## 1. Scope and Application

1.1 The purpose of this document is to provide a relatively simple set of procedures that can be conducted by trained personnel at a drinking water utility to determine the amount of cyanotoxin that may be degraded by the oxidant(s) in use at the drinking water treatment plant over a given time, temperature, and pH condition.

1.2 Oxidants are added to water supplies for the oxidation of organic constituents such as taste-and-odor producing compounds, for disinfection credit, and/or to control iron and manganese. Some oxidants are also useful for the control of cyanotoxins such as cylindrospermopsin and microcystin-LR. However, oxidation of the cyanotoxins is affected by the chemical and physical characteristics of the sample. Sample temperature, pH, contact time, oxidant dose, natural organic matter, and other factors all affect the overall oxidant demand and consumption, while proper measurement technique impacts the ability to interpret and apply the results. The following pages detail the protocols for preparing standardized stock solutions, evaluating cyanotoxin removal, and testing chlorine demand, chloramine demand, ozone demand, chlorine dioxide demand, and permanganate demand for use in the Hazen-Adams CyanoTOX Tool available on the AWWA website.

1.3 This document does not provide protocols for addressing the release of intracellular cyanotoxins that may occur when cyanobacterial cells are oxidized. This protocol ONLY addresses extracellular (dissolved) toxins. Future revisions or additional testing protocols may include recommendations on handling cell lysis and subsequent release of additional cyanotoxins into the water.

1.4 This document was prepared by Ben Stanford, Allison Reinert, Elisa Arevalo, and Erik Rosenfeldt of Hazen and Sawyer, and Craig Adams of Utah State University. This document has been reviewed by the AWWA CCL / Potential Contaminant Technical Advisory Workgroup (TAW), with special thanks to David Cornwell, Keith Cartnick, Rick Sakaji, Issam Najm, and Steve Via for extensive review and comments on testing procedures.

1.5 AWWA makes no guarantee as to the accuracy or applicability of these procedures for a specific utility's drinking water source or the full-scale applicability of results. The user accepts all liability for use of the procedures described herein, and the user is solely responsible for interpretation and implementation of any results derived from the use of these procedures.



## 2. Special Considerations & Initial QA/QC

2.1 **Health and safety is of foremost importance**

- Please note that the handling of oxidants (e.g., ozone, chlorine, chloramine, permanganate, and chlorine dioxide) should be conducted only by trained laboratory personnel using the proper standard operating procedures, safety equipment, protective gear, and ventilated fume hoods.
- For each of the oxidants listed in this document, please follow all required laboratory health and safety considerations prior to beginning any work.
- This document is NOT intended to be a guide for those safety considerations; rather, it is assumed that the user is experienced with the handling and preparation of solutions of varying concentration of the oxidant, toxins and other chemicals, and follows all applicable safety standards and local environmental laws.

2.2 **Selection of test water will impact the results**

- Each water treatment plant is unique in the combinations of source water type/location, treatment processes, chemical usage, etc.
- When conducting cyanotoxin testing, begin by answering the following question: "At which point in the process would I like to determine the impact of oxidation on cyanotoxin removal?"
    - If the answer is "raw water", then the test can be conducted with samples of raw water, with the important caveats listed below.
    - If the answer is "at the clearwell" (or at any other step in the treatment process), then you will need to determine whether to collect water from that point in the process at the plant or whether to mimic the plant's treatment processes (e.g., floc/sed/filtration, pH adjustment) via jar tests and then use the water produced at bench scale to conduct further testing.
- ***Your test water needs to be free of residual oxidant and quenching agents*.** Residual chlorine or other oxidants will impact the results of these tests by reducing the starting concentration of cyanotoxin before the test has begun. Likewise, residual quenching agent (if any) will consume any oxidant added and must be accounted for in experimental design. Therefore, some laboratory personnel may find it easier to mimic plant conditions using jar tests rather than trying to overcome residual oxidant in the water.
- ***Your test water needs to be free of most cyanobacterial cells*.** These procedures are NOT designed to account for cell lysis (i.e., breaking open the cells and releasing additional cyanotoxins into solution), therefore test water should be filtered through a glass-fiber filter or other appropriate media to remove intact cells (specifically 1.2-µm pore size suggested) if not already filtered from treatment processes.
- ***Your test water must have measureable concentrations of cyanotoxins present normally with at least 10 or 20 times the method detection limit*.** This is important because it will impact the decision of whether or not you need to spike cyanotoxins into your test water or not. If there is not a sufficient concentration present, you may need to add additional cyanotoxins from a stock solution to achieve the desired initial concentration (e.g., the expected worst-case concentration that can occur during an

