Cyanotoxins Management Plan



Highlands Mutual Water Company

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## Executive Summary

Highlands Mutual Water Company, with the support of the State of California and the United States Environmental Protection Agency (USEPA), has developed this Cyanotoxins Management Plan (CMP) to prepare for and mitigate risks from harmful algal blooms (HABs) and cyanotoxins occurring in Clear Lake in order to protect public drinking water from cyanotoxin contamination. This document provides steps and documents activities to prepare for and identify a potential HAB occurrence, make treatment and operational adjustments to remove cyanotoxins from drinking water, provide timely information and (as appropriate) an advisory to the water system’s customers and document information about occurrences of HABs so that information can be used to minimize the effect of HABs on the water system in the future. This plan also contains possible future activities the utility could engage in to mitigate the risks from HABs and cyanotoxins, such as long-term source water protection activities.

The steps and activities outlined in this CMP include:

Step 1: Assess Source Water

Step 2: Preparation, Monitoring for Early Warning Signs and Immediate Actions

Step 3: Raw Water Cyanotoxin Monitoring and Treatment Adjustments

Step 4: Finished Water Cyanotoxin Monitoring and Treatment Adjustments

Step 5: Continued Finished Water Cyanotoxin Monitoring, Treatment Adjustments and Public Communication

In addition to the five steps above, long-term activities are also discussed to enhance the utility’s ability to prevent, mitigate and manage the risks from cyanotoxin occurrence in source and finished waters.

## Highlands Mutual Water Company Overview

The Highlands Mutual Water Company is located on the shores of Clear Lake, California and serves 6,169 people through approximately 2,300 service connections. Water is pumped from Clear Lake through an intake located at a depth of approximately 15 to 20 feet. The water is treated using powdered activated carbon (PAC), permanganate, ozone, conventional filtration, granular activated carbon (GAC) filtration and chlorine. A description of the water system’s treatment process is provided below, as well as a schematic of the treatment system. Besides concerns related to HABs, the water system contends with taste and odor problems stemming from geosmin and MIB production by some HABs. The water system is also challenged by Disinfection Byproducts (DBPs) formed when the organically-rich water from the lake is chlorinated.

### Source Water

The only source of water is Clear Lake. The water system draws water from the lake with two vertical turbine pumps, one on line and one on standby. Each pump can produce 2,000 gallons per minute and has a static length of 17 feet from the base of the motor. The pumps can be lowered with a limited adjustment of one to three feet. Limitations with the source are primarily related to water quality, with silts up to 200 nephelometric turbidity units (NTU) in the winter and large algal blooms in late spring and summer. Both of these problems can cause a large percentage of in-service time loss on the dual media filters and GAC filters, as well as adversely affect water quality.

### Treatment Process

Highlands Mutual Water Company provides the following treatment on the water from Clear Lake ([Figure 1](#HFigure1) displays a diagram of the treatment train):

* Lake Water Pumps: Raw water is drawn from Clear Lake and pumped by one of two large vertical turbine pumps located on Beakbane Island to the Hillcrest Avenue Treatment Plant for processing. The water system can produce 2.5 million gallons per day through the treatment plant. During the summer months PAC is added just after the raw water pumps for both taste and odor as well as cyanotoxin control.
* Ozone Gas Treatment and Potassium Permanganate Addition: The primary use of ozone gas is to help control taste and odor problems in the lake water that occur during the warm summer months. Operators are concerned about cell lysis and typically restrict operations to minimize floating material. There is discussion of making post-ozone available between the dual media filters and the GAC filters to minimize cell lysis. Ozone is not used in storage or distribution systems as it does not hold an adequate residual.
* Clarification: Water flows through each ozone contact chamber into parallel upflow clarifiers for the next stage of treatment, with aluminum chloro-hydrate (ACH) added as a coagulant before the water enters the clarifiers. The two clarifiers settle out about 90 percent of the turbidity from the water. Sludge accumulates on the weekends and is a potential source of cyanotoxins. The operators are working on automating the screw press to run during the weekends to process the sludge continually.
* Dual Media Filters: Water is taken from the top of each clarifier and pumped through dual media filters consisting of anthracite coal and filter sand. The two dual media filters are operated in parallel, with one filter per clarifier.
* GAC Filters: Water from the dual media filters flows into two sets of two GAC filters that are operated in series. Their main function is further removal and control of taste and odor compounds and total organic carbon (TOC). The first set of GAC filters contains GAC made from coconut shells, the second set contains GAC made from lignite. The filter media is changed every three to five years.
* Chlorine Disinfection: The final stage of the water treatment process involves the injection of chlorine for disinfection. Sodium hypochlorite is injected before water enters the clearwell, in order for adequate disinfection CT to be achieved. The pH of water can vary from 7.7 to 9.7 depending on the size of the algal bloom and type of algae (or cyanobacteria) in the lake. The water system does not have a disinfection profile or benchmark. The plant is considered equivalent to conventional treatment and is credited with 2.5 log reduction of *Giardia lamblia* cysts. Therefore, the plant is required to achieve 0.5 log inactivation of *Giardia lamblia* cysts through disinfection. The plant typically operates to achieve a detectable residual in the distribution system between 1.6 and 1.8 mg/L chlorine residual at the entrance to the distribution system.

The water system recycles its backwash water within a month, not to exceed 10% of instantaneous production with a target of 2 NTU and filters water to waste before putting its filters back on line after a backwash. The water system pre-chlorinates only for operational reasons. Pre-chlorination is not necessary in order for the water system to achieve its required disinfection CT. When filter problems start occurring due to algae and cyanobacteria in the raw water, the water system begins to pre-chlorinate because adding chlorine seems to help with filter performance. However, pre-chlorination may cause cell lysing and needs to be used with caution. Most of the time, however, the water system does not pre-chlorinate in order to prevent total trihalomethanes and haloacetic acid formation in the clarifiers.

### Routine Water Quality Monitoring

Raw water is monitored by the water system for alkalinity, TOC, pH and turbidity at the raw water pump discharge. Some samples are sent to a certified lab and the results are returned within 7 to 10 working days. Turbidity and pH results that are measured in the plant are available immediately. A scientist from the Elem Colony Tribe (Karola Kennedy) tests the lake water for microcystins biweekly using ELISA (Enzyme-Linked Immunosorbent Assay) method in the lab. Beginning in the summer of 2016, the water system will use test strips during alternate weeks to ensure that source water microcystins analysis takes place on a weekly basis throughout the bloom season (May through October).

