Increased raw water turbidity.
- Increased filter loading and shorter filter run times.
- Reduced treatment plant capacity through clogging of intakes, screens, and filters.
- Increased disinfection byproduct precursors.
- Increased operational costs.
- Odor, taste, and color problems in finished water.
- Loss of consumer confidence in the quality of drinking water.

Systems can prepare for and mitigate these events by proactive planning and active source management. Public water systems using surface water are vulnerable to HABs and should develop a Harmful Algal Bloom Management and Response Plan (HAB Plan). Having procedures in place can prevent harmful levels of cyanotoxins from reaching the distribution system, avoid treatment disruptions, and maintain your customers’ confidence in their drinking water supply.

This document provides guidelines, important information, and references needed to develop an HAB Plan. It includes a protocol for monitoring, sampling, and analysis of source, raw, and finished water. Drinking water health advisory levels for finished water from the Environmental Protection Agency (EPA) for two cyanotoxins (microcystins and cylindrospermopsin) are presented, along with health guidance values for anatoxin-a from other state health agencies.

What are Cyanobacteria?

Cyanobacteria, sometimes called “blue-green algae,” are a type of bacteria with qualities similar to algae and other plants. They occur naturally in freshwater lakes, ponds, impoundments, and in rivers and streams. They are phototrophic (use sunlight as their primary energy source). Cyanobacteria can adjust their buoyancy throughout the day. By moving up and down through the water column they find sunlight at the surface and nutrients in deeper layers. When the amount of sunlight, temperature, and nutrients are adequate they can reproduce rapidly. Cyanobacteria can also grow attached to sediments or rocks in both lakes and rivers. Attached cyanobacteria are referred to as benthic cyanobacteria.

Cyanobacteria and algae found in the water column of lakes and ponds or attached to substrate are part of a group of phototrophic microorganisms called phytoplankton. Unique among the phytoplankton, Cyanobacteria can convert inert atmospheric nitrogen into an organic form usable for growth. This ability to fix nitrogen means blooms often occur in later summer, months after nitrogen has been diminished from the water column from phytoplankton uptake.

What is a Harmful Algal Bloom?

An algal bloom is a sudden increase in the rate of growth or accumulation of phototrophic organisms. In this document, the term algal bloom includes both algae and cyanobacteria. Blooms occur naturally in lakes, reservoirs, ponds, and flowing rivers. A bloom is most likely to occur during sunny, calm weather when high nutrient concentrations (particularly phosphorus) are present in water. Not all algal blooms are harmful. However, blooms have potential to become harmful due to their impacts on treatment processes, creation of taste and odor compounds, and production of cyanotoxins by some species of cyanobacteria.

What are Cyanobacterial Toxins?

There are approximately three thousand known species of cyanobacteria. Over fifty species are identified as capable of producing chemical compounds that pose serious public health risks if found in drinking water sources. These chemical compounds are called cyanobacterial toxins or cyanotoxins. During some blooms cyanotoxins may be released directly into the water source (extracellular) or be contained within the cyanobacteria cells (intracellular). Cyanotoxins can harm people and animals when present in high enough concentrations. They may cause health effects such as skin rashes and lesions, vomiting, gastroenteritis, headaches, and eye, ear, and throat irritations. More severe symptoms affect the liver or nervous system.

This document focuses on the four currently most common cyanotoxins: microcystins, cylindrospermopsin, anatoxin-a, and saxitoxin. Other cyanotoxins exist; we will expand this document as we learn and discover more. The following cyanotoxin descriptions are taken from *Managing Cyanotoxins in Drinking Water: A Technical Guidance Manual for Drinking Water Professionals* (AWWA, WRF 2016) and *Guidelines for Drinking Water Quality, Fourth Edition*. (WHO 2017). More information is available in the references and resources listed at the end of this document.

Microcystins

Microcystins are the most common and heavily researched group of cyanotoxins. Microcystin-LR is the most common of the many variants (compounds with similar structure). Microcystins can be produced by *Dolichospermum (Anabaena), Microcystis, Oscillatoria, Planktothrix, Nostoc*, and *Anabaenopsis* species. More than one type of microcystin may occur in a particular cyanobacteria strain. Microcystins are hepatotoxins (damage the liver). A lethal dose causes death in vertebrates by liver necrosis within hours or up to a few days.

Noticeable symptoms occur only in severe cases. This means that liver injury from a non-lethal dose is likely to go unnoticed. Some studies show that microcystin toxicity is cumulative. Researchers suspect microcystins are liver carcinogens, which could increase cancer risk to humans following continuous, low level exposure.

Unlike other cyanotoxins, microcystins are commonly bound within the cell and only released into water when the cell ruptures, or lyses. When released, microcystins are stable in water and can linger for months.

Cylindrospermopsin

Cylindrospermopsin is a cyanotoxin most commonly found in the southern United States and is rare in Washington. It is water-soluble in the typical pH range of natural waters. It can damage the liver, kidneys, blood cells, and cellular DNA. Cylindrospermopsin has three known variants: CYL, 7-epiCYL, and deoxyCYL.

Anatoxin-a

Anatoxin-a is a potent neurotoxin (attacks the nervous system) and the smallest of the cyanotoxins. It is one of three neurotoxic alkaloids isolated from cyanobacteria, produced by various species of cyanobacteria including *Dolichospermum* (*Anabaena), Planktothrix, Oscillatoria, Aphanizomenon, Cylindrospermum*, and *Microcystis*. Anatoxins are comprised of four main structural congeners; anatoxin-a (ATX), dihydroanatoxin-a (dhATX), homoanatoxin-a (HTX) and dihydrohomoanatoxin-a (dhHTX), and their relative proportions vary in environmental samples. Anatoxin-a was first detected in Canada in the 1960s and detected in the Columbia River in 2021. Cattle, elk, cat, and dog poisonings have been reported in Washington State.

Cyanobacteria cells retain anatoxin-a in favorable growth conditions. However, cells release toxin into the gastrointestinal tract if an animal consumes water containing these cells. Therefore, pets that lick scum from their fur are at highest risk from anatoxin-a exposure. Ingestion of a sub-lethal dose of these neurotoxins leaves no chronic effects and recovery appears to be complete. Anatoxin-a is typically found in its cationic form in natural waters. It degrades to nontoxic products in sunlight and at a high pH (8-9).

Saxitoxin

Saxitoxin is another potent neurotoxin with properties similar to anatoxin-a. Sixteen different saxitoxins have been reported from cyanobacterial samples. Saxitoxins were originally isolated from shellfish, where they are the main cause of paralytic shellfish poisoning. In fresh water saxitoxin is produced by *Aphanizomenon, Dolichospermum* (*Anabaena), Lyngbya, and Cylindrospermopsis*.

Since EPA is not currently considering saxitoxin for future regulation, less information is available on drinking water health effects and treatment effectiveness. For these reasons, saxitoxin is covered only briefly in this document.

What is a Health Advisory Level (HAL)?

The Safe Drinking Water Act gives EPA authority to publish health advisories for contaminants not subject to any national primary drinking water regulation. EPA assesses the latest peer-reviewed science to provide information on the health risks of these chemicals. This allows water system operators, and state, tribal, and local officials who have primary responsibility for overseeing these systems, to take appropriate actions to protect their residents. HALs serve as informal technical guidance for health effects information and methods to sample and treat these non-regulated contaminants in drinking water. HALs are not legally enforceable federal standards and are subject to change as new information becomes available (USEPA 2015a).

Health Advisory Levels for Microcystins, Cylindrospermopsin and Anatoxin-a

Microcystins, cylindrospermopsin, anatoxin-a, and saxitoxin have been found in Washington water bodies. Recreational guidelines have been established and are briefly discussed in section 4.0. There are no state drinking water regulatory limits for cyanotoxins and no immediate plans to develop them.

EPA included ten cyanotoxin variants in the Fourth Unregulated Contaminant Monitoring Rule (UCMR4). The UCMR4 requires selected systems to monitor for these unregulated contaminants. This was a step toward establishing future regulatory limits in drinking water for these contaminants (NHDES 2016).

EPA established ten-day HALs for total microcystins and cylindrospermopsin (USEPA, 2015b and 2015c). The HALs give concentrations at or below which no adverse human health effects would be expected for up to ten days of exposure. HALs for microcystin and cylindrospermopsin are given for two separate population groups. The first group includes infants, pre-school children under six years, and susceptible adults (pregnant women, nursing mothers, elderly, immune-compromised, and dialysis patients). These HALs are shown in Table 1 below. The second group includes school-aged children (six years and older) and other adults. The HALs for both groups are in Appendix E.

Table 1: EPA Cyanotoxin Health Advisory Levels for Vulnerable People*

Cyanotoxin	Cyanotoxin level (µg/L)
Total microcystins	0.3
Cylindrospermopsin	0.7

Infants, pre-school children, susceptible adults (pregnant women, nursing mothers, elderly, immune-compromised, and dialysis patients).

We recommend that public water systems use the lower EPA HALs for infants, pre-school children, and susceptible adults for total microcystins and cylindrospermopsin in drinking water as thresholds to trigger proactive utility actions. Proactive steps could include increased monitoring, changes in treatment strategies, and use of alternative sources.

If a system exceeds EPA HALs for total microcystin or cylindrospermopsin in treated drinking water the utility should provide a "do not drink" advisory to their customers, as cyanotoxins are not destroyed by boiling. More details are in Section 3.4 and Appendix E. Coordinate public notification with ODW.

EPA has not established HALs for anatoxin-a or saxitoxin.