event, or some other anticipated concentration for an event). While cyanotoxins have been measured in source waters at greater than 20,000 µg/L, most raw water concentrations are less than 1000 µg/L.

2.4 **Use a composite sample as the starting solution when possible.**

- If you are conducting multiple decay tests, collect the entire volume of water needed into a large container or carboy, and use that as the source for each subsequent test.
- If this step is skipped (e.g., if you are collecting multiple jars from a running sample tap), you will need to measure the starting concentration for each separate jar test rather than simply measuring the concentration of cyanotoxin in the large-volume container.

2.5 **Maintain an oxidant-free control solution during testing.**

- One sample from the composite container should be collected and maintained without any oxidant added for the duration of the longest test period.
- Measure the final concentration of the oxidant-free control solution at the end of the test to determine if there may be some change in cyanotoxin concentration that is not due to the oxidant being added to the other jars.

2.6 **The selection of analytical methods (e.g., ELISA or LC/MS-MS) may impact results.**

- The current EPA guidance recommends the use of enzyme-linked immunosorbent assay (ELISA) test kits for microcystins and cylindrospermopsin.
- However, it is not fully understood how well those test kits will measure the oxidation (removal) of the cyanotoxins. On the other hand, liquid chromatography with tandem mass spectrometry (LC/MS-MS) will provide more accurate quantitation of the specific cyanotoxins (e.g., MC-LR, MC-RR, etc.) and its subsequent removal, but may not match ELISA test results. Therefore, it is recommended that the utility select whichever method will be used to make decisions regarding public notification as the default test method for the procedures documented in this memo.

## 3. Preparation of Standardized Stock Solutions and Dilutions

3.1 **Chlorine**

- ***Health and Safety Note –*** *Hypochlorite solutions are toxic and hazardous. Hypochlorite may cause skin corrosion and eye damage if it accidentally touches skin or eyes. Every precaution should be taken to avoid release of sodium hypochlorite or chlorine gas into the environment. Additionally, correct personal protective equipment (including but not limited to protective gloves, clothing, and eye/face protection) shall be worn. If sodium hypochlorite splashes into eyes, rinse cautiously with water for several minutes. Do not <u>ever</u> wear contact lenses when working with sodium hypochlorite (as chemicals may get caught between the contact lens and the*

*eye). Work with sodium hypochlorite should be performed in a fume hood with adequate ventilation or lab personnel should be equipped with respirators.*

- Create a standard chlorine solution by diluting commercially available sodium hypochlorite (or an aliquot from the bulk hypochlorite tanks on-site) to a target concentration between 100 and 1000 mg/L (i.e., 0.01% to 0.1%, preferably about 100 times the estimated chlorine demand) and store refrigerated in a brown bottle.
- Alternatively, Standard Methods 2350B can be used to create a stock solution from chlorine gas (not recommended for most labs).
- Standardize the chlorine solution by using one of the titration methods described in Standard Methods 2350B or 4500-Cl (Chlorine Residual).
- The chlorine stock solution should be stored in the dark in a refrigerator and a fresh solution can be stored for up to a year but should be re-standardized weekly.