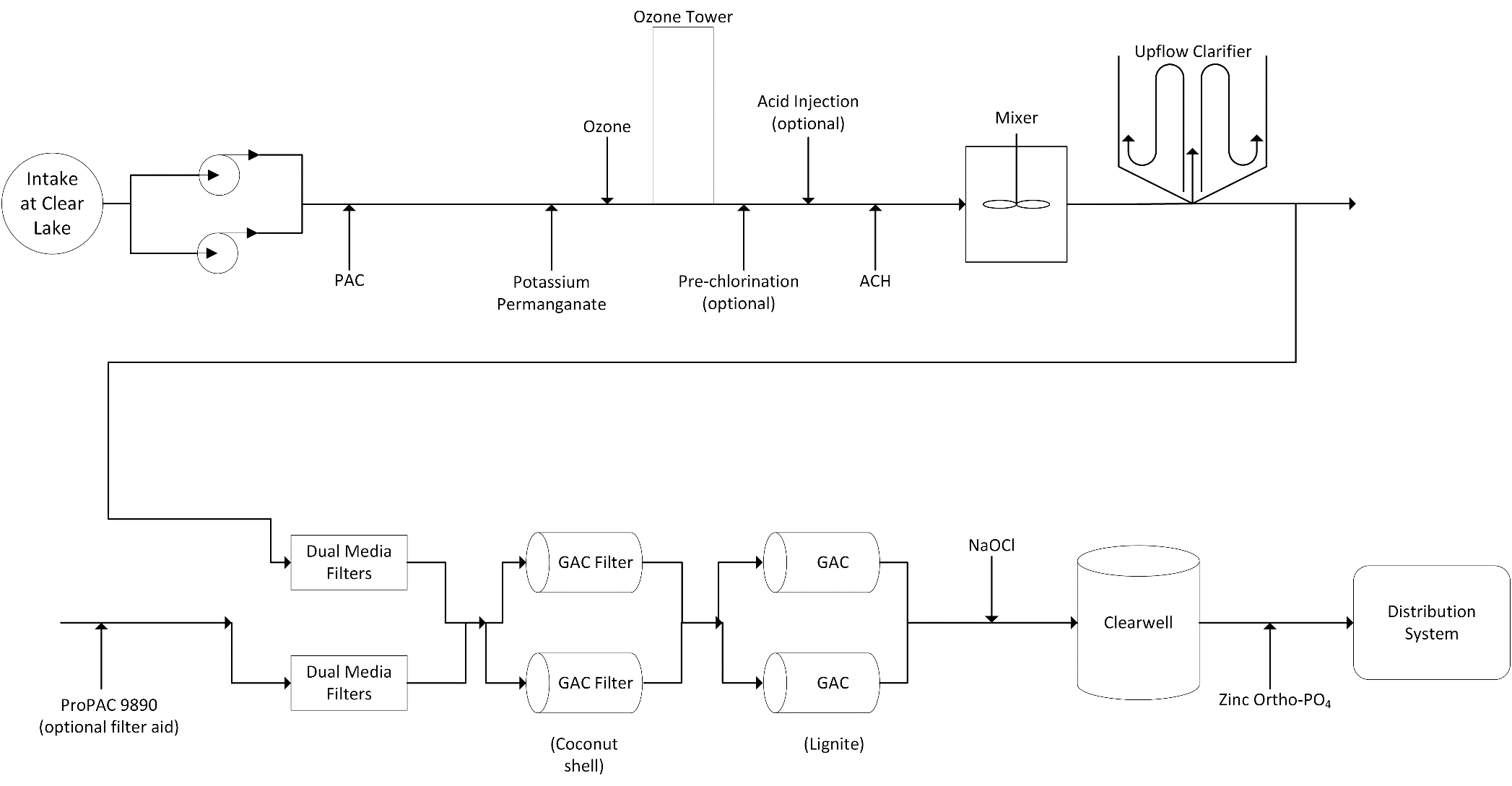
Table 1. Raw Water Monitoring

| **Parameter** | **Location** | **Frequency** | **Who Collects Sample?** | **Who Does Analysis?** |
| --- | --- | --- | --- | --- |
| Alkalinity | Raw Water Pump Discharge | Monthly | Highlands MWC | Lab |
| TOC | Monthly | Operator | Lab |
| pH | Pre-Ozone Tower | Daily | Operator | Plant |
| Turbidity | Pre-Ozone Tower | 15-min | SCADA | Plant |
| Microcystins | Raw Water Pump Discharge | Bi-Weekly | Operator | Test Strip |
| Microcystins | Clear Lake | Bi-Weekly | Elem Colony Tribe | Lab |

## Cyanotoxin Management Plan

Highlands Mutual Water Company and the State of California, with the support of the United States Environmental Protection Agency has developed a Cyanotoxins Management Plan (CMP) detailed in the steps below. This CMP provides an action plan to prepare for and mitigate risks from harmful algal blooms (HABs) and cyanotoxins occurring in Clear Lake in order to protect public drinking water from cyanotoxin contamination. The plan includes immediate steps discussing monitoring and treatment should HABs and cyanotoxins occur as well as long-term steps the system can engage in to protect source waters and to fully evaluate treatment capabilities. A detailed flowchart of the CMP can be found in [Appendix A](#HAppA).

Figure 1. Schematic Diagram of the Treatment System



# Step 1: Assess Source Water

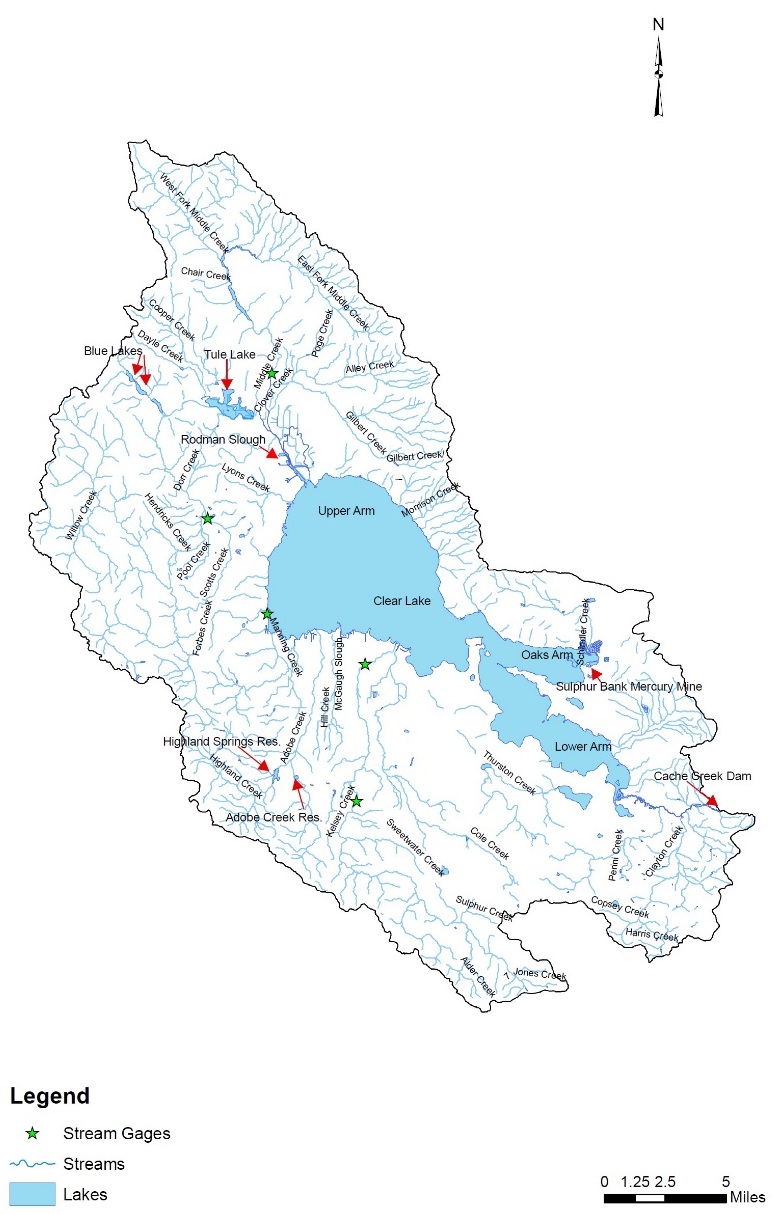
## 1.1 Identify Source Water Protection Areas

A source water assessment is an evaluation of a drinking water source to determine the susceptibility to contamination. The first step of any source water assessment is to delineate (map) the areas of water and land that drain into the water supply that are to be evaluated for contaminant sources. This is called the Source Water Protection Area (State Water Resources Control Board, 1990).

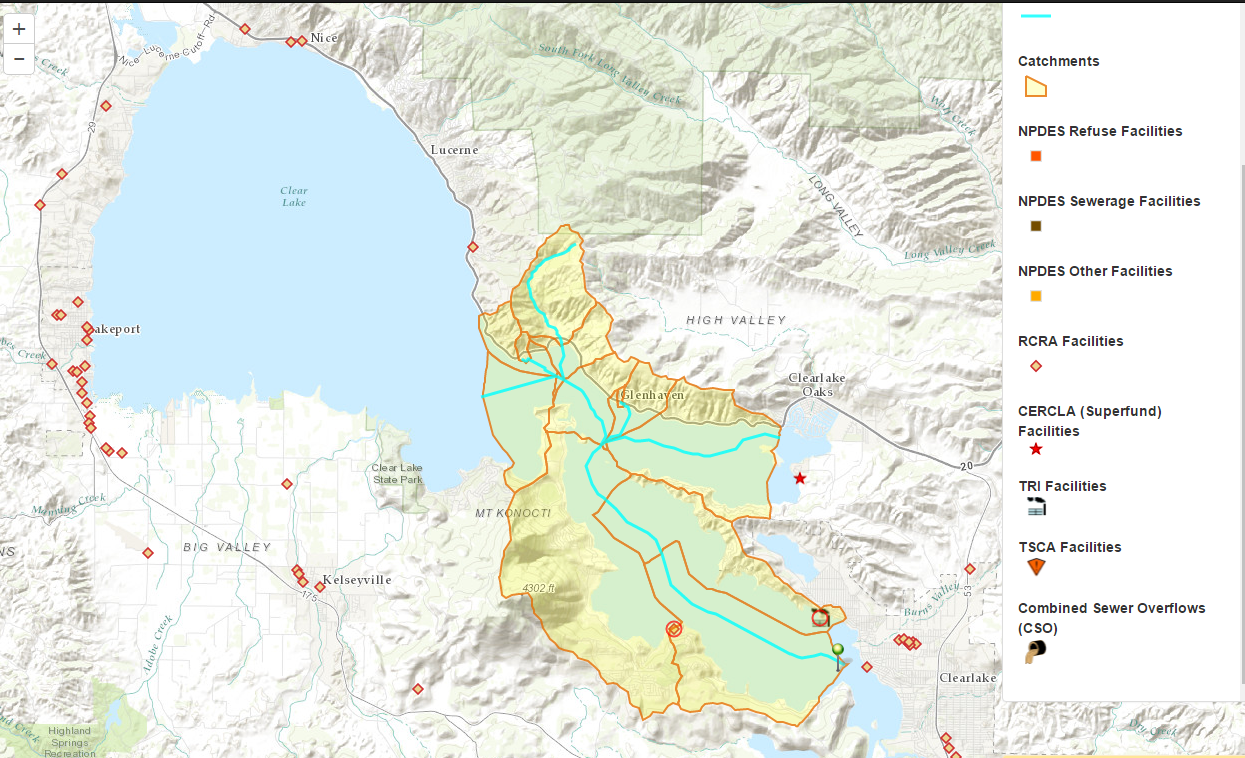
Highlands Mutual Water Company delineated its Clear Lake Source Water Protection Area using the following methods and resources:

1. **2012 Clear Lake Watershed Sanitary Survey**: The water provider referenced the techniques and survey areas described within the 2012 Clear Lake Watershed Sanitary Survey, a report completed by Clear Lake drinking water utilities which summarizes the state of the Clear Lake watershed and the effect of watershed activities on source water quality. The 2012 Sanitary Survey area encompasses the Clear Lake watershed area that drains to Clear Lake and Cache Creek upstream of the Cache Creek Dam. This coincides with the US Geological Survey (USGS) National Hydrography Dataset HUC10 watershed (determined using the USGS National Map). The Survey delineates “Protection Zones” within the survey area based on radial distance around each water system intake. Higher priority Protection Zones represent area in 2,500-foot proximity to a specific intake (Forsgren Associates, Inc., 2012).
2. **Clear Lake Integrated Watershed Management Plan**: Highlands also reviewed the Clear Lake Integrated Watershed Management Plan, which was produced for the County of Clear Lake in 2013. The project boundary for this management plan encompasses the HUC10 watershed area, which corresponds with the survey area of the 2012 Sanitary Survey (Lake County, 2010).
3. **Drinking Water Mapping Application to Protect Source Waters (DWMAPS):** DWMAPS is an online mapping tool for assessing source waters and source water protection planning. The “Find Potential Sources of Contamination” toolbar in DWMAPS maps catchment areas upstream of an intake, and displays point sources of contamination located within the catchment areas.

DWMAPS was used to search a fixed distance of 10 miles upstream of its intake (distance coincides with length of Lower Arm). However, given the size of the Clear Lake watershed, the water system used a two-tiered system for delineating its source water protection area: the Clear Lake watershed (defined as the HUC10 watershed area) is a source water protection area (Tier 1—see [Map 1](#HMap1) below), but the zone of higher concern is the area immediately upstream (15 miles) of the intake (Tier II—delineated by DWMAPS, see [Map 2](#HMap2) below). The purpose of these zones is to define portions of the watershed where activities have a higher risk of contaminating the source water and where waterbody and watershed conditions should be more closely evaluated. The water system can focus a thorough evaluation within Tier II, the zone of higher concern. This tiered approach is consistent with the methods utilized in the 2012 Sanitary Survey and described in the Drinking Water Source Assessment and Protection Program document from the California State Water Resources Control Board Division of Drinking Water (formerly the California Department of Public Health Drinking Water Program).



Map 1. Tier I Source Water Protection Area: USGS HUC 10 watershed 1802011603. Map extracted from Clear Lake Integrated Watershed Management Plan: <http://www.co.lake.ca.us/Assets/WaterResources/Clear+Lake+Integrated+Watershed+Management+Plan/11+Plate+4+Clear+Lake+Watershed+Surface+Water+Resources.pdf>)



Map 2. Tier II Source Water Protection Area: Catchments 10 miles upstream of intake in Clear Lake, CA (Source: DWMAPS)

## 1.2 Create an Inventory of HABs Risk Factors

Clear Lake experiences a variety of HABs risk factors described in detail below and summarized in a table following the discussion ([Table 4](#HTable4)). Risk factors can include source water characteristics, water quality parameters, point source pollution, nonpoint source pollution and climate and weather characteristics.

### 1.2.1 Source Water Characteristics

Clear Lake is the only source of water for Highlands Mutual Water Company. Clear Lake is located in the Coast Range of California, 80 miles north of San Francisco (38.95°N, 122.63°W), and is the largest natural lake entirely within California. The lake is 18 miles long, has 68 square miles (43,790 acres) of surface area, 100 miles of shoreline, and an average depth of 26 feet. Clear Lake is a shallow, warm, nutrient-rich system with three distinct arms: Upper Arm (28,000 acres), Oaks Arm (2,800 acres) and Lower Arm (8,200 acres). The lake is comparatively shallow with an average depth of 23.3 feet in the Upper Arm, 36.4 feet in the Oaks Arm, and 33.8 feet in the Lower Arm, where Highlands Mutual Water Company intake is located. The westerly winds push surface water from the Upper Arm into the Oaks Arm and Lower Arm, setting up a return flow of bottom water (Lake County, 2010; Richerson et al., 1994).

Clear Lake’s water level has been manipulated by operation of the Cache Creek Dam since 1914. The Yolo County Flood Control and Water Conservation District must regulate the depth of the lake (determined by the Rumsey gauge) between 0-7.56 feet, under non-flood conditions and 0-9.00 feet under flood conditions. Clear Lake can drop from 3 - 6.5 feet in any given summer and fluctuates 5.5 feet each year on average (Lake County, 2010).

The lake is generally well-mixed with stable temperature stratification between surface and deeper waters only occurring for short periods during the hot summer periods when wind patterns are calm (Winder et al. 2010); maximum surface water temperatures in July and August are typically near 75°F (24°C) and average 40 °F (4.5°C) in the winter months (Richerson et al., 1994; Lake County, 2010). Prevailing winds and the lake’s modest depth facilitate vertical mixing. Numerous gas vents and subsurface springs help induce mixing in the lake as well (Lake County, 2010). Residence time of the lake (the time it would take to empty at the average annual outflow) is about 4.5 years, which is relatively short (Richerson et al., 1994).

### Land Use

Some land uses, including urban and agricultural uses, have been associated with sources of nutrients (nitrogen and phosphorus) that can contribute to higher occurrences of HABs and cyanotoxins. The water provider referred to the 2012 Sanitary Survey, the Clear Lake Integrated Watershed Management Plan, the Total Maximum Daily Load (TMDL) for Nutrients in Clear Lake, and DWMAPS to gather information on land cover and land use for the Clear Lake watershed.

The Clear Lake watershed (HUC10) includes an area of approximately 450 square miles (282,138 acres) (USGS National Map Viewer). Much of the watershed consists of undeveloped lands. This includes the Bureau of Land Management Cow Management Recreation Area and the U.S. Forest Service Mendocino National Forest. Together, public lands make up 24% of the Clear Lake watershed (Lake County, 2010). Irrigated and non-irrigated agriculture account for the largest use of developed lands (Forsgren Associates, Inc., 2012). Agricultural and urban land uses in the Clear Lake watershed are primarily located in the lowland areas adjacent to the lake. The largest municipality is the town of Clearlake (population 13,100), which is located at the end of the Lower Arm. Urban areas cover less than 2.5% of the total watershed land area (Sanitary Survey, 2012). [Table 2](#HTable2) below describes land use in Clear Lake’s watershed (Tetra Tech, 2004).