Some other states, including Ohio (Ohio EPA, 2020), Minnesota (MDH, 2016), and Vermont (VDH, 2015) have established drinking water health guidance values for anatoxin-a. These advisory levels range from 0.1 to 0.5 µg/L. Ohio, a state with extensive experience with HABs in drinking water, recently updated its anatoxin-a health threshold level for vulnerable people to 0.3 µg/L (OhioEPA, 2020). ODW supports the use of Ohio's health threshold level as an appropriate trigger for increased monitoring, changes in treatment strategies, and use of alternative sources.

Saxitoxin and Other Cyanotoxins

EPA did not list saxitoxin for future regulation and did not develop supporting health effects documentation for it. Ohio is the only state with an established saxitoxin drinking water health threshold, 0.3 µg/L (OhioEPA, 2020). Due to the limited information available and infrequent occurrence of saxitoxin in our state, we cannot recommend a specific trigger value for saxitoxin.

Other cyanotoxins exist and new ones are being discovered. If you detect cyanotoxins in raw water other than the four compounds discussed above, follow the treatment and finished water monitoring guidelines recommended in this document.

Will My Treatment Plant Remove Algae and Cyanotoxins?

Treatment effectiveness for cyanotoxins varies depending upon the type of toxin, whether it is intracellular (inside the cell) or extracellular (outside the cell), and specifics of the treatment processes in your treatment plant. Appendix A1 gives an overview of common treatment strategies and effectiveness of specific treatment processes. The resource section at the end of this document lists additional sources of information.

USEPA provides an overview of treatment strategies to remove algae and remove or oxidize cyanotoxins found in raw water in *Recommendations for Systems to Manage Cyanotoxins in Drinking Water* (USEPA, 2015a). More detailed cyanotoxin treatment information is provided in *Water Treatment Optimization for Cyanotoxins* (Version 1.0) (USEPA, 2016). Oregon Health Authority (OHA, 2019) summarized and expanded

EPA guidance to include filtration technologies common in the Pacific Northwest, including slow sand, bag/cartridge, and membrane filtration.

2.0 Vulnerability of Your Surface Water Source to HABs

All water systems using surface water sources can be impacted by HABs, even if algal blooms have not yet occurred. Previously water systems were encouraged to evaluate the risk for each surface water/GWI source based on the history of cyanobacteria blooms, lake stratification and turn-over patterns, and water quality parameters. Cyanobacteria toxin releases in flowing rivers with low nutrient concentrations indicate that all surface water sources are vulnerable. More frequent toxin detections indicate that past history may not be a good predictor of future events. Even systems with cold, low-nutrient source water should enact some level of bloom surveillance. We encourage all water systems to collect at least some of the water quality parameters listed below to build a baseline of information that will help guide both ongoing management and response efforts.

Historically, public water systems experiencing algal blooms have typically been supplied by a lake or impoundment or were located downstream from a lake or impoundment with an active bloom. Systems with flowing sources (rivers or creeks) have not been considered at risk, but benthic cyanobacteria have now been implicated in cyanotoxin detections in streams and rivers in New Zealand, Utah, Virginia, and here in Washington State.

Because cyanobacteria are present in nearly all surface water sources and cyanotoxins can be released in water bodies that have had no previous history of blooms or cyanotoxin detections, ODW recommends that water systems install and continuously operate an effective cyanotoxin(s) treatment barrier. This is similar to the industry's approach to microbial source contaminates where effective treatment for viruses, bacteria and protozoa is operated continuously. The continuously applied treatment should address intracellular, and extracellular toxins. See Appendix A.1 for additional information on treatment optimization.

Appendix A3 lists Washington State water bodies that serve as public drinking water sources in which the presence of cyanotoxins was previously confirmed. This information is from the Department of Ecology's Fresh Water Monitoring Program and from water system sampling. No statewide sampling program was conducted, so this list is by no means a comprehensive assessment of our region's source waters. Appendix A3 also does not include sources used by private individuals for single family homes. Complete results are at nwtoxicalgae.org.

When evaluating risk, there are many water quality parameters that can be used (see section 3.2). Some are simple, others are complex.

- Presence of blooms and scums on water.
- Fish kills due to hypoxia (low oxygen levels).
- Wildlife and domestic animal deaths resulting from animals consuming water from contaminated sources.
- Secchi disc depth in source water reservoirs/lakes.
- Dissolved oxygen levels and temperature stratification (historical patterns/potential).
- Presence of taste and odor causing compounds (for example, MIB and geosmin).
- Nitrogen and phosphorus levels.
- Cyanobacterial cell counts and dominant cyanobacterial species.
- Phytoplankton cell counts.
- Levels of Chlorophyll-a (green photosynthetic pigment present in algae, cyanobacteria and plants).

- Levels of Phycocyanin (blue photosynthetic pigment present in cyanobacteria).
- Genetic screening tools (qPCR).

In addition, Section 3.2 discusses plant performance measures that can give an indication of phytoplankton blooms. These can include a marked decrease in filter run times and increases in coagulant dose or chlorine demand.

Historical water quality information for larger water bodies may be found in at the National Water Quality Monitoring Council Water Quality Portal, Water Quality Data Home. Other useful resources include Source Water Assessments and Lake Management Plans, as well as Clean Water Act 303(d) and 305(b) Integrated Reports.

3.0 Algal Bloom Management and Response Plan

All water systems with a surface water source should develop a Harmful Algal Bloom Management and Response Plan (HAB Plan) to establish strategies for monitoring and responding to HABs in the source water. The plan guides managers and operators on effective source, raw, and finished water monitoring and treatment adjustments to prevent cyanotoxins from reaching the distribution system. In this document, source water monitoring refers to samples collected from various locations in the lake or other waterbody, especially in the intake vicinity. Raw water monitoring refers to samples collected directly from the water treatment plant intake before any treatment processes. Finished water monitoring refers to samples collected from the distribution entry point, downstream from all treatment processes, including disinfection.

Suggested elements to include in your HAB Plan are outlined below, along with resources, examples, and links for further research. A suggested algal bloom response flowchart is in Figure 1, which will vary depending on the nature of your surveillance or monitoring program and whether recreational advisories occur. Utility decision makers must be involved in your HAB Plan development. Water systems that you sell water to must also know the details of your HAB Plan.

3.1 Existing Treatment Processes and Alternative Source Evaluation

A first step in developing an effective HAB plan is to take stock of your existing water treatment capabilities and limitations relative to removing or eliminating cyanobacteria, algae, and cyanotoxins. This assessment should include alternative water sources that could be used to reduce demands on the surface water treatment facility. Understanding the strengths and weaknesses of your treatment plant helps you identify possible adjustments or additional treatment processes that you can enact to make your system more resilient to meet this potential threat.

If your treatment plant already has advanced treatment processes such as ozonation and /or granular activated carbon (GAC) that can effectively destroy or remove cyanotoxins your risk is low. If not, some suggested steps for evaluating existing capabilities are listed below along with information on optimizing treatment performance and additional treatment options for cyanobacteria, algae, and cyanotoxins.

Existing Treatment Review

- Identify and describe existing surface water source(s).
- Describe current treatment processes and include a treatment schematic. The treatment schematic in your most recent sanitary survey may be useful.

- Determine whether current processes adequately reduce or eliminate algae, cyanobacteria, and cyanotoxins. Evaluate whether supplemental treatment or operational changes, such as adding permanganate or changing the point of oxidant addition, can be implemented now in preparation for the bloom season. Refer to Appendix A.1 and EPA guidance.
- Evaluate alternative sources you could use, including interties, groundwater wells, or other surface water sources.
- Consider your ability to decrease water system demands if alternative sources are limited.
- Evaluate both treatment options and alternative source options relative to the time of year and duration. Algal blooms have distinct durations that may vary year to year. For example, a neighboring utility may be able to provide a larger quantity of water for two weeks, but not for months. Water demand reductions in May could be easier to achieve than in August. Even short duration demand reduction or alternative source production may allow your treatment plant to effectively adjust treatment.
- Consider whether long-term treatment enhancements are warranted (see Section 3.5), based on source water vulnerability and if existing treatment is frequently challenged by cyanotoxins.

Treatment Adjustments in the Event of a Bloom

Create a step-by-step plan to be followed in the event of a bloom occurrence, and in the event of a bloom that leads to a confirmed health advisory or trigger level exceedance of cyanotoxins in finished water.

- Enact treatment adjustments identified previously. Be prepared to adapt your plan based on current information, such as whether the bulk of the cyanotoxin is intracellular or extracellular.
- Activate alternate water sources, including interties with adjacent utilities, if this is available.
- Reduce plant flowrate to improve cell removal.
- Implement water demand reduction strategies.

Optimize Existing Treatment and Identify Additional Needs

You can optimize your existing treatment to remove algae cells and oxidize and/or remove cyanotoxins. Through optimization you can also identify new treatment processes that can make your system more resilient to algal blooms. Appendix A.1 along with EPA guidance contains more information on effectiveness of different treatment processes and how best to optimize your existing treatment. Start with effective processes such as sodium permanganate oxidation that can be installed quickly and at relatively low expense.

3.2 Source Water Observation and Monitoring

Surface water systems should monitor watershed conditions, raw water quality, and treatment plant performance for changes that may indicate the presence of algal blooms containing cyanobacteria or cyanotoxins. Promptly investigate reports of wildlife and domestic animal deaths in your watershed, which could be linked to animals consuming contaminated water. Report all suspected human or animal HABs-associated illnesses or deaths to your local health jurisdiction and the DOH Office of Communicable Disease Epidemiology at 206-418-5500 or waterborne-epi@doh.wa.gov.

Begin your source water observation for algal blooms or monitoring for bloom indicators at the start of each bloom season and continue throughout the bloom season. Continue throughout the year if local climate or bloom history indicates the possibility of blooms year-round.