### 3.2 Chloramine (monochloramine)

- ***Health and Safety Note*** *– When preparing monochloramine for use in testing, caution should be taken with regards to the method of chlorine addition and the handling of the ammonia and chlorine stock solutions.*
- ***Option 1: Creation of a preformed monochloramine (MCA) stock solution.***
    - The monochloramine stock solution can be prepared from the stock sodium hypochlorite (NaOCl) solution from Section 3.1 and ammonium chloride ($NH_4Cl$) at a molar ratio of 1.00:1.05 mol:mol (or a mass ratio of NaOCl: $NH_4Cl$ = 0.755 mg:mg). A slight excess of ammonium can be used to assure that no residual free chlorine is present which could lead to inaccurate results for MCA oxidation due to the presence of the generally more reaction free chlorine species.
    - Recommendations for the best pH to prepare the MCA stock solution is at pH 9 but can range from approximately 8.3 to 10 or higher (e.g., Lee, Westerhoff, Yang, and Shang, 2007, Water Research, 41, 2097-3102; Chang and Blatchley, 1999, ES&T, 33, 2218-2223).
    - The presence of a slight excess of ammonium in solution can be confirmed using either the HACH Nitrogen, Free Ammonia, and Chloramine (Mono) Indophenol Method #10200 using chemicals obtained from the Hach Company (Loveland, CO, USA), and/or by using an ammonium selective electrode (e.g., Orion 9512 Ammonia probe, Thermo-Electron Corporation, Waltham, MA).
    - This solution should be made fresh daily and disposed of down the drain at the end of the day.
- ***Option 2: In-situ monochloramine (MCA) creation.***
    - As an alternative to preformed monochloramine, monochloramine may instead be formed *in situ*.
    - It is assumed that the chlorine stock solution (hypochlorite) described in Section 3.1 will be used to create monochloramine in the sample itself (NOT as a stock solution of monochloramine).

- When preparing monochloramine in solution *in situ*, add the ammonia to the test solution first, followed by chlorine.
- Monochloramine can be made in the test solution using a commercially-available stock ammonia solution and the stock hypochlorite solution. To do this, a source of ammonia (ammonium hydroxide or ammonium chloride) needs to be added to the test solution as 4 parts of ammonia by mass of $NH_3$ to every one part of chlorine by mass as $Cl_2$.
- Use the following equation to calculate the volume (V) of stock ammonia standard needed to spike into the sample water to achieve the ammonia concentration (C) that will provide the 4:1 ratio with the chlorine that will be added later:

$$V_{Stock\ Standard} = \frac{C_{Desired\ in\ Water} \times V_{Sample\ Water}}{C_{Stock\ Standard}}$$

- This same equation should be used to calculate the amount of hypochlorite stock that will be added to the solution after the ammonia.
- This solution cannot be stored and is intended to be made fresh for each experiment.

### 3.3 Ozone (Based on Standard Method 2350 D)

- ***Health and Safety Note –*** *Laboratory personnel should not use an ozone generator until they have fully read and understood the safe operating procedures, including methods for quenching residual ozone gas prior to release to the environment. Ozone is a very reactive gas and it will quickly corrode most metals and damage most plastics. Ozone generators need to be set up within a laboratory fume hood or glove box or proper respirators need to be worn by lab personnel working with ozone. Eye protection and gloves must be worn when handling chemicals. A fire-resistant lab coat must be worn in addition to long pants and closed-toe shoes. Ozone can irritate the eyes and respiratory system, and will cause headaches.*
- Create a standard ozone solution by pouring 800 mL of ozone-demand free water in a 1-L, water-cooled jacketed flask or a 1-L bottle in an ice bath.
- Next either:
  - Bubble ozone through the water for about 30 minutes in the fume hood while stirring at room temperature for a 10 to 20 mg/L ozone concentration, or
  - bubble the ozone through the water for about 30 minutes in an ice bath in the fume hood while stirring to allow the ozone stock solution to come to equilibrium with the gas phase at a stock solution concentration of about 20 to 40 mg/L (depending on gas phase concentration).
- Standardize the ozone solution by using the indigo method described in Standard Method 4500-$O_3$ B for ozone residual measurement (or another approved method).

- The ozone solution is intended for immediate use (within minutes of standardization) and should not be stored. (Note: Recommended continuous bubbling of the ozone gas through the stock solution will maintain a constant ozone stock concentration.) Unused solution should be quenched with sodium thiosulfate, sodium bisulfite, or potassium iodide and disposed of down the drain in a fume hood. Do not pour unused ozone solution into an un-ventilated sink.