Table 2. Land Use in Clear Lake’s Watershed

| **Land Use Category** | **Total Land Area (Acres)** | **Percent Total** |
| --- | --- | --- |
| Bare rock/sand/clay | 966 | 0.34 |
| Deciduous forest  Deciduous shrub land | 110,029  48, 390 | 39.00  17.15 |
| Emergent herbaceous wetlands  Grassland/herbaceous | 90  65,824 | 0.03  23.33 |
| High intensity commercial/industrial/transportation  High intensity residential  Low intensity residential  Mixed forest | 646  2  4,794  23,053 | 0.23  <0.01  1.70  8.17 |
| Open Water (not including Clear Lake)  Other grasses (urban, recreational)  Pasture/hay | 1,491  141  9, 683 | 0.53  0.05  3.43 |
| Planted/cultivated (orchards, vineyards, groves)  Quarries/strip mines/gravel pits  Row crops | 16, 583  58  6 | 5.86  0.02  <0.01 |
| Small grains  Transitional  Woody wetlands | 1  429  1 | <0.01  0.15  <0.01 |

Source: Total Maximum Daily Load (TMDL) for Nutrients in Clear Lake, Tetra Tech, 2004

### 1.2.2 Water Quality Parameters

### Historical Cyanobacteria and Cyanotoxin Events in Source Water

The next step in assessing source water vulnerability to HABs and cyanotoxins is to review source water quality parameters, notably past occurrence of cyanobacteria and cyanotoxin events within the source water protection area. Historical occurrence of HABs, cyanobacterial cell occurrence and cyanotoxins in a source water protection area is a good indication that a surface water system is vulnerable to future occurrences of HABs, and may provide evidence of the potential timing, location and intensity of these blooms.

### Presence of Toxic Cyanobacteria in Clear Lake

Clear Lake is a productive lake where the presence of suspended algae and aquatic vegetation occurs naturally. Several major research efforts, the Clear Lake Algal Research Unit (1970-1990), the Clean Lakes Report (1994), and the Central Valley Regional Water Quality Control Board reports (2011, 2012) indicate recurrent seasonal blooms of toxic species of blue-green algae (cyanobacteria) in Clear Lake. These blooms form noxious, scum-forming mats that can cause considerable degradation of the lakeshore and surface environment of Clear Lake (Forsgren Associates, Inc., 2012). The magnitude and composition of the blooms varies substantially from year to year (Richerson et al., 1994). Algae problems are most serious at the eastern end of the Lake (where Highlands Mutual Water Company intake is located) where prevailing winds can push floating algae into huge rotting mats that produce strong odors. Blooms typically occur in Clear Lake from April to November.

The research indicates that Clear Lake has been seriously impaired by seasonal blooms of scum-forming cyanobacteria for much of the past century, but that blooms became more of a problem in the second half of the 20th century (1970-1990) (Richerson et al., 1994) (Mioni and Kudela, 2011). During this period, researchers found that several genera of cyanobacteria dominated the scum forming algae in Clear Lake: *Anabaena, Aphanizomenon* and *Microcystis. Microcystis* blooms were documented in both the Oaks Arm and Lower Arm, with the largest blooms occurring in the Lower Arm in 1991. *Aphanizomenon* showed similar trends and was the dominant scum former up to 1985, when it suddenly became much less abundant. *Anabaena* was never responsible for blooms on the scale of *Microcystis* and *Aphanizomenon* in any arm but was a common component of the midsummer scums throughout the record (Mioni and Kudela, 2011). *Microcystis* and *Anabaena* were noted to occur from late summer to early fall. *Aphanizomenon* were noted to reach a peak in late spring and early summer, and late fall, but have also been observed blooming in winter months (Lake County, 2010). *Lyngbya* was not observed until 1984 and the first large bloom event dominated by this mat-forming filamentous cyanobacteria was not observed until 2009 (Mioni and Kudela, 2011).

The Clear Lake Nutrient Total Maximum Daily Load Update (2012) notes that blooms occurred with less frequency from the early 1990s until 2004, but that massive algal blooms and nuisance conditions were present in several years since 2004, most notably in the summer and fall months of 2009, 2010 and 2011 (Central Valley Regional Water Quality Control Board, 2012).

Research in 2010 and 2011 by University of California - Santa Cruz researcher Dr. Cecile Mioni for the Central Valley Regional Water Quality Control Board identified presence of *Mycrocystis aeruginosa, Aphanizomenon flos-aquae, Anabaena lemmermanii, Synechococcus,* all of which are capable of producing cyanotoxins. *Aphanizomenon* was noted to have occurred primarily in early summer, *Mycrosystis* in early and late summer, *Anabaena* throughout the summer and *Lyngbya* throughout the summer. Within the Lower Arm, *Lyngbya cincinnati* and *Anabaena spiroides* were the two dominant cyanobacterial species (Mioni et al., 2012).

The Big Valley Rancheria Band of Pomo Indians and the Elem Indian Colony have collaborated since fall 2014 to monitor cyanobacteria and cyanotoxin occurrence in Clear Lake. The Elem Indian Colony is monitoring drinking water sources in the Lower Arm for six of the seventeen surface water treatment plants around the lake.

The State of California Water Quality Monitoring Council maintains a [webmap](http://www.mywaterquality.ca.gov/habs/where/freshwater_events.html) which displays locations of HAB incidents that have been voluntary reported including a bloom reported in June 2016.

### Presence of Cyanotoxins in Clear Lake

Fish kills and neurological disorders in eight domestic cats were reported in the Clear Lake area in 1989 following an exceptionally dense cyanobacterial bloom (*Microcystis*, *Anabaena* and *Aphanizomenon*) (Mioni and Kudela, 2011). These events prompted a special toxicological and epidemiological studies program by the California Department of Health Services (called the California Department of Public Health after 2007). Microcystin toxins were the only toxins examined and were detected over the course of this special study (Mioni and Kudela, 2011). Although recurrent cyanobacterial blooms have plagued Clear Lake for the past century, this is the only toxicology survey available prior to the 2010 and 2011 research by University of California - Santa Cruz under Cecile Mioni and Rapheal Kudela. This 2010 study found low levels of microcystins, below the recreational advisory limit of 8 µg/L for the State of California, however in several samples the microcystins concentrations exceeded the WHO advisory limit for drinking water (1 µg/L) and USEPA’s Health Advisory levels for total microcystins in drinking water. Anatoxin-a was detected in two of the samples collected in the lower arm in August 2010. At both collection sites, anatoxin-a was well below the suggested action levels for recreational use (50 µg/L). Saxitoxins were below the detection limit or not present in the lake surface water (using Abraxis ELISA kits only) (Mioni and Kudela, 2011).

### Nutrients

Clear Lake has been assessed for attainment of surface water quality standards under Section 305(b) of the Clean Water Act (CWA). Based on this assessment, Clear Lake was listed as an impaired waterbody due to nutrients (phosphorus and nitrogen) under Section 303(d) of the CWA. A nutrient TMDL was developed by the Central Valley Regional Water Quality Control Board in 2006 in response to the impairment listing. The TMDL defines targets for nutrient loading to Clear Lake and outlines strategies for reducing nutrient loading, specifically of phosphorous, derived from sediment erosion, which will ultimately reduce algal growth (Central Valley Regional Water Quality Control Board, 2012).

The TMDL notes that there may be other factors, in addition to nutrients, affecting cyanobacterial blooms, including concentrations of sulfate, iron availability and ecological dynamics.

For additional information on Clear Lake water quality (such as nutrient concentrations, temperature, iron, turbidity, chlorophyll-*a*, phycocyanin) and other factors controlling algal blooms, see the [Clear Lake historical Data Analysis, Clear Lake Report](http://celake.ucanr.edu/files/132447.pdf); Central Valley Water Quality Control Board, [Control of Nutrients in Clear Lake report](http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/clear_lake_nutrients/cl_nut_staff_rpt_apr_draft.pdf); [Harmful cyanobacteria blooms and their toxins in Clear Lake and the Sacramento-San Joaquin Delta (California) report](http://www.co.lake.ca.us/Assets/WaterResources/Algae/2011+Cyanobacteria+Report.pdf); [Causes and Control of Algal Blooms in Clear Lake](http://www.co.lake.ca.us/Assets/WaterResources/Algae/Clean+Lakes+Report$!2c+1994.pdf); and the [Clear Lake Integrated Watershed Management Plan](http://www.co.lake.ca.us/Government/Directory/Water_Resources/watershedplan/CLIWMP_Docs.htm). For additional water quality information, see the [CA State Water Resources Control Board](http://www.waterboards.ca.gov/resources/data_databases/) website.

### 1.2.3 Point Sources of Pollution

The water system created an inventory of possible precursors to HABs within its source water protection area using the USEPA DWMAPS tool ([Map 1](#HMap1)). Phosphorus and nitrogen are drivers of algal and cyanobacterial growth in lakes and reservoirs. Sources of phosphorus and nitrogen can include discharge of domestic and industrial wastewater, septic systems and runoff from agricultural and urban lands.