Some specific water quality and operational parameters for treatment plant performance, source water observation and monitoring are listed below followed by additional resources and suggestions. Remember to:

- Evaluate any routine source water quality monitoring for all of your surface water sources, which your water utility conducts or has recently conducted.
- Establish a system-specific monitoring schedule, sampling methods, and compile resources to aid identification of bloom indicators in your source water.
- Establish contact with other watershed stakeholders to potentially coordinate resources, observations, and information.

Treatment Plant Performance

Routine treatment plant monitoring can reveal the presence of blooms in your source waters. Conditions to watch for include:

- Decreased filter run time.
- Increased taste and odor.
- Increased SUVA (Specific ultraviolet absorbance).
- Increased pH from normal levels.
- Increased turbidity.
- Increased coagulant demand.
- Increased chlorine demand.
- Decreased chlorine residual.
- Unusually warm water temperatures.
- Observations of zooplankton that feed on algae, such as Daphnia water flea, in supply lines or raw water equipment like turbidimeters.

Source Water Observation

Source water observation means visually inspecting surface water sources for algal blooms. The frequency of observation should be related to the probability of an algal bloom developing, which is often seasonal and weather dependent. March through October is the typical bloom season in Washington. A word of caution-benthic cyanobacteria blooms may occur and release toxins even before signs of the bloom are apparent.

Blooms can occur anywhere in the water column, sometimes appearing as green or blue-green flecks scattered in the water, scums that float on the surface, or as mats that rest on the bottom of the water body.

Washington State Toxic Algae Program has a photo gallery and instructions to the public on how to report a bloom (nwtoxicalgae.org).

The USGS has a useful online reference for cyanobacteria identification.

For some water bodies, the public is a useful resource in spotting potential source water blooms. It may be valuable to make the information in these links available to your customers.

When a bloom is present, identify phytoplankton to determine whether cyanobacteria are present. This means evaluating water samples under a microscope and identifying the algae and cyanobacteria present. You can do this in-house, by private laboratory, or through the state algal toxin testing program coordinated by the Department of Ecology. Instructions for submitting a sample through the Ecology program are at nwtoxicalgae.org/ReportBloom. Appendix F lists other in-state labs that can do this work.

If cyanobacteria are present then you will need to test the water for cyanotoxins.

Source Water Monitoring

In addition to visual observations and changes in raw water quality parameters and treatment plant performance listed above, you may choose to regularly monitor source water for bloom indicators. Bloom indicators can detect HABs and cyanobacteria that may not be visible but may produce cyanotoxins. Table 2 below is a summary of possible HAB or cyanobacteria indicators for lake sources that you could sample throughout the bloom season and levels that trigger a response. Since some indicators like pH and dissolved oxygen (DO) change through the day, it's important to sample continuously. If continuous monitoring is not feasible, sample at roughly the same time each day. More information on sampling for these indicators is in the USGS Field Manual, *Lakes and Reservoirs: Guidelines for Study Design and Sampling* (USGS, 2018a) and the USGS *National Field Manual for Collection of Water Quality Data* (USGS, 2018b).

Systems that draw from large water bodies (greater than 200 acres) should consider the EPA Cyanobacteria Assessment Network (CyAN) that uses satellite imagery for early detection of cyanobacterial blooms. The CyAN app is free and available in two versions: CyANWeb app and the CyAN Android™ app. Unfortunately, it does not appear to be useful for smaller lakes, impoundments, or river sources.

Historical source water monitoring has focused primarily on ponds, lakes, and impoundments. Recent cyanotoxin events in stream and river sources has prompted a closer look at benthic cyanobacteria.

Conditions that favor the growth of benthic cyanobacteria are:

- Sunlight.
- Temperature—warmer temperatures favor growth.
- Stable water flow (flow increases and turbulence can cause mats to disperse).
- Calm wind conditions.
- Nutrient loading (nitrogen and phosphorus) in the water column **or** in sediments.
- Lack of cyanobacteria grazers such as snails and insect larvae.

What causes benthic cyanobacteria to release toxins is not well understood, but some likely factors are:

- Which cyanobacteria strains are present (not all cyanobacteria produce toxins).
- Their relative abundance.
- Natural degradation as cells die, especially at the end of the growing season. In New Zealand, alert levels are automatically raised when mats are visibly detaching along river or stream banks.

Some potential parameters to monitor are temperature, nutrients (N and P) and cyanobacteria growth indicators (pH, chlorophyll-a and phycocyanin). When phycocyanin levels rise, cyanobacterial identification can indicate which toxins are most likely. An increase in the ratio of phycocyanin to chlorophyll-a can indicate that the character of a bloom is changing, and cyanobacteria are becoming dominant.

Source Water Recreational Advisory

If cyanotoxins are detected in your water source and a recreational water advisory is issued, you should begin raw and finished cyanotoxin monitoring in accordance with Section 3.3.

Table 2—Lake Source Water Bloom Indicators

Bloom indicator	Trigger Level[1]	Response
pH	Increasing from normal levels. pH changes from day to night.	Evaluate other Bloom Indicators
Secchi disk depth	Reduction in visibility (decrease in secchi depth for example >2 ft.) since prior measurement	Evaluate other Bloom Indicators
Temperature	High water temperatures can favor cyanobacteria growth	Implement or increase monitoring program steps
Lake stratification (temperature & DO)	Temperature and DO levels indicate if lake is stratified. Documenting typical times and degrees of stratification may allow correlation of blooms with certain stratification conditions.	Evaluate other Bloom Indicators
MIB and/or Geosmin (Taste and Odor)	Increase of 20-50 ng/L (or presence if not normally found)	Sample phytoplankton for ID at least to genus level
Phytoplankton Cell Counts	Use historical source water quality to establish # cells/mL	Sample phytoplankton for ID at least to genus level
Cyanobacteria Cell Counts	≥ 2,000 cells/mL [2]	Sample phytoplankton for ID of cyanobacteria
Bio-volumes	≥ 0.2 mm^3/L [2]	Sample phytoplankton for ID of cyanobacteria
Chlorophyll-a	Site specific [3]	Sample phytoplankton for ID of cyanobacteria
Phycocyanin equivalents	>100,000 cells/mL[4]	Sample phytoplankton for ID of cyanobacteria
Cyanotoxin Production Genes (qPCR)	In development	In development
Visible surface scum or change in water color		Test for cyanotoxins, sample phytoplankton for ID of cyanobacteria

[1]*These trigger levels are gathered from different academic sources, these criteria must be adjusted to your lake or reservoir.*

[2]*(WHO, 6.3.2, 1999) "Alert Level 1 Thresholds"*

[3]*For example, the City of Bellingham reports an average median summer near surface chlorophyll a concentration of 2.9 µg /L (25-year record) in basin 3 of Lake Whatcom. This is when no bloom is observed—just background summer levels for an oligotrophic portion of the lake.*

[4]*USEPA Cyanobacteria Assessment Network Application (CyAN app)*

If a bloom is detected, then identifying the cyanobacteria present allows you to focus on cyanotoxins typically produced by that group of cyanobacteria and to establish what toxins to test for in raw or finished water. Appendix B provides a table of cyanobacteria and their associated cyanotoxins.

Consider making operational changes and treatment adjustments discussed in Section 3.1 whenever a bloom is present in the vicinity of the intake.

3.3 Raw and Finished Water Cyanotoxin Monitoring

Should you detect an algal bloom containing cyanobacteria in your source water then raw water sampling for cyanotoxins is warranted. If you detect cyanotoxins in the raw water then finished water cyanotoxin testing is needed to determine if your customers are exposed to cyanotoxins. On-line phycocyanin monitoring of raw water entering the treatment plant can be used to provide an early warning.

Some key steps for your HAB plan, along with more in depth considerations for raw water and finished water cyanotoxin monitoring include:

- Describe sampling procedures to be followed in the event of confirmed presence of bloom indicators in your source water.
- Establish a monitoring/sampling schedule for cyanotoxins.
- Determine which toxin analysis methods are feasible for your utility, considering your budget and existing lab capability.
- Identify the laboratories available in your area that can perform cyanotoxin sampling, as well as shipping and handling requirements.
- Describe finished water monitoring procedures to be followed in the event of confirmed cyanotoxins in raw water.
- Determine how to expedite receipt of sampling results. This becomes a key factor when assessing risk for cyanotoxins that have a HAL based on a ten-day exposure.

Raw Water Cyanotoxin Monitoring

Table 3: Raw Water Cyanotoxin Sampling Schedule

Sample Location	Sample Frequency	Cyanotoxins Detected*	Cyanotoxins not Detected, but Bloom observed near Intake	Cyanotoxins Not Detected, and Bloom is Gone
Intake prior to treatment	1-2 times per week	Sample finished water within 24 hours	Continue raw water sampling until bloom is gone	Stop raw water sampling; continue source water observation/monitoring

**Report cyanotoxin analytical results to the ODW within 24 hours of receipt.*

Cyanotoxins may be present both inside (intracellular) and outside (extracellular) the cyanobacteria cells and the relative percentage of intracellular and extracellular cyanotoxins will likely change over the course of the bloom. In some specific cases, depending upon your system's unique treatment capabilities, knowing where the cyanotoxins are located can help you make appropriate treatment decisions. An example is a water system that uses chlorine as a pre-oxidant dealing with microcystin. Pre-oxidation in this case may likely lyse cells creating additional microcystin in the raw water while doing little to reduce toxins through oxidation. If the system can obtain required disinfection levels after the filter component then intracellular toxins may be removed during the filtration process. If on the other hand the effective cyanotoxin treatment component is a strong oxidant like permanganate and your system does not have an effective cell removal step (like DAF) then intra/extracellular cyanotoxin concentrations are not very useful for making treatment decisions. In this case total cyanotoxin concentrations may be sufficient to determine effective permanganate dosing needed to destroy cyanotoxins.

To determine intra and extracellular toxin levels analyze raw water samples for both extracellular cyanotoxin and total cyanotoxin. This allows you to calculate intracellular toxin levels (total minus extracellular equals intracellular). Total cyanotoxin is determined by cell lysing, usually with a freeze/thaw cycle, to release the toxin from within the cells. To determine extracellular toxin the lab will likely need to split the sample and apply a filtration step to one half of the sample. Be sure to discuss this with your lab when arranging for sample analysis. If you have filtration equipment on hand, you can also complete the filtration step on-site.

There are several options available for cyanobacteria and cyanotoxin analysis. Each option has benefits and limitations so it may be useful to use more than one method. Choose the method that works best for your utility. Table 4 contains general information about two different analyses. Appendix D contains acceptable analytical methods for different sampling locations.

Table 4: Cyanotoxin Analysis Methods

Analysis	Toxins	Limitations	Skill Level	Approximate cost per analysis
ELISA kit	Microcystin Cylindrospermopsin Anatoxin-a Saxitoxins	ELISA is a quantitative test and indicates total toxin but does not identify microcystin congeners. A separate ELISA test is required for each of the four listed toxins. Field ELISA test kits indicate the presence or absence of toxins. (EPA Method 546 is only applicable to the ELISA microcystin test).	Intermediate	Lab—$125-$150
LC/MS/MS	Microcystin Cylindrospermopsin Anatoxin-a Saxitoxin	EPA Method 544 & 545 quantitative – For microcystins, Method 544 indicates specific congeners (LA, LF, LR, LY, YR and nodularin) not total toxins. So it is possible to have a non-detect for microcystins using method 544* and positive result with ELISA*.	Advanced	Lab - $250-$500

Table adapted from Utah DEQ (2017).
EPA Methods 544 and 546 (ELISA) results cannot be compared to each other. Results from the same water may differ because the two tests are measuring different things.

The number of in-state accredited labs that offer toxin analysis using ELISA and LC/MS/MS is extremely limited. See Appendix F.

Finished Water Cyanotoxin Monitoring

If you detect cyanotoxins in raw water, you should begin finished water monitoring for the detected cyanotoxins according to the schedule in Table 5 (see Appendix C for sampling details). To shorten your response time during an event, consider collecting 1) a finished sample with every raw water sample, and/or 2) a confirmation sample 24 hours after the initial sample(s) without waiting for initial results.

Also consider treatment train monitoring and distribution system monitoring if cyanotoxins are present in raw water. Treatment train monitoring may help you identify potential optimization strategies. Distribution monitoring could allow you to provide more accurate and specific health information to customers. For example, since chlorine is effective at destroying microcystins, levels may continue to drop as water passes through the distribution system.

Table 5: Initial Finished Water Cyanotoxin Sampling Schedule

Sample Location	Sample Frequency	Result—Cyanotoxins Detected in Finished Water*	Result—Cyanotoxins Detected in Raw but Not Finished Water	Result—No Cyanotoxins Detected in Raw or Finished Water
Distribution system entry point	2 times per week	Collect confirmation sample as soon as possible and within 24 hours; if confirmed **proceed with follow-up sampling per schedule below**	Continue raw and finished water sampling 2 times per week until cyanotoxins are not detected in raw water	Continue **raw water** sampling 2 times per week until bloom is gone (discontinue finished water sampling)

**Report cyanotoxin analytical results to the ODW within 24 hours of receipt.*

If cyanotoxins are detected by a system in finished water, the water system should continue finished water monitoring for cyanotoxins according to the schedule in Table 6.

Table 6: Follow-up Finished Water Cyanotoxin Sampling Schedule

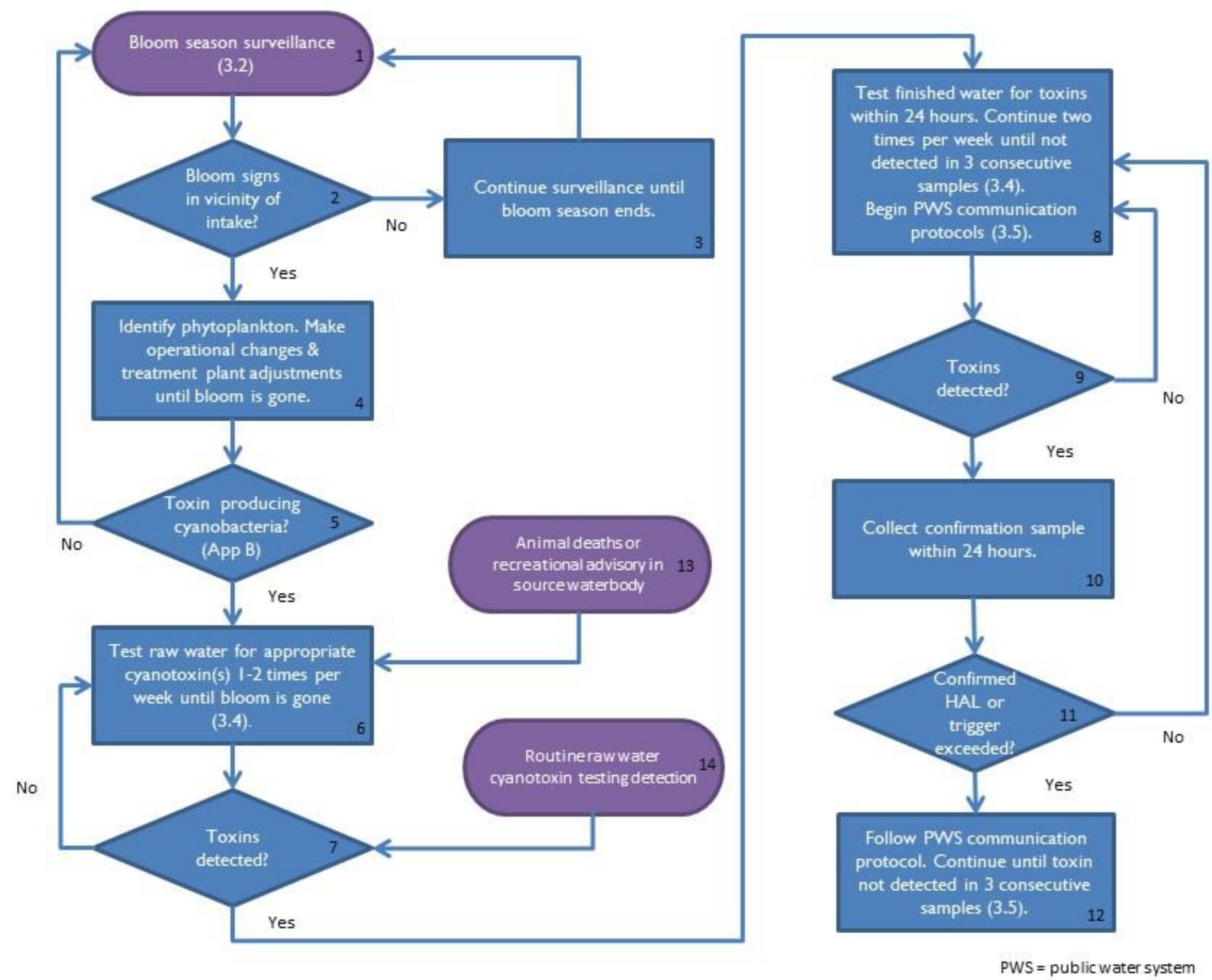
Detection Level in Finished Water	Sample Frequency	How Long?	Then What?
Cyanotoxins **below** trigger or HAL*	2 times per week	Until below detection in finished water and below detection in 3 consecutive raw water samples	Sample raw water 2 times per week if bloom exists; discontinue raw water sampling if bloom is gone
Cyanotoxins **above** trigger or HAL*****	Daily	Until below Health Advisory Levels* in 3 consecutive finished water samples, 24 hrs. apart	Sample raw water 2 times per week if bloom exists; discontinue raw water sampling if bloom is gone

**0.3 µg/L for microcystins; 0.7 µg/L for cylindrospermopsin; 0.3 µg/L for anatoxin-a (see discussion at the end of Section 1.0).*

Acceptable Analytical Methods

You should choose an analytical method suitable to the water being sampled and the intended use of the results. For finished drinking water analyses, a laboratory certified in the use of approved analytical methods for quantifying cyanotoxins, such as ADDA specific ELISA or LC/MS/MS should be used. Appendix D lists the acceptable analytical methods for the analysis of water samples for each cyanotoxin under various circumstances. Early identification of the nearest laboratories capable of performing cyanotoxin analysis and procurement of sampling supplies can save precious time during a potentially serious HAB event.

Figure 1-Algal Bloom Surveillance & Response



3.4 Communication and Public Notice

> **Be First—**When hearing about a new risk, people's perceptions are often shaped by the first message they hear, regardless of the information source. If utilities wait to communicate … they cede any early advantage to other information sources that could be inaccurate or misleading. Utilities should keep in mind that if they are not the first to communicate to customers about these issues, someone with a different agenda will frame the issues for them. (Henderson, K. et.al, JAWWA, May 2020)

Early and effective communication with your customers is critical for maintaining utility credibility. Systems should fully discuss communication and public notification with their governing body during the HAB Plan development. Systems should also consider communications they will have with customers if cyanotoxins are detected but not yet confirmed or are confirmed below the health advisory limit.

Some critical considerations and best practices for your communication plan are listed below.

- Communicate internally first. Water quality, operations, and communication staff need to work collaboratively from the beginning to develop accurate but simple messages that your community will understand.
- Partner with others. Identify agencies and customers that need to be notified (ODW, local health jurisdiction, consecutive systems, large customers, vulnerable customers, medical facilities).
- Be proactive. Update your Public Notification Plan to include cyanotoxins and develop public communication messages and tools now for:
    1) When an algal bloom impacts water quality or treatment,
    2) Detection of cyanotoxins in the raw water, and
    3) Both the presence of cyanotoxins and the exceedance of cyanotoxin trigger levels in finished water.
- Develop health advisory language for confirmed exceedance of cyanotoxin HALs in finished water (templates provided in Appendix E).
- Draft system-specific public notification templates for reporting finished water cyanotoxin detections in the annual consumer confidence report.
- Determine media outlets to use for rapid and widespread distribution of the health advisory. Use multiple platforms (radio, TV, social media, door hangers) to ensure that the message is delivered to all customers.
- Deliver health advisory in multiple languages if you serve a non-English speaking population.
- Remember that a "do not drink" advisory does not allow customers to boil or treat their water, they must obtain bottled water for cooking and drinking. If you must issue a do not drink advisory, evaluate whether you will offer a supply of alternate emergency water to customers.

If cyanotoxins are detected in finished drinking water follow the recommendations in Table 7 below for when to issue a health advisory.

Table 7: Recommended Health Advisories for Cyanotoxin Detections

Location	Cyanotoxin level	Health Advisory	Follow-up
Raw water only	Above detection limit	Not recommended*	Continue raw water monitoring according to Table 3
Finished water	Below health advisories	Not recommended *	Continue finished water monitoring according to Table 6. Include detection in consumer confidence report.
Finished water (initial sample)	At or above the health advisories	Not recommended*	Monitor according to Table 5.
Finished water (confirmed)	At or above the health advisories	Issue **Do-Not-Drink** advisory within 24 hours of receiving the results of the confirmation sample	Issue a second notice removing the advisory after two consecutive finished water samples are below the HALs.

**Communicate results to customers per your communication plan.*

Suggested public notification language for health advisories is in Appendix E. USEPA provides additional communication templates and resources in its *Risk Communication Toolbox* (epa.gov/ground-water-and-drinking-water/drinking-water-cyanotoxin-risk-communication-toolbox-templates). As with any public notice, systems should distribute the notice to all wholesale customers and consider vulnerable populations. Frequently asked questions for utility customers based on the Salem Oregon HABs event are on Oregon Health Authority's HAB resource website.

3.5 Long Term Planning

Many water systems in Washington state are required to prepare comprehensive water system plans (WSP). Some aspects of your HAB Plan dovetail nicely with water system planning for water utilities. Three areas of a HAB plan effort to possibly include in your WSP efforts are:

1. Identify treatment improvements that can remove algae or destroy cyanotoxins. If your water system does not currently have a cyanotoxin destruction or removal process ODW recommends that you move forward with the process for installing one now. For example, permanganate is very effective at destroying microcystins and anatoxin-a at low doses. Dissolved air flotation (DAF) is very effective at removing suspended algae from water. DAF may extend filter runs in non-bloom conditions as well.
2. Identify long term measures to detect, mitigate, and prevent future algal blooms. Some examples include reservoir mixing, or water treatment plant intake modifications. Some additional ideas are provided below.
3. Manage/reduce nutrients. Appendix A.4 shows how risk of algal blooms can be reduced by controlling phosphorus. This is something that could be included in your watershed management efforts.

Source water monitoring and an understanding of the biology and chemistry of the source water can help identify potential management and control measures to reduce both the frequency and magnitude of algal blooms and subsequent levels of cyanobacteria entering your water treatment plant. USEPA provides an overview of source water mitigation strategies in Section 2.4 of *Recommendations for Systems to Manage Cyanotoxins in Drinking Water* (USEPA, 2015a). Systems in Washington have successfully achieved long term reductions in harmful algal blooms by using:

- Mechanical lake mixing,
- Variable intake depths, and
- Spatially separated intakes in the lake or impoundment. (This allows these utilities to avoid algal blooms that occur in only part of their lake or impoundment.)

Other methods used across the country include the addition of alum or bentonite clay (Phoslock®) to remove phosphorous from the water and bind it in lake sediments, and in-lake aeration and oxygenation. Algaecides are not recommended because they fail to correct the underlying cause of the bloom, only provide short term results, can disrupt the ecology of the water body, and most importantly, can release toxins contained inside cyanobacterial cells.

One last consideration for long term planning a couple of systems in Washington have experienced significant algal blooms following modification to their source impoundments (raising a dam). The newly flooded land most likely released nutrients to the source water and certainly changed the historical water quality conditions. Any planned source modifications should anticipate possible algal blooms and evaluate possible mitigation efforts.

4.0 Where to Get Help

While it is the primary responsibility of the affected system to prepare and manage potential HAB events, ODW, Ecology, and several other agencies can assist in the response to algal blooms and cyanotoxins as described below.

Department of Health-Office of Drinking Water (ODW)

Provides technical assistance and advice about sampling, treatment options, and public notice by systems affected by HABs and cyanotoxins. ODW provides the following services:

- Maintains a list of systems and drinking water sources previously impacted by cyanotoxins (Appendix A.2).
- Reviews HAB Plans if requested
- Follows up with a system when an algal bloom, cyanobacteria, or cyanotoxins have been detected in source water.
- Provides technical assistance to systems that detect cyanotoxins in raw or finished water.
- Assists systems in reviewing the adequacy of facilities for treating algae and cyanotoxins.
- Reviews plans for providing temporary treatment of cyanotoxins.
- Reviews plans for constructing permanent facilities to treat algae and cyanotoxins.
- Assists systems with health advisories when cyanotoxins are detected in finished water.

For more information contact your ODW regional office.

Eastern Regional Office	509-329-2100
Northwest Regional Office	253-395-6750
Southwest Regional Office	360-236-3030

Department of Health-Office of Environmental Public Health Sciences

- Provides support to local health jurisdictions (LHJs) on recreational and drinking water HABs-related issues.
- Provides epidemiological and toxicological expertise on cyanotoxin health effects.
- Provides health effects advice for cyanotoxin detections without established HALs.
- Provides recommended public health actions to take when there is an active bloom in a recreational water body.
- Provides outreach materials and warning signs for recreational water HABs.

Department of Health-Office of Communicable Disease Epidemiology

- Follows up to and tracks cases of human or animal illnesses due to HABs.
- Report all suspected human or animal HABs-associated illnesses or deaths to the DOH Office of Communicable Disease Epidemiology at 206-418-5500 or waterborne-epi@doh.wa.gov.

Department of Ecology (Ecology)

Implements the Fresh Water Algae Control Program, which:

- Provides phytoplankton identification and enumeration and cyanotoxin testing through the King County Environmental Lab.

- Maintains a publicly available database of cyanotoxin testing of Washington water bodies.
- Administers a program to provide small grants of up to $50,000 to state agencies, cities, counties, tribes, and special purpose districts to fund projects that prevent, remove, reduce, or manage cyanobacteria. Freshwater Algae Control Grant Program ecology.wa.gov/About-us/Payments-contracts-grants/Grants-loans/Find-a-grant-or-loan/Freshwater-algae-program-grants.

Local Health Jurisdictions

Local health jurisdictions (LHJ) may report algal blooms, collect samples, and provide information concerning algal blooms and cyanotoxins to local residents. Many LHJs monitor beaches and other freshwater recreational sites and post health advisories based on state recreational HABs guidelines. They may also close beaches and recreational sites if they are above recreational guidelines. (doh.wa.gov/CommunityandEnvironment/Contaminants/BlueGreenAlgae/Resources)

LHJs normally refer public water system-related questions to ODW. Some LHJs regulate very small public water systems (group B) either through a local ordinance or delegated responsibility from the Department of Health.

Contact your local health jurisdiction for details on their program. (doh.wa.gov/AboutUs/PublicHealthSystem/LocalHealthJurisdictions)

US Environmental Protection Agency (EPA)

USEPA "Cyanobacterial Harmful Algal Blooms (CyanoHABs) in Water Bodies" webpage contains a wealth of information. (epa.gov/cyanohabs)

Appendix A.1—Algae and Cyanobacteria Treatment Optimization and Resources

All systems with surface water sources are vulnerable to cyanotoxin contamination and should assess adequacy of treatment and, if necessary, make treatment adjustments based on past experience treating cyanotoxins or upon recommendations by USEPA. The specific treatment required may depend on the type of cyanotoxin present, the level of cyanotoxins in the raw water, and whether the cyanotoxins are intracellular or extracellular. Existing surface water treatment may be effective in reducing cyanotoxins to an acceptable level.

For example, if your treatment plant already has advanced treatment processes such as ozonation and /or granular activated carbon (GAC) that can effectively destroy or remove cyanotoxins your risk is low. Conventional surface water treatment, (coagulation, flocculation, sedimentation, and filtration) has been shown to effectively remove intracellular cyanotoxins but has limited ability to remove extracellular toxins. In some cases, treatment adjustments or the addition of treatment processes may be needed.

Systems with existing surface water treatment facilities may be able to adjust treatment to respond sufficiently to cyanotoxins. EPA lists the following commonly used treatment strategies for reducing or eliminating cyanotoxins:

- Remove intact cells containing intracellular cyanotoxins by optimizing existing coagulant chemicals and chemical doses.
- Minimize pre-filtration oxidation of raw water to reduce the risk of releasing intracellular cyanotoxins. (Reminder: If you use pre-chlorination to meet disinfection CT requirements, you may need to adjust the post-filtration disinfection process to achieve your overall CT required.) This action is only useful if you have an effective cyanobacteria cell removal treatment component.
- Increase post-chlorination to oxidize certain extracellular cyanotoxins (caution: this could potentially increase the formation of Disinfection Byproducts and is not effective for all cyanotoxins).

If adjustments to existing treatment facilities do not sufficiently reduce cyanotoxin levels or a system does not have the ability to make treatment adjustments to respond to cyanotoxins, it may be able to shut down the intake and rely on another source, unaffected by cyanotoxins, until the threat from cyanotoxins has passed. If a system is unable to shut down the source or treat to acceptable levels, it must consider installing additional treatment facilities. EPA suggests the treatment options listed below for removing intracellular and extracellular cyanotoxins.

Additional Treatment Options for Intracellular Cyanotoxins (Cell Removal)

1. Dissolved Air Flotation.
2. Microfiltration and Ultrafiltration.

The key to treatment of intracellular cyanotoxins is to remove cyanobacteria cells and limit the release of toxins from the cells. This typically requires a water system to limit algaecide application to source water and stop or limit pre-oxidation during treatment. A water system must consider, however, how changes in pre-oxidation affect other treatment goals.

Additional Treatment Options for Extracellular Cyanotoxins

1. Oxidation using permanganate, ozone or chlorine.

2. Granular Activated Carbon – other treatment benefits include reduced NOM, taste and odor, DBP reductions.
3. Powdered Activated Carbon—limited to systems having sedimentation capacity.
4. Biological Filtration.
5. Nanofiltration and Reverse Osmosis.
6. Ultraviolet Light with Hydrogen Peroxide.

Once cyanobacteria release cyanotoxins, cell removal does little to reduce toxins dissolved in the water. Therefore, conventional surface water treatment, microfiltration, and ultrafiltration are no longer effective. Extracellular, or dissolved, cyanotoxins must be removed through treatment processes such as adsorption, molecular filtration, or oxidation.

General effectiveness of oxidizing agents on various cyanotoxins is described in Table 3-1 of USEPA's *Water Treatment Optimization for Cyanotoxins* (Version 1.0) (USEPA, 2016) shown below. Oxidation by ozone is especially effective in destroying most cyanotoxins.

Oxidant	Anatoxin-a	Cylindrospermopsin	Microcystins	Saxitoxin
Chlorine	Not effective	Effective (at low pH)	Effective*	Somewhat effective
Chloramine	Not effective	Not effective	Not effective at normal doses	Inadequate information
Chlorine dioxide	Not effective at normal doses	Not effective	Not effective at normal doses	Inadequate information
Potassium permanganate	Effective	Data ranges from not effective to possibly effective	Effective*	Not effective
Ozone	Effective	Effective	Very effective	Not effective
UV / advanced oxidation	Effective	Effective	Effective at high UV doses*	Inadequate information

* Dependent on initial cyanotoxin concentration, pH, temperature, and presence of NOM.

Other oxidants such as chlorine, potassium permanganate, and UV vary in their effectiveness to remove a given cyanotoxin. CyanoTOX® Version 3.0 is an oxidation calculator designed to help utilities evaluate how treatment adjustments (such as pH, oxidant dose, and contact time) may influence degradation of individual cyanotoxins and some groups of cyanotoxins. It includes a module to model intracellular and extracellular toxins throughout the water treatment plant. **Important:** to account for differences between laboratory and real-world results, apply a safety factor of at least 2.0 to CyanoTox results.

ODW can help review the adequacy of cyanotoxin treatment or evaluate options to install additional treatment. Installation of cyanotoxin treatment requires that plans be submitted to ODW for review and approval prior to construction.

Appendix A.2—Washington Waterbodies with Public Water System Intakes and Cyanotoxin Detections

Name	County	Cyanotoxin detected*	Date/Concentration
Crescent Lake*	Clallam	Anatoxin-a, Microcystin	10/1/2019 Anatoxin-a 0.010 µg/L; Microcystin 0.968 µg/L
Columbia River at Kennewick, Pasco & Richland	Benton and Franklin	Anatoxin-a	2021 – 3 months. Up to 14.4 µg/L in shoreline samples.
Lake Margaret*	King	Anatoxin-a	06/05/2017 0.027 µg/L
Lake McMurray*	Skagit	Microcystin	09/21/2015 0.160 µg/L 08/10/2015 1.160 µg/L
Lake Whatcom*	Whatcom	Microcystin	12/12/2017 Microcystin 0.200 µg/L

Source: Freshwater Sampling Program database. Accessed 5.13.2020.
**Cyanotoxins were detected in the waterbody, not in public water system intakes.*

You can view drinking water source protection areas for a specific waterbody by using the Source Water Assessment Program (SWAP) Mapping Tool at GIS Mapping Tool : Washington State Department of Health. Navigate to the area you are interested in and select Group A Surface Water Protection Areas. Click on a source protection area to see the name(s) of the public water systems that obtain water from that area. Select Group B Surface Water Protection Areas if you want to see very small public water systems.

Appendix A.3—Impact of Phosphorus on Bloom Risk

Risk	History of Cyanobacteria	Water Temp (°C)	Total P (ug/L)
Very Low (Good)	No	<15	<10
Low	Yes	<15-20	<10
Moderate	Yes	20-25	10-25
High	Yes	>25	25-100
Very High (Poor)	Yes	>25	>100

One pound of phosphorus can create 700 pounds of algae (Reference *Historical Perspectives on the Phosphate Detergent Conflict, Knud-Hansen*, 1994.) For this reason, the amount of phosphate in laundry soaps has been limited to less than 0.5 percent by weight in Washington state since 1994, and this limit applied to dishwasher detergents starting in July 2010. (Sam Perry, Washington Department of Health, *Potential Risks from Algae Blooms in Water Supplies*, AWWA-Pacific Northwest Section, Annual Conference, April, 2018.)

Appendix B—Cyanobacteria and Associated Toxins They May Produce

	Hepatotoxins		Neurotoxins		Tastes and Odors	
Cyanobacterial Genera	Cylindro-Spermopsin	Microcystins	Anatoxin	Saxitoxins	Geosmin	MIB
Anabaenopsis		x				
Aphanizomenon	x	x	x	x	x	
Aphanocapsa		x				
Arthrospira		x	x			
Chrysosporum	x					
Cuspidothrix	x	x	x	x	x	
Cylindrospermum	x		x	x		
Dolichospermum (Anabaena)	x	x	x	x	x	
Fischerella		x			x	
Gloeotrichia		x				
Hapalosiphon		x				
Hyella					x	x
Leptolyngbya (Plectonema)		x			x	x
Limnothirix		x				
Lyngbya (Microseira)	x	x		x	x	x
Merismopedia		x				
Microcystis		x				
Nostoc		x		x	x	x
Oscillatoria	x	x	x	x	x	x
Planktothrix	x	x	x	x	x	x
Phormidium (Anagnostidinema, Geitlerinema, Microcoleus)		x	x	x	x	x
Pseudanabaena		x				x
Raphidiopsis (Cylindrospermop-sis)	x	x	x	x		
Scytonema		x				
Snowella		x				
Synechococcus		x			x	x
Synechocystis		x				
Umezakia	x	x				
Woronichinia		x	x			

MIB is 2-methylisoborneol, a compound commonly associated with taste and odor complaints along with geosmin.
Adapted from: Public Water System Harmful Algal Bloom Response Strategy, Ohio EPA, April 2020.

Appendix C—Cyanotoxin Sample Handling and Details

- **Handling**—follow collection and handling procedures established by method or laboratory.
- **Lab Analysis**—use lab-provided sample containers.
- **Containers**—typically 500 ml amber glass with PTFE-lined cap.
- **Quenching**—quench immediately upon sampling if exposed to oxidants (follow lab instructions).
- **Cooling**—cool on ice (≤10° C) immediately after collection, during shipping, and pending analysis (EPA Method 546).
- **Holding Time**—analyze within fourteen days of collection (EPA Method 546).

Important: Follow the specific instructions provided by your lab.

Appendix D—Acceptable Analytical Methods for Cyanotoxin

Toxin	Source/Raw Water Investigations	Finished Water Investigation	Finished Water Confirmation
Microcystins	EPA 546 ADDA ELISA	EPA 546 ADDA ELISA	EPA 546 ADDA ELISA
	LC/MS/MS*	EPA 544 LC/ESI-MS/MS	EPA 544 LC/ESI-MS/MS
Anatoxin-a	Anatoxin-a ELISA	Anatoxin-a ELISA	NA
	LC/MS/MS *	EPA 545 LC/ESI-MS/MS	EPA 545 LC/ESI-MS/MS
Cylindrospermopsin	Cylindrospermopsin ELISA	Cylindrospermopsin ELISA	NA
	LC/MS/MS *	EPA 545 LC/ESI-MS/MS	EPA 545 LC/ESI-MS/MS
Saxitoxin	Saxitoxin ELISA	Saxitoxin ELISA	Saxitoxin ELISA
	LC/MS/MS*	LC/MS/MS	LC/MS/MS

**LC/MS/MS methods may require cleanup/solid-phase extraction of thick blooms prior to instrument analysis.*

EPA Approved Lab Methods for Cyanotoxins in drinking water:

1. *EPA Method 544: Microcystin-LA, Microcystin-RR, Microcystin-LF, Microcystin-YR, Microcystin-LR, Microcystin-LY, Nodularin (LC/MS/MS).*
2. *EPA Method 545: Cylindrospermopsin, Anatoxin-a (LC/ESI-MS/MS).*
3. *EPA Method 546: Total Microcystins (ELISA).*

Appendix E—Public Notification/Water Use Advisories for Cyanotoxins in Drinking Water

Health Advisory Levels for Microcystins, Cylindrospermopsin, and Anatoxin-a

Cyanotoxins are currently not regulated by EPA and do not have maximum contaminant levels (MCLs). However, they are on EPA's Contaminant Candidate List (CCL), and are thereby under consideration for future regulation under the Safe Drinking Water Act. In 2015 the EPA established ten-day non-regulatory HALs for total microcystins and cylindrospermopsin (USEPA, 2015b and 2015c). The health advisories identify concentrations at or below which no adverse human health effects would be expected for up to ten days of exposure. The EPA issued health effects documents for microcystin, cylindrospermopsin, and anatoxin-a along with the 2015 HALs but did not include an acute reference dose for anatoxin-a (USEPA, 2015d), as adequate toxicity data were not available at the time.

HALs for microcystin and cylindrospermopsin are given for two separate population groups. The first group includes infants, pre-school children under six years, and susceptible adults (pregnant women, nursing mothers, elderly, immune-compromised, and dialysis patients). The second group includes school-aged children (six years and older) and other adults.

Table E1: Cyanotoxin Do Not Drink Health Advisory Levels (EPA)

10-DAY HEALTH ADVISORIES	LEVEL
Microcystins	
Children pre-school age and younger (under 6 years old)	**0.3 µg/L**
School-age children (6 years and older)	**1.6 µg/L**
Cylindrospermopsin	
Children pre-school age and younger (under 6 years old)	**0.7 µg/L**
School-age children (6 years and older)	**3.0 µg/L**

Table 1. U.S. EPA's National 10-Day Health Advisories

Public Notification Templates for EPA HALs are provided below. Also included are health advisory templates for anatoxin-a exceeding the ODW recommended trigger value for which no EPA HAL exists.

1. Anatoxin-a Above Recommended Trigger Value for Bottle-Fed Infants and Young Children of Pre-School Age but Below Health Advisory Value for School-Age Children through Adults.
2. Anatoxin-a Above Recommended Trigger Value for All Consumers.

3. Cylindrospermopsin Above Health Advisory Value for Bottle-Fed Infants and Young Children of Pre-School Age but Below Health Advisory Value for School-Age Children through Adults.
4. Cylindrospermopsin Above Health Advisory Value All Consumers.
5. Microcystins Above Health Advisory Value for Bottle-Fed Infants and Young Children of Pre-School Age but Below Health Advisory Value for School-Age Children through Adults.
6. Microcystins Above Health Advisory Value All Consumers.

DRINKING WATER WARNING

Anatoxin-a Health Advisory for Vulnerable Populations

The ____________________Water System, ID ________, located in ___________ County is contaminated with anatoxin-a.

Anatoxin-a are compounds produced by cyanobacteria (formerly called blue-green algae). Anatoxin-a have been detected in our treated drinking water. A sample collected on _________ shows anatoxin-a at ____ micrograms/liter (µg/L). The Washington Department of Health recommends the following individuals **DO NOT DRINK THE WATER** when the anatoxin-a level is above 0.3 µg/L:

> If you are pregnant, breastfeeding, receiving dialysis treatment, elderly, immune-compromised or children younger than 6 years old.

Consuming water containing anatoxin-a may result in loss of coordination, muscular twitching, convulsions, difficulty breathing, and potentially other neurotoxicity symptoms: headache, dizziness, a floating sensation, muscle soreness, muscle weakness, nausea or vomiting, and paralysis. Seek medical attention if you or anyone in your family is experiencing any of these symptoms.

What should I do?

If you are pregnant, breastfeeding, receiving dialysis treatment, elderly, immune-compromised or children younger than 6 years old, use alternative water, such as commercially available bottled water for drinking, making infant formula, making ice, brushing teeth, and preparing food for bottle-fed infants.

Healthy children above the age of 6 and adults not in the categories listed above may drink the water. Water may be used by all individuals for bathing, washing hands, washing dishes, doing laundry, and flushing toilets. Children younger than 6 years of age must be supervised while bathing to prevent accidental ingestion of water. After bathing provide a final rinse of skin with uncontaminated water for people with open wounds or skin conditions such as eczema. Rinse items that go into the mouths of infants and children (i.e., teething rings, nipples, bottles, toys, silverware) with uncontaminated water.

Dispose of all ice and mixed beverages made with contaminated water if individuals described above have access to these products.

Contact a veterinarian immediately if pets or livestock show signs of illness.

Do not boil the water. Boiling the water will not destroy anatoxin-a and it may become more concentrated as a result of boiling.

What happened? What is being done?

______________________, a source of drinking water for our water system, is experiencing a harmful algal bloom (HAB). We are working closely with local and state public health agencies to address and resolve the situation. We are making adjustments to our treatment processes to reduce anatoxin-a and we will continue to sample our water. We will keep you informed as the situation is resolved. Additional information about HABs can be found at epa.gov/cyanohabs.

For more information, please contact _____________________________at______________________.

Please share this information anyone who drinks this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools and businesses). You can do this by posting this notice in a public place or distributing copies by hand or mail.

This notice is sent to you by _____________________________Water System on ____/____/_____.

DRINKING WATER WARNING

Anatoxin-a Health Advisory (General Population)

The ___________________Water System, ID _______, located in __________ County is contaminated with anatoxin-a.

Anatoxin-a are compounds produced by cyanobacteria (formerly called blue-green algae). Anatoxin-a have been detected in our treated drinking water. A sample collected on ______________ shows anatoxin-a at ____________ micrograms/liter (µg/L). The Washington State Department of Health recommends all individuals **DO NOT DRINK THE WATER** when the anatoxin-a level is above 1.6 µg/L:

Consuming water containing anatoxin-a may result in loss of coordination, muscular twitching, convulsions, difficulty breathing, and potentially other neurotoxicity symptoms: headache, dizziness, a floating sensation, muscle soreness, muscle weakness, nausea or vomiting, and paralysis. Seek medical attention if you or anyone in your family is experiencing any of these symptoms.

What should I do?

Alternative water, such as commercially-available bottled water, should be used for drinking, making infant formula, making ice, brushing teeth, and preparing food.

Water may be used for bathing, washing hands, washing dishes, doing laundry, and flushing toilets. Infants and children must be supervised while bathing to prevent accidental ingestion of water. After bathing provide a final rinse of skin with uncontaminated water for people with open wounds or skin conditions such as eczema. Rinse items that go into the mouths of infants and children (i.e., teething rings, nipples, bottles, toys, silverware) with uncontaminated water.

Dispose of all ice and mixed beverages made with contaminated water.

Pets should not drink the water. Contact a veterinarian immediately if pets or livestock show signs of illness.

Do not boil the water. Boiling the water will not destroy anatoxin-a and it may become more concentrated as a result of boiling.

What happened? What is being done?

______________________, a source of drinking water for our water system, is experiencing a harmful algal bloom (HAB). We are working closely with local and state public health agencies to address and resolve the situation. We are making adjustments to our treatment processes to reduce anatoxin-a and we will continue to sample our water. We will keep you informed as the situation is resolved. Additional information about HABs can be found at epa.gov/cyanohabs.

For more information, please contact ___________________________at____________________.

Please share this information anyone who drinks this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools and businesses). You can do this by posting this notice in a public place or distributing copies by hand or mail.

This notice is sent to you by _____________________________Water System on ____/____/_____.

DRINKING WATER WARNING

Cylindrospermopsin Health Advisory for Vulnerable Populations

The ____________________system, ID _______, located in __________ County is contaminated with cylindrospermopsin.

Cylindrospermopsin, a compound produced by cyanobacteria (also called blue-green algae) has been detected in our treated drinking water. A sample collected on _________ shows cylindrospermopsin at ______ micrograms/liter (µg/L). The Washington Department of Health recommends the following individuals **DO NOT DRINK THE WATER** when the cylindrospermopsin level is above 0.7 µg/L:

If you are pregnant, breastfeeding, receiving dialysis treatment (or have a pre-existing liver condition), elderly, immune-compromised or children younger than 6 years old.

Consuming water containing concentrations of cylindrospermopsin over the action level may result in abdominal pain, fever, vomiting, diarrhea, or impaired liver or kidney function. Seek medical attention if you or anyone in your family is experiencing any of these symptoms.

What should I do?

If you are pregnant, breastfeeding, receiving dialysis treatment (or have a pre-existing liver condition), elderly, immune-compromised or children younger than 6 years old use alternative water, such as commercially-available bottled water, for drinking, making infant formula, making ice, brushing teeth, and preparing food for bottle-fed infants.

Healthy children above the age of six and adults not in the categories listed above may drink the water. Water may be used by all individuals for bathing, washing hands, washing dishes, doing laundry, and flushing toilets. Children younger than six years of age must be supervised while bathing to prevent accidental ingestion of water. After bathing provide a final rinse of skin with uncontaminated water for people with open wounds or skin conditions such as eczema.

Dispose of all ice and mixed beverages made with contaminated water if individuals described above have access to these products.

Pets should be given alternative water. Contact a veterinarian immediately if pets or livestock show signs of illness.

Do not boil the water. Boiling the water will not destroy cylindrospermopsin and it may become more concentrated as a result of boiling.

What happened? What is being done?

______________________, a source of drinking water for our water system, is experiencing a harmful algal bloom (HAB). We are working closely with local and state public health agencies to address and resolve the situation. We are making adjustments to our treatment processes to reduce cylindrospermopsin and we will continue to sample our water. We will keep you informed as the situation is resolved. Additional information about HABs can be found at epa.gov/cyanohabs.

For more information, please contact ____________________________at_____________________.

Please share this information anyone who drinks this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools and businesses). You can do this by posting this notice in a public place or distributing copies by hand or mail.

This notice is sent to you by ____________________________system on ____/____/_____.

DRINKING WATER WARNING

Cylindrospermopsin Health Advisory (General Population)

The ___________________system, ID _______, located in __________ County is contaminated with cylindrospermopsin.

Cylindrospermopsin, a compound produced by cyanobacteria (also called blue-green algae) has been detected in our treated drinking water. A sample collected on _____________ shows cylindrospermopsin at ____________ micrograms/liter (µg/L). The Washington State Department of Health recommends all individuals **DO NOT DRINK THE WATER** when the cylindrospermopsin level is above 3.0 µg/L:

Consuming water containing concentrations of cylindrospermopsin over the action level may result in abdominal pain, fever, vomiting, diarrhea, or impaired liver or kidney function. If you are pregnant, breastfeeding, receiving dialysis treatment (or have a pre-existing liver condition), elderly, immune-compromised or children younger than 6 years old you may be more susceptible than the general population to the health effects of cylindrospermopsin. Seek medical attention if you or anyone in your family is experiencing any of these symptoms.

What should I do?

Alternative water, such as commercially-available bottled water, should be used for drinking, making infant formula, making ice, brushing teeth, and preparing food.

Water may be used for bathing, washing hands, washing dishes, doing laundry, and flushing toilets. Children younger than six years of age must be supervised while bathing to prevent accidental ingestion of water. After bathing provide a final rinse of skin with uncontaminated water for people with open wounds or skin conditions such as eczema.

Dispose of all ice and mixed beverages made with contaminated water.

Pets should be given alternative water. Contact a veterinarian immediately if pets or livestock show signs of illness.

Do not boil the water. Boiling the water will not destroy cylindrospermopsin and it may become more concentrated as a result of boiling.

What happened? What is being done?

_____________________, a source of drinking water for our water system, is experiencing a harmful algal bloom (HAB). We are working closely with local and state public health agencies to address and resolve the situation. We are making adjustments to our treatment processes to reduce cylindrospermopsin and we will continue to sample our water. We will keep you informed as the situation is resolved. Additional information about HABs can be found at epa.gov/cyanohabs.

For more information, please contact ___________________________at____________________.

Please share this information anyone who drinks this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools and businesses). You can do this by posting this notice in a public place or distributing copies by hand or mail.

This notice is sent to you by _____________________________system on ___/___/____.

DRINKING WATER WARNING

Microcystins Health Advisory for Vulnerable Populations

The ___________________system, ID _______, located in __________ County is contaminated with microcystins.

Microcystins are compounds produced by cyanobacteria (also called blue-green algae). Microcystins have been detected in our treated drinking water. A sample collected on ________ shows microcystins at ____ micrograms/liter (µg/L). The Washington State Department of Health recommends the following individuals **DO NOT DRINK THE WATER** when the microcystins level is above 0.3 µg/L:

If you are pregnant, breastfeeding, receiving dialysis treatment, elderly, immune-compromised or children younger than 6 years old.

Consuming water containing concentrations of microcystins over the action level may result in abnormal liver function, diarrhea, vomiting, nausea, numbness or dizziness. Seek medical attention if you or anyone in your family is experiencing any of these symptoms.

What should I do?

If you are pregnant, breastfeeding, receiving dialysis treatment, elderly, immune-compromised or children younger than 6 years old, use alternative water, such as commercially available bottled water for drinking, making infant formula, making ice, brushing teeth, and preparing food for bottle-fed infants. Healthy children above the age of six and adults not in the categories listed above may drink the water. Water may be used by all individuals for bathing, washing hands, washing dishes, doing laundry, and flushing toilets. Children younger than 6 years of age must be supervised while bathing to prevent accidental ingestion of water. After bathing provide a final rinse of skin with uncontaminated water for people with open wounds or skin conditions such as eczema.

Dispose of all ice and mixed beverages made with contaminated water if individuals described above have access to these products.

Pets should be given alternative water. Contact a veterinarian immediately if pets or livestock show signs of illness.

Do not boil the water. Boiling the water will not destroy microcystins and it may become more concentrated as a result of boiling.

What happened? What is being done?

_____________________, a source of drinking water for our water system, is experiencing a harmful algal bloom (HAB). We are working closely with local and state public health agencies to address and resolve the situation. We are making adjustments to our treatment processes to reduce microcystins and we will continue to sample our water. We will keep you informed as the situation is resolved. Additional information about HABs can be found at epa.gov/cyanohabs.

For more information, please contact ___________________________at____________________.

Please share this information anyone who drinks this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools and businesses). You can do this by posting this notice in a public place or distributing copies by hand or mail.

This notice is sent to you by _____________________________system on ____/____/_____.

DRINKING WATER WARNING

Microcystins Health Advisory (General Population)

The ___________________system, ID _______, located in __________ County is

contaminated with microcystins.

Microcystins are compounds produced by cyanobacteria (also called blue-green algae). Microcystins have been detected in our treated drinking water. A sample collected on _____________ shows microcystins at ____________ micrograms/liter (µg/L). The Washington State Department of Health recommends all individuals **DO NOT DRINK THE WATER** when the microcystins level is above 1.6 µg/L:

Consuming water containing concentrations of microcystins over the action level may result in abnormal liver function, diarrhea, vomiting, nausea, numbness or dizziness. If you are pregnant, breastfeeding, receiving dialysis treatment (or have a pre-existing liver condition), elderly, immune-compromised or children younger than 6 years old you may be more susceptible than the general population to the health effects of microcystins. Seek medical attention if you or anyone in your family is experiencing any of these symptoms.

What should I do?

Alternative water, such as commercially-available bottled water, should be used for drinking, making infant formula, making ice, brushing teeth, and preparing food.

Water may be used for bathing, washing hands, washing dishes, doing laundry, and flushing toilets. Children younger than six years of age must be supervised while bathing to prevent accidental ingestion of water. After bathing provide a final rinse of skin with uncontaminated water for people with open wounds or skin conditions such as eczema.

Dispose of all ice and mixed beverages made with contaminated water.

Pets should be given alternative water. Contact a veterinarian immediately if pets or livestock show signs of illness.

Do not boil the water. Boiling the water will not destroy microcystins and it may become more concentrated as a result of boiling.

What happened? What is being done?

_____________________, a source of drinking water for our water system, is experiencing a harmful algal bloom (HAB). We are working closely with local and state public health agencies to address and resolve the situation. We are making adjustments to our treatment processes to reduce microcystins and we will continue to sample our water. We will keep you informed as the situation is resolved. Additional information about HABs can be found at epa.gov/cyanohabs.

For more information, please contact ___________________________at____________________.

Please share this information anyone who drinks this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools and businesses). You can do this by posting this notice in a public place or distributing copies by hand or mail.

This notice is sent to you by ______________________________system on ____/____/_____.

Appendix F—Lab Lists

Lab capacity and lab turnaround time for cyanotoxin analysis is currently a significant challenge for utilities encountering a cyanobacteria bloom. For finished water drinking water samples, we recommend using a Washington state-certified lab if one is available and can provide adequate turnaround time. Check the Ecology website for the most current list.

Labs approved for Cyanotoxin analysis by Ecology lab certification program

Approved Labs	Location	Phone	EPA Method 544[1]	EPA Method 545[2]	EPA Method 546[3]
King County Environmental[4]	Seattle, WA	(206) 477-7117	Yes	Yes	Yes
Eurofins Eaton Analytical, LLC	Monrovia, CA	(626) 386-1170	-	Yes	Yes

Source: *apps.ecology.wa.gov/laboratorysearch*.

EPA Approved Lab Methods for Cyanotoxins:

1. EPA Method 544: Microcystin-LA, Microcystin-RR, Microcystin-LF, Microcystin-YR, Microcystin-LR, Microcystin-LY, Nodularin (LC/MS/MS).
2. EPA Method 545: Cylindrospermopsin, Anatoxin-a (LC/ESI-MS/MS)
3. EPA Method 546: Total Microcystins (ELISA).
4. Accepts outside samples by special arrangement only, contact ODW regional office

Labs approved for Cyanotoxin analysis by other states' programs

If a Washington state certified lab is unavailable, the next-best option is to use a lab accredited by another state. The National Environmental Laboratory Accreditation Conference (NELAC) provides a listing of member state certified labs at Home Page—TNI LAMS—National Environmental Laboratory Accreditation Management System (nelac-institute.org).

EPA Approved Labs for UCMR4 Cyanotoxins

A third option is to use a UCMR4-approved lab. Use caution, now that UCMR4 monitoring is complete, EPA is not maintaining this list. Make sure the lab is still actively performing the method(s) you need.

The following table lists in-state UCMR4 approved labs. Full list at epa.gov/dwucmr/list-laboratories-approved-epa-fourth-unregulated-contaminant-monitoring-rule-ucmr-4.

Approved Labs	Location	Phone	EPA Method 544[1]	EPA Method 545[2]	EPA Method 546[3]
King County Environmental	Seattle, WA	(206) 477-7117	Yes	Yes	Yes
Water Management	Tacoma, WA	(253) 531-3121	-	Yes	Yes

Labs for Cyanobacteria identification and enumeration only

Note: In addition to the following, labs listed above can usually identify and enumerate freshwater phytoplankton.

Lab Name	Address	Phone
Advanced Eco-Solutions, Inc. Darren Brandt Darren.brandt@adveco-sol.com	1324 N Liberty Lake Rd, #124 Liberty Lake, WA 99019	(509) 226-0146 (208) 660-8733
Aquatic Analysts Jim Sweet jwsweet@aol.com www.AAalgae.com	43 Telegraph Ln Friday Harbor, WA 98250	(503) 869-5032
EcoAnalysts www.ecoanalysts.com also provide chlorophyll-a (EPA methods 445 and 446) and phycocyanin analysis	1420 S Blaine St, Suite 14 Moscow, ID 83843	(208) 882-2588 Ext 21

Source: epa.gov/cyanohabs/laboratories-analyze-cyanobacteria-and-cyanotoxins#washington.

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Carpenter, A.T. (2020), Cyanobacteria: Coming Soon to Water Near You. J Am Water Works Assoc, 112: 8-8. doi:10.1002/awwa.1475

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Other Resources

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Ohio EPA Harmful Algal Blooms webpage: epa.ohio.gov/ddagw/HAB.aspx.

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