### 3.5 Chlorine Dioxide

- ***Health and Safety Note –*** *Chlorine dioxide, and the chemicals used to produce it are hazardous chemicals. Chlorine dioxide is an oxidizer, corrosive and an acute toxin. Swallowing can result in nausea, vomiting, diarrhea, abdominal pain and gastrointestinal burns. Chlorine dioxide is also corrosive to eyes and skin. Contact can result in permanent injury. Inhalation of chlorine dioxide may also cause respiratory irritation. Personal protective equipment, including gloves (nitrile recommended), eye protection, and flame resistant lab coats must be worn. It is also required that any work conducted with chlorine dioxide be completed within a fume hood with proper ventilation and grounded electrical lines and equipment.*
- ***Option 1 (Recommended)***
  - Purchase a "storage stable" chlorine dioxide solution such as CDG 3000 and then standardize using Standard Method 4500-$ClO_2$.
  - The "storage stable" solution can be stored for up to 6 months but should be re-standardized weekly.
- ***Option 2***
  - Create a standard chlorine dioxide solution and standardize by Standard Method 4500-$ClO_2$-C
  - The laboratory-made solution should be made daily and not be stored for future use. Unused solution should be quenched with sodium thiosulfate or sodium bisulfite and disposed of down the drain in a fume hood. Do not pour unused chlorine dioxide solution into an un-ventilated sink.

### 3.6 Permanganate

- ***Health and Safety Note –*** *Potassium permanganate is a strong oxidant and can react violently with a number of different compounds. As such, caution should be exercised whenever working with this oxidizing agent. Ensure that potassium permanganate does not mix with either hydrochloric acid (generates toxic chlorine gas) or concentrated sulfuric acid (explosive reaction). Dermal contact with permanganate may cause skin staining. Correct personal protective equipment, including safety glasses, gloves, lab coat, long pants and closed-toe shoes are required. Potassium permanganate is sensitive to light and should be stored in a brown/amber glass bottle.*
- Prepare a strong stock solution and the test stock solution using reagent grade solid potassium permanganate.
  - ***Strong Stock Solution*** **-** Place 5.0 grams potassium permanganate ($KMnO_4$) in a 500-mL volumetric flask with distilled water and mix until all crystals have dissolved.

- ***Test Stock Solution*** **-** Use a volumetric pipette or other precise pipetting device to transfer 1.0-mL strong stock solution in a 100 mL volumetric flask and fill to the line with distilled water.
- Each 10 mL of the test stock solution added to a 1000 mL sample equals 1 mg/L.

## 4. Cyanotoxin Oxidation by Chlorine, Ozone, Chlorine Dioxide, Preformed Monochloramine or Permanganate

4.1 Refer to the Special Considerations section prior to beginning testing in this section.

4.2 Oxidation testing should be conducted in duplicate samples at least in 20-25% of samples to establish precision and reproducibility.

4.3 No recommendations are being provided for the appropriate dose of oxidant to use or for the appropriate time to hold the sample prior to collection and analysis. Each site will have specific chemical usage patterns and target C·T values (mg min/L) which will need to be applied to these testing procedures.

4.4 Collect water to be used for testing, either from bench-top jar tests (Note: Procedures not presented in this document) or from water collected from within the treatment plant or source, and store in a container with enough volume to accommodate all of the testing that will be completed.

- If the source water does not have the cyanotoxin of interest present, use a commercially-available stock standard (generally available at 10 µg/mL in water) to spike into the water. (IMPORTANT: Cyanotoxin standards are toxic by definition, and must only be handled by trained personnel using proper procedures and protocols.)
- Use the following equation to calculate the volume (V) of stock standard needed to spike into the sample water to achieve the desired concentration (C, recommending somewhere between 100 µg/L and 1000 µg/L):

$$V_{Stock\ Standard} = \frac{C_{Desired\ in\ Water} \times V_{Sample\ Water}}{C_{Stock\ Standard}}$$

4.5 **Always use clean glassware to avoid cross-contaminating blanks, controls, and test solutions.**