A query of the USEPA DWMAPS tool as well as the USEPA Discharge Monitoring Report for nitrogen and phosphorus loading indicates that there are no National Pollutant Discharge Elimination System (NPDES) permitted wastewater dischargers or Combined Sewer Overflows within 10 miles upstream of Clear Lake. However, the Clear Lake TMDL set specific phosphorous load limits for several point source dischargers within the Clear Lake watershed. Point source dischargers, Lake County Storm Water Permittees (Lake County, Cities of Clearlake and Lakeport), and the California Department of Transportation (Caltrans), were given a waste load allocation of 2,000 kg and 100 kg per year, respectively. This is a small portion of the combined total point and nonpoint source phosphorous load allocation of 87,100 kg per year. Caltrans maintains a statewide Stormwater Program, which identifies how Caltrans will comply with the provisions of its NPDES permit and its Municipal Separate Storm Sewer System permit (MS4) (California State Water Resources Control Board, 2012). [Table 3](#HTable3) below describes Clear Lake annual phosphorus loading.

Table 3. Clear Lake Annual Phosphorus Loading

| **Source** | **Source Type** | **Load Allocation (kg/yr)** |
| --- | --- | --- |
| Lake County Stormwater Permittees | Waste Load (point source) | 2,000 |
| California Department of Transportation (Caltrans) | Waste Load (point source) | 100 |
| United States Forest Service, Bureau of Land Management, Lake County, irrigated agricultural dischargers | Load (nonpoints source) | 85,000 |
|  | Total | 87,100 |

Source: Clear Lake Nutrient Total Maximum Daily Load Control Program update, Central Valley Regional Water Quality Control Board, 2012.

### 1.2.4 Nonpoint Sources of Pollution

As mentioned previously, The Clean Lakes Report (1994), the Clear Lake Algal Research Unit (1970-1990), and the State Water Resources Control Board report (2011, 2012) indicate that that excess phosphorus is a primary driver of nuisance cyanobacterial blooms in Clear Lake. The 2006 amendment to the TMDL for Nutrients in Clear Lake (2006) notes that most sources of phosphorus to Clear Lake are sediment driven, and that the following activities are the most likely sources of excess phosphorus to Clear Lake (Central Valley Regional Water Quality Control Board, 2006):

* Erosion from paved and unpaved roads
* Urban stormwater runoff
* Instream channel erosion (accelerated by removal of riparian vegetation)
* Construction
* Gravel Mining
* Wildfires and controlled burns
* Timber harvesting
* Livestock grazing
* Dredging and filling
* Failing septic systems

The Clear Lake TMDL allocates 85,000 kg per year (of a total 87,100 kg per year) of phosphorous—a 40% reduction in average annual phosphorous loading by 2017-- to nonpoint source dischargers, which include the Bureau of Land Management, the United States Department of Agriculture’s Forest Service, irrigated agricultural dischargers and Lake County. While agriculture is one of the major land use and economic activities in the Clear Lake watershed, phosphorous fertilizer is applied at such low rates that it is unlikely to be a significant phosphorous source to Clear Lake (Lake County, 2010). However, past agricultural development and associated wetland reclamation projects (total loss of approximately 79% of wetland area) removed much of the lake’s natural filtration system for removing eroded sediments from the upper watershed and contributed to streambank channelization and erosion above natural levels. Road development and modifications (1,500 miles of unpaved road in Clear Lake watershed) is also considered a significant source of fine sediments and phosphorous (Lake County, 2010).

A summary of phosphorous reducing activities by TMDL regulated entities can be found at the [California Central Valley Regional Water Quality Control Board website](http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/clear_lake_nutrients/cl_nut_2013feb07_trifold_handout.pdf).

### 1.2.5 Climate and Weather

Clear Lake is located within Lake County, CA, which is typified by warm, dry summers and moist, cool winters. Clear Lake is prone to periodic drought, at times severe. Recent notable droughts occurred from 1976-1977 and 1986-1992 (Lake County, 2010). During winter months (December-February), average high temperatures are in the 50s (Fahrenheit) and average lows are in the 30s (Fahrenheit) (Lake County, 2010). Temperatures below freezing can occur throughout the watershed, although they are less common adjacent to Clear Lake. Summer average high temperatures at lake level are in the low 90s (Fahrenheit), but can reach over 100°F. On most nights during the summer, there is significant cooling (by 30-40°F) (Lake County, 2010).

Most precipitation in the Clear Lake watershed occurs as rainfall with minor amounts of snow at the highest elevations. Prevailing winds blow from the west and northwest during most of the year and bring winter Pacific storms to the watershed during the rainy season (September-May). Average annual precipitation at lake level is about 30 inches, with most precipitation occurring between December and March (Lake County, 2010). In wet years, or during strong storm events, stream-flows tend to be extremely “flashy”; that is, they are subject to very rapid rises and fluctuation in flow (Forsgren Associates, Inc., 2012).

Table 4. Summary of Clear Lake HABs Risk Factors

| HABS Risk Factor | Measure | Data Source | Risk Ranking |
| --- | --- | --- | --- |
|  | *Source Water Characteristics* |  |  |
| **Source Water Type**  **Mean Surface Water**  **Temperature (F)**  **Water Body Depth (ft)**  **Vertical Stratification**  **Residence Time** | Lake/Reservoir  Lower Arm ~ 75°F (24°C) (July-August)  Lower Arm Mean: 33.8 ft; intake depth 15-20 ft  Well-mixed; few occurrences of sustained stratification  4.5 years, relatively short | USGS NHDPlus  [CA Department of Water Resources](http://www.co.lake.ca.us/Assets/WaterResources/Clear+Lake/Clear+Lake+Average+Water+Temperature.pdf)  [Clear Lake Report (2010)](http://celake.ucanr.edu/files/132447.pdf)  Lake County  Richerson et al., 1994 | High  High  High  Low  Low |
|  | *Water Quality Parameters* |  |  |
| **Cyanobacteria Occurrence**  **Cyanotoxin Levels (µ/L)**  **Nutrient Enrichment: CWA 303(d) Impairment Status** | *Microcystis, Anabaena, Aphanizomenon, Lyngbya*  Lower Arm: .52 anatoxin-a (2010)  Impaired, Nutrients (1986); Nutrient TMDL (2006) | Horne, 1975; Richerson et al., 1994; Mioni and Kudela, 2011  Mioni and Kudela, 2011  Clear Lake Nutrient TMDL (2006) | High  High  Medium |
|  | *Point Sources* |  |  |
| **Point Sources of Nutrients** | Lake County Stormwater Permittees; California Department of Transportation (Caltrans): 2,100 kg phosphorous TMDL discharge limit | Clear Lake Nutrient TMDL (2006) | Low |
|  | *Nonpoint Sources* |  |  |
| **Nonpoint sources of nutrients** | Bureau of Land Management, the United States Department of Agriculture’s Forest Service, irrigated agricultural dischargers, and Lake County; 85,000 kg TMDL discharge limit | Clear Lake Nutrient TMDL (2006) | High |
|  | *Climate and Weather Conditions* |  |  |
| **Ambient temp F°, May- September;**  **Drought Risk** | Range: High Ave 92°, Low Ave 45° | National Oceanic and Atmospheric Administration (NOAA) National Weather Service  U.S. Drought Monitor | High  Med |

## 1.3 Assess Vulnerability

A weight of evidence approach was used to characterize the vulnerability of Clear Lake to occurrence of cyanobacterial blooms and cyanotoxin occurrence. Evidence includes all of the discussion in this section and results of the HAB risk factor inventory including: historical occurrence of cyanobacteria and cyanotoxins, source water characteristics, external point and nonpoint sources of nutrients and other known factors controlling algal productivity, Clear Lake water quality parameters and impairment status, and climate and weather information. Clear Lake is vulnerable to occurrence of HABs, typically occurring between April and November. Highlands Mutual Water Company intends to take additional steps (moving to [Step 2](#HStep2)) to prepare for cyanobacterial blooms and cyanotoxin occurrence described in the following steps.

# Step 2: Preparation, Monitoring for Early Warning Signs and Immediate Actions

## 2.1 Preparation

Since Highlands Mutual Water Company determined that its source water is vulnerable to cyanobacterial blooms, the next step is to consider how to prepare for blooms and cyanotoxin occurrence. Preparation includes preparing to monitor raw and finished waters such as ordering necessary laboratory equipment or establishing contracts with outside laboratories, preparing for treatment adjustments and establishing communication plans including communication with other water utilities with the same source water.

### Prepare Staff and Equipment for Monitoring

The water system will carry out the following activities in order to be prepared for the monitoring steps described in this plan:

1. Train operators on algae and cyanobacteria identification, counting and identification of gas vacuoles.
2. Train operators on how to use microcystins test strips.
   * Establish sampling procedures
   * Establish testing procedures
   * Establish quality assurance procedures
   * Document all sampling, testing and quality assurance procedures
3. Enter into an agreement with a laboratory that can reliably and promptly analyze samples using the Adda-specific ELISA test.
4. Establish a procedure for submitting Adda-specific ELISA samples to the identified laboratory.
   * Document all sampling, testing and quality assurance procedures for lab samples
   * Have coolers, chain of custody forms and shipping labels on site and ready for use
   * Ensure that the appropriate bottles (glass or polyethylene terephthalate glycol, minimum 100 mL volume) are on site for the Adda-specific ELISA sampling in the event that such sampling is required
   * Also have sodium thiosulfate available for quenching disinfected samples as soon as they are collected

## Prepare for Treatment Adjustments

Highlands Mutual Water Company will carry out the following activities in order to be more prepared to treat its source water during a HAB:

1. Ensure all required materials for cyanotoxin treatment are available.
2. Consider either:
   * Moving the ozone application point from before the upflow clarifier to after the mixed media filters (but before the GAC) to reduce the risk of toxin release, or
   * Introducing the option of two ozone injection points: the existing one before the clarifier and a new one between the media filters and the GAC.
3. Begin tracking chlorine CT daily using a spreadsheet or computer program. This will allow the water system to know how much chlorine CT is in place when different microcystins concentrations are measured in the raw water (and how much microcystins protection is being provided through chlorination).
4. Begin testing for ammonia in the raw water, upflow clarifier effluent (before 2nd chlorine injection point), and before the clear well (before the 3rd chlorine injection point).
5. Measure free and total chlorine to see if the free chlorine is at least 80 percent of the total chlorine; if not, the water system may be making chloramines. While this is not directly a cyanotoxins concern, it may be related to the presence of cyanobacterial activity in the treatment plant (e.g., the upflow clarifier).
6. Evaluate the toxin removal capacity of the current treatment process using jar tests spiked with varying levels of toxins.

### Communications

### Establish Communication Plan with other Source Water Users

Several water utilities draw their water from the lake; a few also have wells. A large tributary enters the lake at the northern end, and water systems located in this area often experience algal problems prior to the water systems farther south. Highlands Mutual Water Company draws water from the southeastern part of the lake. As a result, communication among the lake’s various water system operators provides an important warning of impending HABs. During the summer months, Highlands Mutual Water Company operators are in constant communication with the other two water systems with which they are interconnected. They share information related to chemical doses, physical problems with the water, and how the water is reacting to sedimentation and filtration. The system’s operators are also in contact with water companies at the northern end of the lake to try to get early warning of water quality problems they may soon face.

### Communication with Stakeholders

The water system will carry out the following activities in order to be more prepared for the communications steps described in this plan:

1. Develop a stakeholders list ([Appendix B](#HAppB)) and reevaluate on a recurring basis to maintain an up-to-date list.
2. Add language to the water system’s consumer confidence report asking home and clinic dialysis customers to contact the water system so they can be added to the stakeholders list and receive early warning about potential microcystins contamination of the finished water. Explanations of when stakeholders will be contacted about a HAB are provided in [Step 5](#HStep5) of this plan.
3. Prepare a public health advisory template that is available and ready for use if necessary. Also prepare another notice that would be issued to lift an existing public health advisory. Explanations of when a public health advisory will be issued or lifted are provided in [Step 5](#HStep5) of this plan. (See [Appendix C](#HAppC) for draft template)
4. Prepare and have available a “Frequently Asked Questions” outreach document for water consumers and have copies available in the office where customers pay their bills and/or include it with their bills. (See example in USEPA’s [Cyanotoxin Risk Communication Toolbox](https://www.epa.gov/ground-water-and-drinking-water/cyanotoxins-drinking-waterr)).

## 2.2 Monitoring the Early Warning Signs

Based on historical bloom occurrence in Clear Lake, Highlands Mutual Water Company begins looking for signs of blooms in April. Signs of bloom occurrence include early indicators such as drinking water treatment operational challenges. Identified in this section are early warning signs that operators can look for during the system’s normal operation, routine water quality monitoring, as well as follow-up activities if any of the early warning signs are observed.

### Early Indicators of a Cyanobacterial Bloom

The water system operators have identified several early warning signs that a cyanobacterial bloom is likely to occur in the very near future (or has begun to occur). The following early warning signs are a combination of observations of conditions in the lake itself and in the treatment plant:

* Visual observations show cyanobacteria mats forming (depending on cyanobacteria or algae type)
* Algae rising to the surface or gathering on the tules (bulrushes) during daily visual inspections of the lake at the intake from April through November
* Algae buildup on equipment in the plant
* Sludge coming off the screw press begins looking green
* Raw water pH shows a strong, sharper daily swing, or raw water pH >9 (before PAC addition)
* Raw water pH swings from day to night
* Raw water pH probe’s sample cell has algal growth and an odor
* Coagulant dose increases
* Filter performance degrades
* Backwashing of the carbon filters is needed twice as often
* Strainers for the pump control plug with algae or cyanobacteria and cause operational challenges
* Individual filter effluent turbidity is slow to respond or stabilize at the beginning of a filter run
* Increased differential pressure across filter beds
* Odor in the raw water and odor coming off the lake strengthens
* Chlorine demand increases
* Other water utilities call and report problems, especially the water utilities in the northern part of the lake
* Weekly routine raw water monitoring results show presence of cyanotoxins

In addition, the state will soon be providing the water system with an on-line fluorometer. While it has not been installed yet, it is anticipated that fluorometric readings at the source will show increased chlorophyll-*a* or phycocyanin. Once the fluorometer has been installed and readings have been observed, the water system will see if HAB levels of concern can be identified.

## 2.3 Immediate Actions if a Bloom is Suspected

### Monitoring Actions in Response to Early Warning Signs

If there are any early indicators of a cyanobacterial bloom, the following actions will be immediately taken:

1. Immediately collect a source water sample at the intake before PAC is added.

Ideally, collect samples that represent several depths or collect a composite sample that represents the entire water column. The sample should be collected before PAC addition because it will be inspected through the microscope and there should be no interference.

Identify the algae present in the sample using water company microscope:

* Refer to the algae keys and any catalog of previous algae identified in Clear Lake.
* Check with Elem Colony Tribe to confirm algae and/or cyanobacteria identifications and utilize Greenwater Laboratories if still unable to identify.

1. If cyanobacteria are identified, also check whether gas vacuoles are present.

When gas vacuoles are present, the cyanobacteria are more difficult to remove in the upflow clarifier.

1. Move to [Step 3](#HStep3).

### Communication Actions in Response to Early Warning Signs

Call neighboring water utilities to see if they are having problems and to let them know what Highlands Mutual Water Company has found.

### Source Water Mitigation Actions in Response to Early Warning Signs

Lake County treats Clear Lake with the aquatic herbicide Sonar for weed control two or three times per year. No other in-lake mitigation measures are currently taken.

# Step 3: Raw Water Cyanotoxin Monitoring and Treatment Adjustments

If a cyanobacterial bloom is identified during [Step 2](#HStep2), the Highlands Mutual Water Company plans to begin monitoring water quality in multiple locations, adjusting treatment and communicating with utilities that are using the same source water.

## Monitoring if Cyanobacteria are Identified or Suspected

Analyze samples for microcystins as soon as possible using test strips using the following steps:

1. Test a raw water sample as soon as possible for microcystins using a test strip. The sample should be collected before PAC has been added. If the raw water sample collected has ≥0.3 µg/L microcystins using the test strip go to #2(a) and 2(b).
2. (a) Use test strips to measure microcystins at both of the following locations:

* Source water before PAC addition (again, 2nd sample)
* Entry point to the distribution system (EPTDS)

AND

(b) Use test strips to sample at each of the following locations, following the flow of water until microcystins are not detected:

* After permanganate is added
* After the clarifier
* After the media filters
* After the first set of GAC filters (the “new” GAC filters)
* After the second set of GAC filters (the “old” GAC filters)
* The mixture of sampling water and filter-to-waste water

1. Track weekly routine sampling results, discussed under routine water quality monitoring in the overview, and follow # 2a-b if a weekly raw water sample has ≥0.3 µg/L microcystins

It is important to monitor the performance of individual unit processes across the treatment train to help understand what is happening in the treatment train or identify possible treatment breakdown. If either monitoring determined necessary by a suspected bloom or routine monitoring results indicate the presence of cyanotoxins in the raw water, additional confirmation sampling (#2 above) will take place before Highland Mutual Water Company continues to [Step 4](#HStep4). Follow-up sampling will take place within 24 hours after the first detection of cyanotoxins in the raw water collected. If the follow-up sampling continues to show cyanotoxins in the raw water, Highlands Mutual Water Company continues to [Step 4](#_Step_4:_Finished).

## Operational Adjustments Based on Raw Water Cyanotoxin Measurements

Highlands Mutual Water Company does not wait for finished water cyanotoxin detections to adjust treatment, but rather begins making treatment adjustments when cyanobacteria are detected in the raw water. The following are treatment adjustments that will be made when cyanobacteria or cyanotoxins are identified in the raw water. Please note that these proposed treatment adjustments are empirical and have not been comprehensively evaluated or supported by engineering studies.

If potential toxin-producing cyanobacteria are identified in the source water sample(s) then:

* Increase PAC dose. Conduct jar tests to help determine the optimal PAC dose
* Lower ozone dose if:
  + Algae appear to be in growth phase
  + *Lyngbya* or *Anabaena* are found in the samples
* Turn off ozone if:
  + Gas vacuoles are seen on cyanobacteria in microscope samples
  + Green foam comes out of the ozone vents or off-gas destruct unit
* Begin pre-chlorinating before clarifier because the upflow clarifiers can have difficulty removing cyanobacteria that can regulate their buoyancy with gas vacuoles
* Dose Pro Pac 9890 filter aid at 0.1 mg/L to control trouble from cyanobacteria on the filters
* Increase ACH (coagulant) dose (use jar tests to determine an optimal ACH dose)
* Add small amount of ACH directly onto the clarifiers
* Consider stopping the recycling backwash process or adding PAC to recycle water stream if:
  + The test strip (or routine source water monitoring) detects ≥0.3 µg/L microcystin

## Communications Based on Raw Water Cyanotoxin Measurements

1. Contact the two water utilities with interconnections to alert them of any cyanotoxin results available from sampling the different treatment segments.
2. Contact all water utilities that draw water from the lake to alert them of the raw water cyanotoxin results.

# Step 4: Finished Water Cyanotoxin Monitoring and Treatment Adjustments

Detecting and positively confirming cyanotoxins in the finished water indicates that cyanotoxins have broken through the treatment barriers. Again, it is important to monitor the performance of individual unit processes across the treatment train to help understand what is happening in the treatment train or identify possible treatment breakdown. If cyanotoxins have been detected in the finished water, Highlands Mutual Water Company should continue implementing the treatment strategies described in [Step 3](#HStep3) and carry out the additional testing and treatment adjustments described in this section.

## Finished Water Microcystins Monitoring

If finished water monitoring is determined necessary by [Step 3](#HStep3), take a sample from the EPTDS. If this sample is ≥0.3 µg/L microcystins using the test strip, sample at the following locations as soon as possible:

1. Repeat the monitoring at the EPTDS as soon as possible with a test strip
2. Repeat the monitoring with test strips at the following locations:

* Source water before PAC addition
* After permanganate is added
* After ozone is used
* After the clarifier
* After the media filters
* After the first set of GAC filters (the “new” GAC filters)
* After the second set of GAC filters (the “old” GAC filters)

1. If the repeat sample tests are negative, test water at the EPTDS a third time as soon as possible with a test strip
2. If 2 out of the 3 entry point samples are ≥0.3 µg/L total microcystins using the test strips, lab-based Adda-specific ELISA samples will be collected as soon as possible at the following locations (samples should contain sufficient quenching agent to consume any residual oxidant):

* Raw water before PAC addition
* EPTDS
* Four routine coliform monitoring sites
* Dialysis center

1. Also collect Adda-specific ELISA samples after each of the following treatment steps (samples should contain sufficient quenching agent to consume any residual oxidant):

* After permanganate is added
* After ozone is used
* After the clarifier
* After the media filters
* After the first set of GAC filters (the “new” GAC filters)
* After the second set of GAC filters (the “old” GAC filters)
* The mixture of instrument waste stream and filter-to-waste

1. If any of the Adda-specific ELISA samples in the distribution system conducted by the laboratory are positive (≥0.3 µg/L) go to [Step 5](#HStep5)

## Treatment

In addition to the treatment adjustments listed in [Step 3](#HStep3), Highlands Mutual Water Company will conduct the following additional treatment optimization activities:

1. Increase chlorine dose before clearwell (i.e., second injection point) if test strip monitoring indicates microcystins have made it through the GAC filters
2. Monitor raw water pH closely to ensure proper chemical dosages
3. Use turbidity and UV254 readings to track plant performance for particle and organics removal

## Communications

Highlands Mutual Water Company will carry out the following communications as soon as possible if Adda-specific ELISA results are equal to or exceed the 0.3 µg/L microcystins level:

1. Call the laboratory (Greenwater Laboratories) to let them know samples will be coming for Adda-specific ELISA analysis or EPA Method 544
2. Notify stakeholders that preliminary results show microcystins levels ≥0.3 µg/L while waiting for confirmation samples from the laboratory
3. Fill out the previously prepared public notice template to have it ready should the public notification step be reached in [Step 5](#HStep5) ([Appendix C](#HAppC))

# Step 5: Continued Finished Water Cyanotoxin Monitoring, Treatment Adjustments and Public Communication

[Step 5](#HStep5) contains communication actions, treatment actions and additional monitoring that should be carried out based on the concentrations of cyanotoxins confirmed in the finished water. This fifth step enables Highlands Mutual Water Company to act quickly if cyanotoxins are confirmed in the finished water.

## Continued Finished Water Microcystins Monitoring

If any Adda-specific ELISA or EPA Method 544 results exceed ≥0.3 µg/L microcystins, conduct the following monitoring:

1. Continue monitoring the raw water tap before PAC addition and water from the EPTDS using test strips

* Flush around any distribution system sites that tested positive, measuring the effectiveness of the flushing using test strips

When the test strip results are >0.3 µg/L, conduct the following monitoring:

1. Collect Adda-specific ELISA lab based samples as soon as possible at:

* Raw water sample tap
* EPTDS
* Four routine total coliform monitoring sites
* Dialysis center

1. Also collect Adda-specific ELISA samples at each of the following treatment steps:

* After permanganate is added
* After ozone is used
* After the clarifier
* After the media filters
* After the first set of GAC filters (the “new” GAC filters)
* After the second set of GAC filters (the “old” GAC filters)
* The mixture of sampling water and filter-to-waste

Highlands Mutual Water Company will continue looking for early warning signs ([Step 2](#HStep2)) for cyanotoxins when all Adda-specific ELISA results are below <0.3 µg/L.

## Treatment

If any Adda-specific ELISA Result is at or above 0.3 µg/L Highlands Mutual Water Company will, in addition to the treatment optimization steps identified in earlier steps of this plan, conduct jar testing to optimize PAC and coagulation/flocculation processes and evaluate the condition of the GAC media.

## Communications

Highlands Mutual Water Company will provide the following notifications:

* If the follow-up distribution system confirmation samples or the entry point samples tested with the Adda-specific ELISA lab based method exceeds 0.3 µg/L:
* Notify stakeholders that microcystins levels ≥0.3 µg/L have been confirmed in the finished water.
* Issue public health advisory system-wide (even if the toxin is only found in one distribution system pressure zone).
* If microcystins are detected in raw water samples with the Adda-specific ELISA lab-based method but not detected at the EPTDS or in the distribution system, Highlands Mutual Water Company will:
* Notify stakeholders that microcystins remain a concern in the raw water but microcystins levels ≥0.3 µg/L were not confirmed in the finished water.
* If Adda-specific ELISA results for all distribution samples are below 0.3 µg/L, Highlands Mutual Water Company will:
* Lift the public health advisory if it has been issued.

# Long-Term Activities

Additional long-term activities can be undertaken by Highland Mutual Water Company to better understand treatment effectiveness, develop a cohesive monitoring program, explore monitoring other cyanotoxins of concern in addition to microcystins and engage in additional source water protection activities.

## Treatment Activities

Evaluation of treatment adjustments will require jar testing. The Highlands Mutual Water Company may consider conducting jar tests to determine proper doses of chemicals (such as ozone, ACH and filter aid) or media (PAC) for control of cyanotoxins while achieving other treatment goals (e.g., control of taste and odor, removal of DBP precursors, etc.). In addition, the Highlands Mutual Water Company will need to evaluate the effectiveness of these treatment adjustments based on sampling results and refine these approaches as appropriate.

## Monitoring Activities

Consider establishing a cohesive, routine raw water and in-plant process control sampling and monitoring protocol for HABs. Consider monitoring the distribution of the toxin in the cells of the clarifier sludge to determine percentage of intra- or extra-cellular during onset and/or peak of blooms to assess clarifier rake speed/check if adequate. Also consider monitoring the pre-ozone dosage using microscopy to assess cell condition to determine cell lysis or limit to 2.7 µg/L.

Additionally, consider learning more about cylindrospermopsin and anatoxin-a test strips. If appropriate (based on lake monitoring results and information about the test strips, their cost, detection levels, and accuracy), work them into the cyanotoxins management plan.

## Source Water Protection Management Approaches

* Identify all ongoing monitoring, committees, government programs and other organized watershed management activities taking place related to Clear Lake. For each of these provide activity descriptions, milestone dates, lists of key players and funding sources. Identify ways Clear Lake’s water utilities could become more involved and the benefits to the water utilities of greater involvement. Prioritize which of these may be the most helpful for furthering the specific interests of the water utilities in the watershed.
* The Highlands Mutual Water Company could assist water quality efforts in the watershed by identifying its role in Clear Lake’s Watershed Management Plan, or by working with county and state officials to identify an appropriate role, which may be in the form of an activity such as providing additional water quality monitoring.
* Development of a well-designed network of monitoring sites would help provide greater understanding of the water quality and cyanobacteria/algae dynamics in Clear Lake partnering with other utilities and/or state agencies. A monitoring strategy could be developed that uses targeted sampling to gather as much relevant information as possible. In addition, it would be beneficial to understand the differences among vegetative covers and land uses in terms of nutrient and sediment export. The monitoring strategy should take into account watershed size and consider other aspects of monitoring design in order to effectively determine loadings/impacts to the lake, such as intake location.
* Apply for State Revolving Funds (or other funding sources) to improve source water quality.
* In April 2016, in partnership with the State of California, the utility and interested stakeholders conducted an evaluation of activities the utility could engage in to enhance source water protection. The evaluation determined what additional steps could be taken by the utility to mitigate HAB occurrence. The result of the evaluation was that the utility could include additional activities in the upcoming watershed sanitary survey related to nutrient pollution in source waters. Based on a review of the last (2012) watershed sanitary survey, it was identified that it would also be helpful to address nutrient loading and associated water quality problems in Clear Lake in greater detail in the 2017 Watershed Sanitary Survey.

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Appendix A  
Cyanotoxin Management Flowchart

This is a flowchart depicting the actions to monitor cyanotoxin occurrence and minimize exposure. 

Appendix B  
Contacts and Stakeholder Information

| Agency/Company | | Title | | Contact Name | | | Contact Phone | | Contact Email | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Local/State Organizations | | |  | | |  | |  | |  |
| Lake County | | Public Health Officer | | Karen Tait, M.D. | | |  | |  | |
| Central Valley Water Board | |  | | Holly Grover | | |  | |  | |
| Mendocino District Office, State Drinking Water Field Office Branch, SWRCB | | District Engineer | | Sheri Miller, P.E. | | |  | |  | |
| City of Clearlake | | Foreman | | Chuck Davis | | |  | |  | |
| City of Clearlake | | Public Works Director | | Douglas Herren | | |  | |  | |
| Medical Facilities |  | | | | |  | |  | |  |
| Dialysis Center | |  | | Jim Nalor | | |  | |  | |
| Medical Facilities | |  | | Clearlake St. Helena Hospital | | |  | |  | |
| Medical Facilities | |  | | Meadowood Nursing Center | | |  | |  | |
| Hospitals | |  | | St. Helena | | |  | |  | |
| Hospitals | |  | |  | | |  | |  | |
| Veterinarians | |  | | Clearlake Veterinary Clinic | | |  | |  | |
| Veterinarians | |  | | Doc Jerri’s Animal Hospital of Lake County | | |  | |  | |
| Tribal Communication | | |  | | |  | |  | |  |
| Elem Indian Colony | | Environ-mental Director | | Karola Kennedy | | |  | |  | |
| Big Valley Rancheria Band of Pomo Indians | |  | | Sarah Ryan | | |  | |  | |
| Neighboring Public Water Systems | | | | |  |  | |  | |  |
| Konocti County Water District | |  | | Frank Costner | | |  | |  | |
| Golden State Water Company | |  | | Keith Ahart | | |  | |  | |

Appendix C  
Notifying the Public of Cyanotoxins in their Water

The State of California has provided the following draft template (in English and Spanish) for Highlands Mutual Water Company to use, as appropriate, when issuing a do not drink advisory:

English version:

LETTERHEAD OR INSERT HIGHLANDS WATER COMPANY LOGO

IMPORTANT INFORMATION REGARDING YOUR DRINKING WATER

**Low Levels of Cyanotoxins Found in Treated Drinking Water**

Low levels of [specific cyanotoxin] were found in your treated drinking water. [specific cyanotoxin] is a cyanotoxin. Cyanotoxins are created by bacteria known as cyanobacteria or blue-green algae. Under certain environmental conditions, the cyanobacteria can create harmful algal blooms that can create a health risk if ingested. However, not all ‘blooms’ produce these cyanotoxins. Your treated drinking water was sampled to determine if cyanotoxins were present when a suspected bloom was occurring. The sampling was conducted on [date]. The test results confirmed on [date] showed cyanotoxins are present in your treated drinking water and may present a health risk. As a result, we are changing our treatment operations to lower concentrations of [specific cyanotoxin] as quickly as possible.

**What should I do?**

* Use bottled drinking water for the preparation of baby formula, cooking, and as your source of drinking water for humans and pets until further notice. Boiling water will not remove the cyanotoxins.
* Seek medical treatment immediately if a person, pet, or livestock might have been exposed to cyanotoxins. Common symptoms of exposure to cyanotoxins include: eye irritation, skin rash, mouth ulcers, vomiting, diarrhea, and cold or flu-like symptoms.
* Use this water for showering (avoid swallowing the water), washing dishes, cleaning, laundry, watering gardens, and flushing toilets.

**What is being done?**

We are working hard to correct this problem, and do not expect this problem to last more than [number of days]. We will notify you when the water is acceptable for drinking. More information can be found at: [link].

For questions, please contact: INSERT NAME at [(xxx) xxx-xxxx].

Date Distributed: Month Day, Year

**Spanish version:**

LETTERHEAD OR INSERT HIGHLANDS WATER COMPANY LOGO

INFORMACIÓN IMPORTANTE SOBRE SU AGUA POTABLE

Se Encontraron Nivel Bajos de Cianotoxinas en Agua Potable Tratada

Se encontraron bajos niveles de [specific cyanotoxin] en su agua potable tratada. La/el [specific cyanotoxin] es una cianotoxina. Las cianotoxinas son creadas por bacterias conocidas como cianobacterias o algas verde-azules. Bajo ciertas condiciones ambientales, las cianobacterias pueden crear floraciones de algas nocivas que pueden crear un riesgo para la salud si son ingeridas. Sin embargo, no todas la ‘floraciones’ producen estas cianotoxinas. Se tomaron muestras de su agua potable tratada para determinar si había cianotoxinas presentes en su agua cuando había sospecha de floración. El muestreo se llevó a cabo el [date]. Los resultados de las pruebas confirmados en [date] muestran que hay cianotoxinas presentes en su agua potable tratada y pueden presentar un riesgo para la salud. Como resultado, vamos a cambiar nuestras operaciones de tratamiento para disminuir las concentraciones de [specific cyanotoxin ] tan pronto como sea posible.

**¿Qué debo de hacer?**

        Hasta nuevo aviso, use agua potable embotellada para preparar la fórmula infantil, para cocinar y como fuente de agua potable para los seres humanos y mascotas. Las cianotoxinas no se eliminan hirviendo el agua.

         Busque tratamiento médico inmediatamente si una persona, mascota, o ganado podrían haber estado expuestos a cianotoxinas. Los síntomas comunes de haber estado expuesto a cianotoxinas incluyen: irritación de los ojos, ronchas, úlceras en la boca, vómito, diarrea y síntomas de resfriado o gripe.

         Evitando tragar agua, puede usar esta agua para bañarse, para lavar los trastes, limpiar, lavar la ropa, regar jardines y para el inodoro.

**¿Qué se está haciendo?**

Estamos trabajando diligentemente para corregir este problema y no se espera que éste problema dure más de [number of days]. Nosotros le notificaremos cuando el agua se pueda usar para beber. Puede encontrar más información en: [link].

Para preguntas, puede contactar a: INSERT NAME al [(xxx) xxx-xxxx].