- All glassware should be thoroughly cleaned prior to use. Older glassware should not be used.
- Any glassware that is to come into contact with oxidant should be preoxidized prior to use to remove residual oxidant demand by filling the glassware with the oxidant solution, letting stand for 30 minutes, and then rinsing the glassware three times with pure laboratory water.
- For each oxidant dosage and contact time, collect 250 mL or 500 mL of test solution with the cyanotoxin of interest present in a beaker or flask and set aside as the control with no oxidant to be added (label the vessel as “Control”).
- Likewise, for QA/QC, place an identical volume of laboratory grade water into a beaker or flask, label the vessel as “Blank”, and treat the same way as the control.

- Place an identical volume of test solution ("Sample") in the same type of vessel on a stir plate with moderate mixing energy.

4.6 Use the above equation to calculate the volume of chlorine, ozone, preformed monochloramine, chlorine dioxide, or permanganate stock solution to add to the test water. Using a volumetric pipette or equivalent precise measuring device, dose the appropriate volume of oxidant stock solution into the beaker or flask of test solution on the stir plate and begin timing using a standard stopwatch.

4.7 **Oxidation Testing**

- It is helpful to pre-label all of the laboratory sample vials/bottles with the appropriate information (e.g., sample type/name, oxidant type and amount added, holding time, date, staff initials).
- Both Option 1 and Option 2 (below) can be repeated at multiple starting oxidant concentrations. Plan to double, triple, quadruple, etc., the volume of solutions, standards, glassware, and sample bottles needed depending on the number of additional oxidant doses desired.
- ***Option 1. Single contact time oxidation test, with single oxidant dose:***
    - In the case where a single holding time is desired, allow the test solution plus oxidant to mix on a stir plate under continuous mixing for the desired amount of time (e.g., 1 minute, 5 minutes, 30 minutes, or 1 hour).
    - For holding times of longer than 30 minutes, it is recommended that the test be conducted in a closed jar.
    - Once the desired holding time has been reached, quench the sample with an appropriate quenching agent. (Note: Discuss with the analytical laboratory which agents may be appropriate and not interfere with the cyanotoxin analysis. Sodium thiosulfate will generally work to quench all of the oxidants in this section).
    - Once quenched, fill the sample container provided by the analytical laboratory, label with the appropriate information (e.g., sample type/name, oxidant type and amount added, holding time, date, staff initials) and ship or transfer the sample according to the instructions provided by the laboratory.
    - Add the same amount of quenching agent to the control and blank solutions and repeat the same instructions for labeling and shipping the samples.
- ***Option 2. Multiple contact time oxidation tests:***
    - In the case where multiple holding times are desired for the same initial oxidant dose, the same procedures from Option 1 can be followed with the exception of the addition of the quenching agent.
    - Prior to starting the test, ensure all laboratory-provided sample containers are pre-dosed with the appropriate quenching agent.
    - Proceed with the oxidation addition and timing of the test solution until the first holding time is reached.

- Once the desired time for the first sample is reached, pour the required volume of test solution into the sample container provided by the laboratory with the quenching agent already in the container.
- Close the sample container and mix gently 3 to 4 times.
- Return the test solution to the stir plate or counter (in a closed vessel) and repeat when the next holding time is reached.
- Once all samples are collected, ship or transfer the samples according to the instructions provided by the laboratory.
- Similarly, pour the blank into the laboratory-provided sample container with quenching agent and repeat for the control solution.

## 5. Cyanotoxin Oxidation by Monochloramine formed *In Situ*

5.1 Refer to the Section 2 (Special Considerations) prior to beginning testing is this section.

5.2 Oxidation testing should be conducted with duplicate samples in at least 20-25 percent of samples.

5.3 No recommendations are being provided for the appropriate dose of oxidant to use or for the appropriate time to hold the sample prior to collection and analysis. Each site will have specific chemical usage patterns and target C·T values (mg min/L) which will need to be applied to these testing procedures.

5.4 Refer to Section 3.3 for monochloramine stock solution procedures.

- Depending on the method selected, use the following equation to calculate the volume (V) of stock chloramine standard into the test solution. This will either be performed with the monochloramine stock or with ammonia and hypochlorite added separately, depending on which option was selected.

$$V_{Stock\ Standard} = \frac{C_{Desired\ in\ Water} \times V_{Sample\ Water}}{C_{Stock\ Standard}}$$

5.5 Collect water to be used for testing, either from bench-top jar tests (procedures not presented in this document) or from water collected from within the treatment plant or source and store in a container with enough volume to accommodate all of the testing that will be completed.

- If the source water does not have the cyanotoxin of interest present, use a commercially-available stock standard (generally available at 10 µg/mL in water) to spike into the water.
- Use the equation above to calculate the volume (V) of stock standard needed to spike into the sample water to achieve the desired concentration (C; e.g., between 100 µg/L and 1000 µg/L).

5.6 **Always use clean glassware to avoid cross-contaminating blanks, controls, and test solutions.**

- All glassware should be thoroughly cleaned prior to use. Older glassware should not be used.

- Any glassware that is to come into contact with oxidant should be preoxidized prior to use to remove residual oxidant demand by filling the glassware with the oxidant solution, letting stand for 30 minutes, and then rinsing the glassware three times with pure laboratory water.
- For each oxidant dosage and contact time, collect 250 mL or 500 mL of test solution with the cyanotoxin of interest present in a beaker or flask and set aside as the control with no oxidant to be added (label the vessel as "Control").
- Likewise place an identical volume of laboratory grade water into a beaker or flask, label the vessel as "Blank", and treat the same way as the control.
- Place an identical volume of test solution ("Sample") in the same type of vessel on a stir plate with moderate mixing energy.

5.7 Use the dilution equation from the previous page to calculate the volume of ammonia and chlorine stock solutions or the monochloramine stock solution (depending on the method selected) to add to the test water.

- Using a volumetric pipette or equivalent precise measuring device, dose the appropriate volume of ammonia stock solution into the beaker or flask of test solution on the stir plate and allows to mix for at least 30 seconds.
- Then, using a volumetric pipette or equivalent precise measuring device, dose the appropriate volume of hypochlorite stock solution into the beaker or flask of test solution on the stir plate and immediately begin timing using a standard stopwatch.

5.8 **Oxidation Testing**

- Both Option 1 and Option 2 (below) can be repeated at multiple starting oxidant concentrations. Plan to double, triple, quadruple, etc. the volume of solutions, standards, glassware, and sample bottles needed depending on the number of additional oxidant doses desired.
- ***Option 1. Single contact time oxidation test***:
    - In the case where a single holding time is desired, allow the test solution plus oxidant to mix on a stir plate for the desired amount of time (e.g., 1 minute, 5 minutes, 30 minutes, 1 hour).
    - For holding times of longer than 30 minutes, it is recommended that the test be conducted in a closed jar; mixing of the solution can be stopped after 2 – 3 minutes (though continuous mixing is preferred).
    - Once the desired holding time has been reached, quench the sample with an appropriate quenching agent (Note: Discuss with the analytical laboratory which agents may be appropriate and not interfere with the cyanotoxin analysis; sodium thiosulfate will generally work to quench all of the oxidants in this section).
    - Once quenched, fill the sample container provided by the analytical laboratory, label with the appropriate information (sample type/name, oxidant type and amount added, holding time, date, staff initials) and ship or transfer the sample according to the instructions provided by the laboratory.

- Add the same amount of quenching agent to the control and blank solutions and repeat the same instructions for labeling and shipping the samples.

- ***Option 2. Multiple contact time oxidation tests:***
  - In the case where multiple holding times are desired for the same initial oxidant dose, the same procedures from Option 1 can be followed with the exception of the addition of the quenching agent.
  - It is helpful to pre-label all of the laboratory sample vials/bottles with the appropriate information (e.g., sample type/name, oxidant type and amount added, holding time, date, staff initials).
  - Prior to starting the test, ensure all laboratory-provided sample containers are pre-dosed with the appropriate quenching agent. Proceed with the oxidation addition and timing of the test solution until the first holding time is reached.
  - Once the desired time for the first sample is reached, pour the required volume of test solution into the sample container provided by the laboratory with the quenching agent already in the container.
  - Close the container and mix gently 3 to 4 times. Return to the test solution to the stir plate or counter (in a closed vessel) and repeat when the next holding time is reached.
  - Once all samples are collected, ship or transfer the samples according to the instructions provided by the laboratory.
  - Similarly, pour the blank into the laboratory-provided sample container with quenching agent and repeat for the control solution.

## 6. Analysis and Conclusions

6.1 Record data and information related to the oxidation experiments in a laboratory notebook. A suggested method for organizing data is shown in the table on the last page of this document.

6.2 Upon receipt of the analytical results of the cyanotoxin concentration measurements, record those data in the notebook as well.

6.3 Confer with management and operations staff to discuss the following:

- ***Oxidant Dose:*** Was there an oxidant dose that provided the required level of cyanotoxin removal for a given set of water quality conditions?
- ***Oxidation time (or CT):*** Was there a particular holding time (or CT) that provided the required level of cyanotoxin removal for a given set of water quality conditions?
- ***Unintended consequences:*** Would the oxidation conditions that provide optimal cyanotoxin removal potential interfere with disinfection requirements and/or DBP compliance?

6.4 Based on discussions and evaluation of options and unintended consequences, list recommendations on the report form and in the laboratory notebook.

6.5 Place a copy of the test report and recommendations in the test binder stored in the laboratory and provide a copy to the operations manager and all other required personnel.

6.5 This information can be part of a cyanobacterial bloom action plan that should complement other source water management, withdrawal, and treatment modifications.

## 7. Quality Control

7.1 Stock solutions should be calibrated and/or disposed of according to instructions listed in each relevant oxidant protocol section.

7.2 Any working dilutions of cyanotoxins should be made fresh daily and disposed of in accordance with local regulations or law (potentially, simply down the drain).

7.3 Raw water (or test water) should be collected and used within 24 hours, preferably on the same day of collection. However, allow the solution to reach room temperature or the desired testing temperature (using a water bath) prior to commencing oxidation experiments.

7.4 Dispose of remaining test solutions in accordance with local regulations or law (potentially, simply down the drain).

7.5 Wash all glassware immediately after testing is complete. Do not allow chemicals to dry onto glass surfaces.

7.6 Work on clean laboratory surfaces with fresh laboratory bench paper or bench mats.

7.7 Use proper personal protective equipment; use clean gloves to avoid cross-contaminating equipment, surfaces, and glassware.

## 8. Sources of Additional Information

8.1 AWWA Standard Methods for the Examination of Water and Wastewater, 20th Edition.

8.2 Phipps and Bird Jar Testing Procedures.

8.3 The UC Center for Laboratory Safety.

8.4 Lee, Westerhoff, Yang, and Shang, 2007, Water Research, 41, 2097-3102.

8.5 Chang and Blatchley, 1999, Environmental Science and Technology, 33, 2218-2223.

**Utility Name:**
**Today's Date:**
**Time:**
**Analyst's Name:**

**Cyanotoxin Analytical Lab:**
**Cyanotoxin Analysis Method:**

| | |
|---|---|
| **Water Source:** | **Oxidant Type:** |
| **Date Collected:** | **Stock Concentration:** |
| **Working Temperature (°C):** | **Stock Calibration Date:** |
| **Starting pH:** | **Volume Stock Used (mL):** |
| **Spike Concentration (µg/L):** | **Dilution Volume (mL):** |
| **Cyanotoxin(s) Spiked:** | **Quenching Agent Used:** |

| **Sample Name** | **Holding Time (min)** | **Oxidant Dose (mg/L)** | **Measured Cyanotoxin Concentration (µg/L)** | **% Removal ($C/C_0$ x 100%)** |
|---|---|---|---|---|
| Lab Water Blank<br>(Raw Water Blank, optional)<br>Control, $C_0$ (Spike; No oxidant)<br>Sample A<br>Sample B<br>Sample C<br>…<br>…<br>… | | | | |

Management Notes and Recommendations: