JULY 2022

Quad Cities

ALGAL BLOOM MANAGEMENT AND RESPONSE PLAN

PREPARED BY RH2 ENGINEERING, INC.

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CERTIFICATION

This Algal Bloom Management and Response Plan for the Cities of Richland, West Richland, Kennewick, and Pasco was prepared under the direction of the following professional engineers registered in the State of Washington.

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1 | INTRODUCTION

AUTHORIZATION

The City of Richland (Richland) authorized RH2 Engineering, Inc., (RH2) to prepare this Algal Bloom Management and Response Plan (Plan) for the Quad Cities (Richland, West Richland, Pasco, and Kennewick, hereinafter "Cities") in accordance with the guidance of the Washington State Department of Health's (DOH) 331-654, *Dealing with Cyanobacteria: Time to Make a Plan* (April 2022).

PURPOSE OF MANUAL

This Plan is a living document that will be updated regularly as the understanding of contaminant monitoring and treatment processes change over time. This is a tool for the Cities and will become of little value if not accurately maintained.

Table 1-1 outlines the original completion date of this Plan, as well as future revisions. Each time this Plan is updated, the table and footer should be updated to reflect these changes.

Table 1-1

Plan Revision Log

Revision	Chapters Updated	Month	Year
Original Manual	All	July	2022
Revision No. 1	CHP 3	June	2023
Revision No. 2			
Revision No. 3			
Revision No. 4			
Revision No. 5			

INTRODUCTION

The Columbia River is the Cities main source of supply, and the Cities have a combined six intakes on the river for obtaining source drinking water. In summer 2021, algal blooms on the Columbia River resulted in the detection of anatoxin-a in water samples taken near Richland. As a result, DOH is suggesting the Cities to create a plan for monitoring and responding to an algal bloom event on the Columbia River, specifically the occurrence of anatoxin-a and microcystins. The purpose of this Plan is as follows:

- Introduce the cyanobacteria and cyanotoxins that are currently anticipated to occur in the Columbia River.
- Discuss existing Health Advisory Levels and guidelines.
- Describe the current watershed, intake facilities, and treatment techniques.
- Consider long-term treatment enhancements and capital improvements that may be needed.
- Create a step-by-step plan to follow in the event of an algal bloom/confirmed health advisory exceedance.
- Discuss the source, raw, and finished water monitoring programs.
- Discuss the Cities communication plan for notifying the public in the event of a health advisory warning.
- Describe the long-term efforts to manage algal blooms.

The information in this chapter is based on information found in DOH Guidance 331-654, *Dealing with Cyanobacteria: Time to Make a Plan* (April 15, 2022).

CYANOBACTERIA AND CYANOTOXINS

Per DOH 331-654, cyanobacteria, sometimes called “blue-green algae,” occur in freshwater lakes, ponds, impoundments, rivers, and streams. They are a type of bacteria similar to algae that move vertically in the water column to find sunlight at the surface and nutrients in the deeper layers. Cyanobacteria convert inert atmospheric nitrogen into an organic form that is usable for growth. When the amount of sunlight, temperature, and nutrients are adequate, they reproduce rapidly. This rapid growth creates blooms that can appear as visible scum on the surfaces of lakes and rivers. They also can grow attached to sediments or rocks in rivers and lakes. When attached, these are known as benthic cyanobacteria. Since bacterial growth may not be apparent in visual inspection, water samples must be collected and analyzed for blooms. Blooms typically occur in late summer after nitrogen has been diminished from the water column.

Cyanotoxins are chemical compounds produced by some species of cyanobacteria that pose public health risks if they are found in drinking water. When cyanotoxins are present in high concentrations, they can harm people, animals, and wildlife. Health effects on people can include skin rashes, vomiting, gastroenteritis, headaches, and eye, ear, and throat irritations. Severe symptoms can affect a person’s liver or nervous system.

Anatoxin-a and total microcystins are the two cyanotoxins that are currently of concern in the Cities’ Columbia River water source. Both of these cyanotoxins are introduced in the sections that follow.

Anatoxin-a

Anatoxin-a is a potent neurotoxin (it causes damage to the nervous system) and is the smallest of the cyanotoxins. Anatoxin-a was first detected in the Columbia River in 2021, along with reports of cattle, cat, and dog poisonings. Algal cells retain anatoxin-a in favorable growth conditions. These cells then release toxins if disrupted, such as when exposed to chlorine or through biological methods. When an animal consumes water that contains the algal cells either through drinking the contaminated water or licking the toxins on their fur, the cells will enter the animal's gastrointestinal tract. Pets are at high risk for anatoxin-a exposure. However, ingestion of a sub-lethal dose leaves no chronic effects and recovery appears to be complete. Anatoxin-a degrades to a non-toxic product in sunlight and at a high pH (8 to 9).

Microcystins

Microcystins are the most common cyanotoxin, and more than one microcystin may occur in a particular cyanotoxin strain. Microcystins cause liver damage; at lethal doses they can cause death by liver necrosis within a few hours or up to a few days. However, noticeable symptoms only occur in severe cases. Researchers suspect that microcystins are liver carcinogens, which would increase the cancer risk to humans following continuous low-level exposure. Unlike other cyanotoxins, microcystins are bound within the cell and are only released into water when the cell ruptures due to being oxidized. When released, microcystins are stable in water and can be found in the water for months.

HEALTH ADVISORY LEVELS

As part of the Safe Drinking Water Act, the U.S. Environmental Protection Agency (EPA) has the authority to publish health advisories for contaminants that are not subject to national primary drinking water regulations. Health Advisory Levels (HALs) serve as informational guidance for health effects information and methods to sample and treat these non-regulated contaminants. HALs are not legally enforceable federal standards.

DOH currently has not set any regulatory limits for cyanotoxins and cyanobacteria in drinking water sources. However, the EPA has established 10-day HALs for total microcystins. The HAL is 0.3 micrograms per liter (µg/L) for children under 6 years old and susceptible adults (pregnant women, nursing mothers, elderly, immunocompromised, and dialysis patients), and 1.6 µg/L for school-aged children and other adults. The HAL identifies concentrations at or below which no adverse human health effects would be expected for up to 10 days of exposure.

The EPA has not established a HAL for anatoxin-a at this time. However, other states, including Ohio and Vermont, have established advisory levels for anatoxin-a. DOH supports the use of Ohio's health threshold of 0.3 µg/L for anatoxin-a as a trigger for increased monitoring and changes in treatment strategies.

DOH recommends that public water systems like the Cities use the lower EPA HAL for total microcystins (0.3 µg/L) in drinking water as a threshold to trigger proactive action. If a public water system exceeds the EPA's HAL for total microcystins in treated drinking water, the system should issue a "do not drink" advisory to its customers, as boiling water does not destroy cyanotoxins.

CYANOBACTERIA AND CYANOTOXINS OF POSSIBLE FUTURE CONCERN

Besides anatoxin-a and microcystins, other cyanotoxins exist and new ones are still being discovered. Cylindrospermopsin is a cyanotoxin that is more commonly found in the southern United States and it can damage the liver, kidneys, blood cells, and cellular DNA. The EPA has set a HAL for cylindrospermopsin at 0.7 µg/L for children under 6 years old and susceptible adults, and 3.0 µg/L for school-aged children and other adults. DOH recommends that public water systems use the EPA's lower HAL for cylindrospermopsin found in drinking water as a threshold to trigger action.

Saxitoxin is another potent neurotoxin with properties similar to anatoxin-a. Saxitoxin is rare in Washington freshwater bodies, and neither DOH nor the EPA have developed HALs for saxitoxin at this time.

LIST OF ABBREVIATIONS

Table 1-2 includes a list of abbreviations and acronyms that are used throughout this Plan.

Table 1-2

Abbreviations

Abbreviation	Description
AOPs	advanced oxidation processes
ASR	aquifer storage and recovery
BFHD	Benton-Franklin Health District
Cities	Richland, West Richland, Pasco, and Kennewick
COWR	City of West Richland
CT	chlorine contact time
DO	dissolved oxygen
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
ELISA	enzyme linked immunosorbent assay
EPA	U.S. Environmental Protection Agency
ERP	Emergency Response Plan
GAC	granular activated carbon
gpm	gallons per minute
HAB	harmful algal bloom
HAL	Health Advisory Level
H_2O_2	hydrogen peroxide
ICS	Incident Command System
KCEL	King County Environmental Lab
Kennewick	City of Kennewick
mg/L	milligrams per liter
MGD	million gallons per day
mj/cm^2	millijoule per square centimeter
NRW	North Richland Wellfield
PaCl	powdered activated carbon
PaCl	polyaluminum chloride
Pasco	City of Pasco
Plan	Algal Bloom Management and Response Plan
QAPP	Quality Assurance Project Plan
RH2	RH2 Engineering, Inc.
Richland	City of Richland
SCADA	supervisory control and data acquisition
SMCL	Secondary Maximum Contaminant Level
µg/L	micrograms per liter
UV	ultraviolet light
WPWTP	West Pasco Water Treatment Plant
WTP	Water Treatment Plant

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2 | EXISTING TREATMENT AND SOURCE EVALUATION

INTRODUCTION

This chapter of the Algal Bloom Management and Response Plan (Plan) includes high level summaries of pertinent drinking water treatment technologies, introduces the Cities' (Richland, West Richland, Pasco, and Kennewick) watershed and six existing water intakes on the Columbia River, evaluates short-term treatment enhancements and alternative sources available during the event of an algal bloom, and outlines a step-by-step plan for the Cities to follow in the event of a confirmed health advisory.

TREATMENT TECHNOLOGIES

Filtration

Filtration is a physical separation process that removes suspended and colloidal particles from water. Various forms of filtration are used throughout each of the Cities' treatment facilities, including conventional filtration, slow sand filtration beds, high throughput anthracite/sand beds, pressurized membrane systems, vacuum (a.k.a. submerged) membrane systems, and riverbank filtration. The physical removal of intact cyanobacteria by filtration is beneficial, as all intracellular cyanotoxins are removed in the process; however, both physical and chemical means of cell lysis (i.e. destruction) release extracellular cyanotoxins that cannot be removed using any form of filtration currently in operation at the Cities. Additionally, means of filtration subject to external pressure (e.g., pumping through filter membranes) present a risk of physical cell lysing, thereby releasing cyanotoxins beyond the filters and impacting the distribution system. Advanced membrane systems which employ nanofiltration modules are generally effective at removing microcystins, and reverse osmosis systems may remove both microcystins and cylindrospermopsin. In the absence of advanced membrane systems, chemical oxidation or adsorption are necessary to eliminate cyanotoxins in water treatment facilities.

Chlorination

Chlorine is an oxidant and disinfectant that is commonly used in drinking water treatment. The Cities disinfect with chlorine through liquid sodium hypochlorite and chlorine gas systems. Chlorine has been demonstrated to lyse cyanobacterial cells at CT (concentration x contact time) within the range of normal disinfection practices, releasing intracellular cyanotoxins in the process. Chlorine can be effective at destroying microcystins, cylindrospermopsin, and saxitoxins, depending on factors such as CT, temperature, dissolved organic matter concentration, and the initial cyanotoxin concentration. However, the CT necessary to achieve 99-percent (3-log) removal of microcystins is not typical at surface water filtration plants that receive significant log-reduction credits for their filtration, like the Cities. Additionally, chlorine is not effective at destroying anatoxin-a. Several of the Cities' drinking water primary treatment facilities utilize pre-chlorination to achieve their required log-removal credit; therefore, additional treatment technologies are necessary to mitigate the toxins released by pre-chlorination.

Permanganate

Permanganate is an oxidizing agent with disinfecting properties that is commonly used in drinking water treatment to alleviate taste and odor issues. It is available in two forms: liquid sodium permanganate and solid potassium permanganate granules. Liquid sodium permanganate is commercially available at 40-percent concentration and can be fed neat into the process pipe. The solid potassium permanganate is typically saturated with water and then the solution is fed into the process pipe. It has been demonstrated that low doses of permanganate can be used for pre-oxidation without lysing cyanobacterial cells (Fan, et al., 2013[1]). Permanganate has been shown to effectively treat anatoxin-a and microcystins, depending on factors such as CT, temperature, dissolved organic matter concentration, and the initial cyanotoxin concentration. Permanganate is ineffective for oxidizing saxitoxins, and its ability to oxidize cylindrospermopsin is not yet well understood.

The use of permanganate faces operational challenges. First, the disintegration of permanganate crystals in water results in a deep purple/pink water color that transitions to brown as manganese dioxide precipitates. Given insufficient contact time, unreacted permanganate can bypass filtration, resulting in colored water and elevated manganese levels, a secondary contaminant, in the distribution system. The secondary maximum contaminant level (SMCL) for manganese in finished water is 0.05 milligrams per liter (mg/L), but black to brown color, staining, and a bitter metallic taste can be noticed by customers at half the SMCL or 0.025 mg/L. For this reason, permanganate typically must be introduced at the head of the water treatment plant (WTP) and its concentration carefully adjusted to prevent breakthrough to the finished water. Secondly, permanganate injection increases solids loading in the form of manganese oxides. High permanganate dosing has been attributed to pressure filter media failure, filter cementation, and irreversible mudball precipitant formation. Care must be taken when dosing permanganate to protect downstream filters with carefully designed backwash or clean-in-place procedures.

An online permanganate analyzer should be installed at the end of the contact basin or contact time pipeline to measure permanganate residual and calculate permanganate contact time. This will allow water systems to adjust the permanganate dose accordingly based on the level of toxins present.

Appendix A includes information about online permanganate analyzers that may work for the Cities.

Carbon

Granular activated carbon (GAC) removes certain chemicals dissolved in water as they pass through GAC contactors. Treatment plants that use GAC can effectively destroy and/or remove cyanotoxins from drinking water. It also has the benefits of reducing taste and odor and reducing disinfection byproducts.

[1] Fan, J., Daly, R., Hobson, P., Ho, L., & Brookes, J. (2013). *Impact of potassium permanganate on cyanobacterial cell integrity and toxin release and degradation.* Chemosphere 92. Pgs. 529-534.

Powdered activated carbon can be fed into the process pipe and performs similarly to GAC. However, this process requires a sedimentation step to remove the carbon, so its feasibility is limited.

Ultraviolet Light

Ultraviolet light (UV) uses short-wave radiation to inactivate or kill bacteria and pathogens. UV dose intensities of 10 to 40 millijoules per square centimeter (mJ/cm^2) are typically implemented in drinking water treatment applications. Unfortunately, UV-based destruction of microcystins, anatoxin-a, and cylindrospermopsin require prohibitively high doses ranging from 1,530 to 20,000 mJ/cm^2. For this reason, facilities reliant upon UV as their sole source of disinfection require additional treatment technologies to address extracellular cyanotoxins.

Advanced Oxidation Processes

Advanced oxidation processes (AOPs) are typically deployed post-filtration to oxidize especially recalcitrant contaminants. Well-established AOPs include combinations of ozone, hydrogen peroxide (H_2O_2), and UV with various catalysts to generate powerful reactive oxygen species. One AOP consisting of UV coupled with hydrogen peroxide has been identified as effective at treating anatoxin-a, cylindrospermopsin, and microcystins, depending on factors such as hydrogen peroxide concentrations, UV intensity, reaction time, dissolved organic matter concentration, and the initial cyanotoxin concentration. Unfortunately, the reaction time required by this process is prohibitively high with respect to the flow rate through high throughput UV reactors like those utilized by the Cities. Recent studies have demonstrated the ability of UV and H_2O_2 with the addition of an iron catalyst to significantly accelerate the destruction of cyanotoxins; however, the implications of this process at full scale are not yet well understood.

COLUMBIA RIVER WATERSHED

The Cities currently obtain surface water from the Columbia River at six different intake facilities. Per the U.S. Environmental Protection Agency (EPA), the Columbia River Basin is one of the largest watersheds in the United States and provides drinking and irrigation water along its course.

In September 2021, anatoxin-a was detected in water samples along the Columbia River. This event represents a significant expansion in potential surface water sources vulnerable to cyanotoxins.

EXISTING FACILITIES

This section describes the existing intake and water treatment facilities on the Columbia River for the Cities, including the existing treatment methods. **Chapter 4** includes a discussion of the capital improvements needed to treat cyanotoxins and cyanobacteria at these facilities.

City of Kennewick

Water Treatment Plant

The City of Kennewick's (Kennewick) Columbia River surface WTP was constructed in 1980 with an original capacity of 7.5 million gallons per day (MGD). The plant has since been expanded to 15 MGD, with infrastructure in place to be expanded to 30 MGD in the future.

Water from the Columbia River intake is first treated at the Kennewick WTP by sodium permanganate at a concentration of 0.35 mg/L to improve taste and odor. The water then proceeds through several hundred feet of on-site piping prior to an optional sodium hypochlorite addition for pre-chlorination (which has been offline for more than 5 years) at the rapid mixer. At the existing permanganate dose, color bleed through the plant is already negligible by the time water exits the rapid mixer. Permanganate is dosed between 0.4 mg/L and 0.8 mg/L at the Kennewick WTP; higher doses contribute to color issues in the finished water. Polyaluminum chloride (PaCl) is added at the rapid mixer as a coagulant and precipitant. The WTP also has provisions to add powdered activated carbon as an adsorbent at the rapid mixer; however, it is not currently in use since it has previously contributed to membrane fouling issues downstream. Following the rapid mixer, there are three stages of flocculation and an array of inclined plate settlers. Supernatant from the settlers is then filtered through membrane microfiltration. The Kennewick WTP uses a Memcor continuous microfiltration-submerged (CMF-S) membrane system, with four cells of polyvinylidene difluoride (PVDF) membrane modules. The potential for membrane fouling, often experienced at membrane filtration plants, is significantly reduced by Kennewick's use of conventional coagulation, flocculation, and sedimentation upstream of the membrane system. Finally, the filtered water is sent to the clearwell where sodium hypochlorite is added through an injection line. A current, simplified treatment process diagram for the Kennewick WTP is shown in **Figure 1**. The current treatment process currently appears sufficient to adequately reduce or eliminate all cyanotoxins with no modifications. Depending on the incoming concentration of anatoxin-a, Kennewick's WTP can effectively oxidize approximately 47 micrograms per liter (µg/L) of toxin at 0.35 mg/L of permanganate or up to 100 µg/L at 1 mg/L.

Ranney Wells

In the late 1950s, Kennewick installed five Ranney collector wells on Clover Island and near Columbia Park with an original combined capacity of 24.5 MGD. Since that time, three of the Ranney wells have been removed from service. Ranney Wells No. 4 and 5, near Columbia Park, have a remaining capacity of approximately 15 MGD, but current groundwater and turbidity conditions limit the combined capacity to approximately 8.7 MGD.

Water supplied by the Ranney wells is provided through riverbank filtration with several hundred feet of natural porous media. The water is then subjected to phosphoric acid as a color and corrosion inhibitor prior to UV disinfection to treat for *Cryptosporidium* and *Giardia lamblia*. Sodium hypochlorite is injected into the water prior to entering a dedicated chlorine contact time pipeline upstream of distribution. A current, simplified treatment process diagram for the Ranney Well Collector No. 5 is shown in **Figure 2**. Depending upon the ability of the Ranney wells riverbank filtration to physically remove all cyanobacteria, the current treatment process currently appears sufficient to adequately reduce or eliminate most cyanotoxins with no modifications. If extracellular cyanotoxins are detected, then Kennewick should implement a permanganate feed system similar to the system discussed in **Chapter 4** for long-term planning at this facility.

City of Pasco

Butterfield Water Treatment Plant

The City of Pasco's (Pasco) Butterfield WTP is located on the east side of Pasco's water service area. The plant was originally built in 1948 and has since gone through multiple phases of improvements. The Butterfield WTP is capable of supplying 26.8 MGD from the McNary Pool of the Columbia River.

Water from the Columbia River intake is first treated at the Butterfield WTP by potassium permanganate at a concentration of 0.14 to 0.28 mµ to control taste and odor. The water then proceeds through approximately 40 feet of on-site piping prior to pre-chlorination using chlorine gas and the addition of liquid aluminum sulfide (alum) as a coagulant at the static mixers. Between the static mixers and flocculation basins, the Butterfield WTP is equipped for the addition of several chemicals: anionic polymer as a flocculant, activated carbon as an adsorbent, and caustic soda to adjust pH; however, no chemicals are currently injected at this location. From the flocculation basins, water enters the sedimentation basins. At the high end of the existing permanganate dose range, color bleed through the plant is noticeable through the first third of the sedimentation basins. Permanganate doses between 0.3 mg/L and 0.4 mg/L are potentially attainable at lower flow rates at the Butterfield WTP before color issues impact finished water. Following sedimentation, water enters an array of conventional sand media filters. Finally, the filtered water is sent to the clearwell where additional chlorine and caustic soda may be added. Hydrofluosilicic acid is added to fluoridate the water ahead of it being pumped to distribution. A current, simplified treatment process diagram for the Butterfield WTP is shown in **Figure 3**. Considering Pasco's limited ability to increase the permanganate dose and dependence on chlorination to meet the required CT at the Butterfield WTP, the current treatment process may not be sufficient to adequately reduce or eliminate all cyanobacteria or cyanotoxins.

West Pasco Water Treatment Plant

Raw water from the Columbia River is conveyed to the West Pasco Water Treatment Plant (WPWTP) from the Intake Pump Station. The WPWTP has a current capacity of 6 MGD, but improvements are currently in construction to expand capacity to 12 MGD, and eventually full 18 MGD buildout.

Water from the Intake Pump Station is first treated at the head of the WPWTP with aluminum chlorohydrate as a coagulant and sodium hypochlorite for pre-chlorination. The plant also was originally equipped to inject sodium permanganate at this location; however, it is not currently in use since it contributed to downstream membrane fouling during pilot testing. The water is then pre-treated with two 300-micron pre-filtration strainers (two additional strainers are in construction). The pre-treated water is then filtered with two parallel membrane filtration racks (two additional membrane racks are in construction) that include a separate chemical feed system for maintenance and clean-in-place activities. The Pall Water pressurized membrane racks house

Microza UNA-620A PVDF microfiltration modules. The membrane maintenance chemicals include caustic soda, sodium hypochlorite, and a sulfuric and citric acid mix. Filtered water is sent to a clearwell that provides chlorine contact time detention and storage. Post-clearwell, hydrofluosilicic acid is added to fluoridate the water ahead of it being pumped to distribution. A current, simplified treatment process diagram for the WPWTP is shown in **Figure 4**. The current treatment process is not sufficient to adequately reduce or eliminate all cyanobacteria or cyanotoxins.

City of Richland

Columbia River Water Treatment Plant

The City of Richland's (Richland) Columbia River WTP is currently Richland's primary source of supply and is located at Saint Street and Harris Street along the Columbia River. Five vertical turbine pumps at Richland's intake structure pump water from the Columbia River to the WTP. The plant was constructed in 1963 with an original capacity of 15 MGD. Upgrades in 1980 and 1995 have increased the production capacity to 36 MGD.

Water from the Columbia River intake is first treated at the Richland WTP by sodium permanganate at a concentration of 0.05 mg/L as part of a pilot installation to control cyanobacteria/cyanotoxins. The water then proceeds through approximately 10 feet of on-site piping prior to sodium hypochlorite and PaCl addition at the Parshall flume. From the flume, water is rapid mixed and delivered to the contact basins. At the existing permanganate dose, color bleed through the plant is apparent into the first third of the contact basins, and permanganate doses at 0.15 mg/L have been observed to cause color issues throughout the contact basins. Following the contact basins is a normal injection point for secondary flocculant, and an optional point of lime addition for pH control or activated carbon adsorbent for improving taste and odor. Water then proceeds through direct filtration utilizing eight high rate filtration beds of anthracite coal and sand. Finally, the filtered water is sent to the clearwell where additional sodium hypochlorite may be added through a normally closed injection line on an as-needed basis. A current, simplified treatment process diagram for the Richland WTP is shown in **Figure 5**. Considering Richland's limited ability to increase the permanganate dose at the Richland WTP, the current treatment process may not be sufficient to adequately reduce or eliminate all cyanobacteria or cyanotoxins.

North Richland Wellfield

The North Richland Wellfield (NRW) is a slow sand filtration facility. The infiltration basins provide a hydraulic barrier to the southward flow of potential contaminants from the Hanford site and supplement production capacity. These basins also provide water to the NRW. The westernmost basin serves as a settling basin and is connected to the north and south infiltration basins. Columbia River water is pumped by two vertical turbine pumps at the City's intake structure to the NRW infiltration basins. The water is disinfected at the NRW by a UV system at approximately 10 mJ/cm^2 and further treated with sodium hypochlorite to provide a chlorine residual before entering the distribution system. A current, simplified treatment process diagram for the NRW is shown in **Figure 6**. Depending upon the ability of Richland's slow sand filtration to physically remove all cyanobacteria, the current treatment process may not be sufficient to adequately reduce or eliminate all cyanotoxins.

SHORT-TERM TREATMENT ENHANCEMENTS

If, during a harmful algae bloom (HAB) event, the Cities' water systems cannot shut down their Columbia River intake sources or rely on other sources that are unaffected by cyanotoxins, they must implement and activate additional treatment processes or facilities. To effectively treat for anatoxin-a and microcystins, the Cities treatment plants should be upgraded to include potassium permanganate processes in the near-term (roughly within 1 to 2 years to procure and install a simple chemical feed system). Currently, Kennewick's Ranney wells and North Richland Wellfield's UV systems are unprotected in the rare event that cyanobacteria accumulate throughout the system and release toxins that bypass initial filtration. Both Pasco's Butterfield WTP and Kennewick's WTP currently use permanganate for taste and odor control, and Richland's WTP has a pilot permanganate installation, but adjustments to these chemical feed systems may be needed for treatment of cyanotoxins in response to a significant HAB event. Pasco's WPWTP should be equipped with a temporary permanganate feed system injecting downstream of the membrane filters, along with an analyzer to measure and control this dose. Feeding permanganate downstream of the filters should be pilot tested in advance of a HAB event to determine feasibility and assess negative impacts, such as increased sediment or increased manganese levels entering distribution, or more difficulty in preventing a color event. Permanganate is a cost-effective treatment technology and will be discussed further as a possible treatment technique for future cyanotoxin events. A chemical contact time of 1 to 2 milligram minutes per liter (mg-min/L) of permanganate can treat 100 micrograms per liter (µg/L) of anatoxin-a, so the dose would vary depending on each systems existing hydraulic residence time.

Operational Changes

Temporary operational changes may be necessary during a HAB event. Where relevant, the following operational changes should be considered:

- Filter backwash supernatant recycling should be suspended for plants that have this process.
- Filter backwash frequency should be increased.
- Filter-to-waste cycles should follow backwashing.
- Sludge should be removed from sedimentation basins more frequently, daily if possible.
- Operate plants at lower capacity to achieve longer contact time.
- Swap permanganate pre-oxidation and chlorine pre-chlorination injection points.
- Adjust pre-oxidation and pre-chlorination doses to either avoid releasing cyanotoxins ahead of the filters or completely oxidize them.
- Test and evaluate alternative oxidants in a full scale pilot study with chemicals approved for use in drinking water (e.g., H_2O_2) to mitigate a HAB event.

- Sample additional locations throughout the treatment process to evaluate the success and drawbacks of individual treatment technologies.

Near-Term Capital Improvements

Based on the existing treatment capabilities of the Cities' facilities, the following near-term capital improvements may be necessary for each city.

City of Kennewick

Water Treatment Plant

The Kennewick WTP includes a sodium permanganate feed system at the intake. A secondary permanganate feed system is suggested to inject downstream of the membrane filters and upstream of the clearwell. It is recommended that two real-time permanganate sensors be installed: one downstream of the clearwell and one at the entry to distribution. The supervisory control and data acquisition (SCADA) system should be programmed to accept data from the clearwell sensor and provide feedback control to the permanganate metering pump to maintain a setpoint dose. Precise permanganate dose control is reportedly the key to oxidizing cyanotoxins without lysing cyanobacteria. The addition of a permanganate feed system and an inline permanganate analyzer that does not require chemical reagents is estimated to cost approximately $28,000 without installation and SCADA upgrades. Kennewick also should consider distribution system flushing to handle the additional solid loading and sediment sloughing from permanganate reacting with distribution system piping.

Ranney Wells

It is not anticipated that Kennewick requires any near-term capital improvements at the Ranney wells. Kennewick currently samples twice per month for aerobic endospore as an ongoing evaluation of the effectiveness of riverbank filtration and Kennewick averages 3-log removal. Current routine HAB raw water sampling is taken at the Columbia Park Pond upstream of riverbank filtration, which would provide valuable understanding of the Ranney wells vulnerability during a HAB event. In the event that increased monitoring uncovers a cyanotoxin breakthrough downstream of the wells, additional long-term treatment improvements will be necessary to augment UV disinfection and post-chlorination.

City of Pasco

Butterfield Water Treatment Plant

The Butterfield WTP includes a potassium permanganate feed system as part of its treatment process. A secondary permanganate feed system is suggested to be injected downstream of the filters and upstream of the clearwell. It is recommended that one real-time permanganate sensor be installed downstream of the clearwell. The SCADA system should be programmed to accept data from the clearwell sensor and provide feedback control to the permanganate metering pump to maintain a setpoint dose. The addition of one inline permanganate analyzer that does not require chemical reagents is estimated to cost approximately $13,000 without installation and SCADA upgrades.

The Butterfield WTP currently relies upon a single hopper-fed batch mixer and two diaphragm pumps to supply potassium permanganate. This system faces shortcomings in dose control, as it is unable to maintain a fully mixed batch of permanganate while actively feeding the plant. As a result, the plant is susceptible to slugs of unmixed, and thus, under--concentrated permanganate. If this system was to be relied upon for more than odor and taste control in the long-term, it would be necessary to implement a second batch mixer system such that one tank may feed the plant while the other prepares fresh solution. It also is recommended that the existing diaphragm pumps be replaced with peristaltic pumps to increase system resiliency. Upgrading the existing permanganate injection equipment is estimated to cost approximately $25,000. Although outside the scope of this Plan, additional consideration may be given to replacing the entire batch system with a saturator system and injecting at the intake. Pasco also should consider additional filter maintenance to handle the additional solid loading from added permanganate and cyanobacteria. The extent of additional maintenance depends on the size of the bloom and the permanganate dose.

West Pasco Water Treatment Plant

The WPWTP is considered the Cities' most vulnerable treatment facility during an HAB event. The WPWTP does not currently include an active chemical feed system that would effectively treat for anatoxin-a or microcystins, nor does it include conventional flocculation and sedimentation upstream of the membranes. Pasco is currently working with their membrane manufacturer to run small scale tests to determine the impacts permanganate may have on the membrane fibers, if any. Process recommendations will be provided once the testing results are available.

If permanganate is feasible, one real-time permanganate sensor should be installed downstream of the clearwell. The SCADA system should be programmed to accept data from the clearwell sensor and provide feedback control to the permanganate metering pump to maintain a setpoint dose. The addition of a permanganate feed system and an inline permanganate analyzer that does not require chemical reagents is estimated to cost approximately $28,000 without installation and SCADA upgrades. Pasco also should consider additional strainer and membrane filter maintenance, such as more aggressive clean-in-place measures, to handle the additional solid loading from added permanganate and cyanobacteria. The extent of additional maintenance depends on the size of the bloom and the permanganate dose.

City of Richland

Columbia River Water Treatment Plant

The Richland Columbia River WTP includes a pilot sodium permanganate feed system as part of its treatment process. To treat anatoxin-a and microcystins, Richland may need to increase the feed rate during a HAB event, but there has been a history of color breakthrough at the higher end of the plant's treatment range. A more effective strategy may be to relocate the feed system (or install another one) downstream of the filters. Additional data should be gathered this year with the pilot permanganate feed system in place. It is recommended that one real-time permanganate sensor be installed downstream of the clearwell. The SCADA system should be programmed to accept data from the clearwell sensor and provide feedback control to the permanganate metering pump to maintain a setpoint dose. The addition of a permanganate feed system and one inline permanganate analyzer that do not require chemical reagents is estimated to cost approximately $28,000 without installation and SCADA upgrades. Richland also should consider distribution system flushing to handle the additional solid loading and sediment sloughing from permanganate reacting with distribution system piping.

North Richland Wellfield

It is not anticipated that Richland requires any capital improvements at the NRW. Additional monitoring is necessary at the UV disinfection facility to evaluate the efficacy of slow sand filtration. The City plans on sampling before and after filtration to assess the effectiveness of this natural method of pathogen removal. Sample acquisition upstream of any chemical injection or UV disinfection would provide valuable understanding of the NRW’s possible vulnerability during a HAB event. In the event increased monitoring uncovers a cyanobacteria breakthrough downstream of the infiltration basins, additional treatment will be necessary to augment UV disinfection and post-chlorination to treat the toxins that may be released.

ALTERNATIVE SOURCES

City of Kennewick

Kennewick has two emergency intertie agreements with Richland; however, only one intertie has the ability to provide up to 1 MGD to Kennewick. In the event of an emergency situation when one or more water system(s) loses its main source of supply and is unable to provide a sufficient quantity of water to its customers, the intertie can be used.

Kennewick also completed construction of an aquifer storage and recovery (ASR) well in 2014. The well and its storage capacity have been tested since the well was constructed. The ASR Well is now fully developed, and a maximum of 2,080 gallons per minute (gpm) may be pumped from the well to Kennewick’s Zones 4 and 5. If needed, some water can be provided to Zone 3 through a pressure reducing valve.

City of Pasco

Pasco does not currently have any emergency interties with adjacent water purveyors.

City of Richland

Richland has two wells at its Wellsian Well Field and the Columbia Well that are able to provide a domestic supply capacity of 3.2 MGD. Richland also has an emergency intertie agreement with Kennewick that is able to supply a few million gallons per day to Richland if needed.

City of West Richland

The City of West Richland (COWR) has 5 groundwater wells located throughout the City that cumulatively pump up to 5,310 gpm. COWR also has 4 reservoirs for storing supply that have a total capacity of 4.4 million gallons. COWR's alternative sources can nearly meet its peak day demand of 7.82 MGD without using the intertie with Richland. In the event of a HAB event at Richland's WTP, COWR would turn off the intertie and implement water conservation measures until the bloom event has cleared.

ALGAL BLOOM HEALTH ADVISORY STEPS

In the event of an algal bloom of total microcystins or anatoxin-a that triggers health advisory levels (HALs), the Cities should take the following steps for the protection of its drinking water sources:

1. Notify the public per the communications plan provided in **Chapter 3**.
2. Implement the treatment adjustments identified in the **Short-Term Treatment Enhancements** section.
3. Plan for and/or implement the permanent treatment adjustments identified in the **Capital Improvement Plan** section in **Chapter 4**.
4. Begin using alternate water sources, if available.
5. Reduce the flow rate at the Cities' facilities to improve cell removal.
6. Implement water demand reduction strategies.

These steps are broken down further for each of the Cities' individual facilities in the sections that follow.

City of Kennewick

Water Treatment Plant

In the event of a detectable toxin level at the Columbia River WTP intake, the following treatment response will immediately occur.

To remove intact algal cells and prevent lysing of cells:

1. Turn off permanganate feed system at intake.
2. Perform additional cyanobacteria and cyanotoxin sampling.
3. Consider accumulation of cyanobacteria in flocculation and inclined plate settlers and schedule cleaning if necessary.
4. Optimize polyaluminum chloride flocculation with either jar testing or via streaming current.
5. Increase sedimentation basin vacuum frequencies.

Note: Inventory polyaluminum chloride and order as needed.

To reduce or remove algal toxins:

1. Increase raw water permanganate dose based on cyanotoxin levels.

Note: Inventory sodium permanganate and order as needed.

2. Maintain chlorine dosing at injection point downstream of membranes only.

Note: If toxins are found in the finished water, consider curtailment to increase contact time in the treatment process or increase the permanganate dose at the low lift or both.

Ranney Wells

In the event of a detectable toxin level at the pump wet well, the following treatment response will immediately occur.

To reduce or remove algal toxins:

1. Install pilot sodium permanganate feed upstream of UV reactors and determine dose response based on cyanotoxin levels.

Note: If toxins are found in the finished water, consider curtailment of Ranney collector pumps to increase riverbank filtration contact time.

City of Pasco

Butterfield Water Treatment Plant

In the event of a detectable toxin level at the Columbia River intake, the following treatment response will immediately occur.

To remove intact algal cells and prevent lysing of cells:

1. Lower pre-chlorination dose of raw water to minimum required to meet inactivation ratios.

Note: Consider accumulation of cyanobacteria in flocculation and sedimentation basins and schedule cleaning if necessary.

2. Optimize polymer flocculation.

Note: Inventory polymer feed and order as needed.

To reduce or remove algal toxins:

1. Increase raw water permanganate dose based on cyanotoxin levels.

Note: Inventory potassium permanganate and order as needed.

2. Change chlorine dosing points to downstream of filters only.

Note: If toxins are found in the finished water, consider curtailment to increase contact time in the treatment process.

West Pasco Water Treatment Plant

In the event of a detectable toxin level at the Columbia River intake, the following treatment response will immediately occur.

To remove intact algal cells and prevent lysing of cells:

1. Stop pre-chlorination of raw water upstream of membranes. This may change to lowering the pre-chlorination dose after a tracer study is conducted on the clearwell.

Note: Consider accumulation of cyanobacteria in strainer and membrane racks and plan on increased residuals handling if necessary.

2. Optimize aluminum chlorohydrate flocculation.

Note: Inventory aluminum chlorohydrate feed and order as needed.

To reduce or remove algal toxins:

1. Implement permanganate feed at the raw water intake and set dose based on cyanotoxin levels.

Note: Inventory permanganate and order as needed.

2. Change chlorine dosing points to downstream of membranes only.

Note: If toxins are found in the finished water, consider curtailment to increase contact time in the treatment process.

City of Richland

Columbia River Water Treatment Plant

In the event of a detectable toxin level at the Columbia River intake, the following treatment response will immediately occur.

To remove intact algal cells and prevent lysing of cells:

1. Lower pre-chlorination dose of raw water to minimum required to meet inactivation ratios.

Note: Consider accumulation of cyanobacteria in contact basin and schedule cleaning if necessary. Also consider adverse impacts to the filter system and adjust operations as needed.

2. Optimize polyaluminum chloride flocculation.

Note: Inventory polyaluminum chloride and order as needed.

To reduce or remove algal toxins:

1. Increase raw water permanganate dose based on cyanotoxin levels.

Note: Inventory sodium permanganate and order as needed.

2. Change chlorine dosing points to downstream of filters only.

Note: If toxins are found in the finished water, consider curtailment to increase contact time in the treatment process.

North Richland Wellfield

In the event of a detectable toxin level at the wellfield pond, the following treatment response will immediately occur.

To reduce or remove algal toxins:

1. Install pilot sodium permanganate feed and determine dose response based on cyanotoxin levels.

Note: If toxins are found in the finished water, consider curtailment of wellfield pumps to increase contact time in the treatment process.

City of West Richland

In the event of a detectable toxin level at the City of Richland’s Columbia River intake, COWR will turn off the intertie with the City of Richland and activate its groundwater sources.

3 | MONITORING PROGRAM

INTRODUCTION

This chapter of the Algal Bloom Management and Response Plan (Plan) will discuss the Cities (Richland, West Richland, Pasco, and Kennewick) source water, raw water, and finished water monitoring program and sampling procedures, as well as the Cities' communication plan for notifying the public in the event of an algal bloom event.

SOURCE WATER MONITORING

Source water monitoring should be completed at the start of each bloom season and continue throughout the bloom season, which is typically March through October in Washington State. Source water monitoring can include treatment plant performance monitoring, field monitoring, and sampling, as discussed in the sections that follow. U.S. Environmental Protection Agency (EPA) Region 10, the Department of Ecology, and the Department of Health (Office of Drinking Water and Office of Environmental Public Health Sciences – Climate Change and Health) have been collaborating on analyzing the Columbia River watershed to determine if a source for the cyanobacteria can be identified and mitigated.

Water Treatment Plant Performance

During the bloom season, the Cities should be monitoring the performance of their water treatment plants (WTPs) for changes in performance that might indicate the presence of a harmful algal bloom (HAB). This includes monitoring for decreased filter run times and decreased chlorine residual, as well as increased taste and odor issues, increased pH, increased turbidity, and increased coagulant demand, among others. If any of these criteria are being noticed by operators, then the Cities should begin evaluating any routine source water quality monitoring that is conducted for all surface water sources for signs of cyanotoxins or cyanobacteria.

Field Monitoring

Another way to monitor source water is through field monitoring. City staff can visually inspect its source waters to identify bloom conditions, including assessing water clarity and color, and looking for suspended algal blooms. The frequency of field monitoring should be related to the probability of a HAB event, which is often seasonal and weather dependent. City staff can look for blue-green or green flecks scattered in the water or scums that float on the surface.

If City staff identify a bloom during their field monitoring, a sample should be evaluated to identify phytoplankton and determine if cyanobacteria are present. This can be done in-house, by private laboratory, or through the state algal toxin testing program coordinated by the Washington State Department of Ecology (Ecology). If cyanobacteria are present, the sample will need to be further tested for cyanotoxins.

Per the Washington State Department of Health's (DOH) *Quality Assurance Project Plan for Cyanotoxin-Producing Harmful Algal Bloom (HAB) 2022 Monitoring in the Columbia River at*

Richland, Pasco, and Kennewick, WA (QAPP) (DOH, February 2022), DOH will be installing a water quality data logger (sonde) at the Richland WTP intake, downstream of the intake screens prior to chemical addition. The sonde will have sensors for temperature, pH, conductivity, dissolved oxygen (DO), total phosphorus, total nitrogen, and chlorophyll-a/phycocyanin. DOH will use this data to look for early indications of when blooms might occur, in the hopes that it may provide an early warning sign for operators to start a modified treatment program.

Source Water Sampling

In addition to field monitoring and observing changes in WTP performance, the Cities may choose to regularly monitor source water for bloom indicators. Source water monitoring can detect HABs and cyanobacteria that may not be visible. At a minimum, in accordance with the guidance of DOH 331-654, *Dealing with Cyanobacteria: Time to Make a Plan* (April 2022), if a bloom is detected through either visual observations or changes in treatment plant performance, source water sampling should be conducted. Since some indicators can change throughout the day, it is important that samples are taken at roughly the same time each day throughout the bloom season, as needed.

If a sample detects a bloom indicator at or above the trigger levels identified in **Table 3-1**, then identifying the type of cyanobacteria present will allow the Cities to establish what toxins to test for in their raw or finished water. When blooms are present in the vicinity of an intake, the Cities should consider making operational changes and treatment adjustments as discussed in **Chapter 2**.

Table 3-1

Source Water Bloom Indicators
[Excerpted from Table 2 of DOH Guidance 331-654]

Bloom Indicator	Trigger Level[1]	Response
pH	Increasing from normal levels. pH changes from day to night.	Evaluate other bloom indicators
Secchi disk depth	Reduction in visibility (decrease in secchi depth for example >2 ft.) since prior measurement	Evaluate other bloom indicators
Temperature	High water temperatures can favor cyanobacteria growth	Implement or increase monitoring program steps
River stratification (temperature & DO)	Temperature and DO levels indicate if river is stratified. Documenting typical times and degrees of stratification may allow correlation of blooms with certain stratification conditions.	Evaluate other bloom indicators
MIB and/or Geosmin (Taste and Odor)	Increase of 20-50 ng/L (or presence if not normally found).	Sample phytoplankton for ID at least to genus level
Phytoplankton Cell Counts	Use historical source water quality to establish the no. of cells/mL.	Sample phytoplankton for ID at least to genus level
Cyanobacteria Cell Counts	$\geq$ 2,000 cells/mL[2]	Sample phytoplankton for ID of cyanobacteria
Bio-volumes	$\geq$ 0.2 mm^3/L[2]	Sample phytoplankton for ID of cyanobacteria
Chlorophyll-a	Site specific[3]	Sample phytoplankton for ID of cyanobacteria
Phycocyanin equivalents	> 100,000 cells/mL[4]	Sample phytoplankton for ID of cyanobacteria
Cyanotoxin Production Genes (qPCR)	In development	In development
Visible surface scum or change in water color		Test for cyanotoxins, sample phytoplankton for ID of cyanobacteria

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

2. (WHO, 6.3.2, 1999) "Alert Level 1 Thresholds."

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

4. USEPA Cyanobacteria Assessment Network Application (CyAN app)

MIB = two-methylisoborneol, a naturally occurring compound produced by cyanobacteria and other bacteria.

RAW AND FINISHED WATER MONITORING

If source water monitoring detects HABs or cyanobacteria indicators at or above trigger levels (**Table 3-1**), then the Cities should monitor their raw water for the specific cyanotoxins identified in the bloom.

If cyanotoxins are detected at or above the 0.3µg/L from a certified lab in a raw water sample, then finished water sampling is needed to determine if customers have been exposed to cyanotoxins. Finished water should be sampled within 24 hours of the raw water testing to confirm if cyanotoxins are detectable.

Health Advisory Levels

As discussed in **Chapter 1**, the EPA has determined HALs for some cyanotoxins, including total microcystins and cylindrospermopsin. Other states, like Ohio, have determined health guidelines for anatoxin-a, which DOH supports as an appropriate trigger level for increased monitoring (DOH Guidance 331-654, April 2022). These HALs for sensitive groups are shown in **Table 3-2** for reference.

Table 3-2

HALs for Cyanotoxins

Cyanotoxin	HAL
Microcystins	0.3 µg/L
Cylindrospermopsin	0.7 µg/L
Anatoxin-a	0.3 µg/L

µg/L = micrograms per liter

Please note, as of the writing of this Plan, cylindrospermopsin is not currently a concern in the Columbia River; however, the Cities may test for this in the future for historical data collection.

Sampling Plan

Recreational Water Sampling

Benton-Franklin Health District (BFHD) responds to health and safety concerns of HAB events at recreational areas along the Columbia River. In 2021, BFHD collected 89 samples at 30 different recreational locations along the Columbia River – from Ringold to the Plymouth Boat launch – and tested for anatoxin-a, cylindrospermopsin, microcystin, and saxitoxin. A total of 41 samples detected toxin concentrations at or above the reporting limits between September 13, 2021 and November 16, 2021.

Recreational sampling at boat launches and park beaches does not necessarily predict the water quality of drinking water samples, but it can be an early indication that water system operators should be investigating visual signs of blooms and changes in the raw water quality that may impact treatment effectiveness.

BFHD intends to continue sampling in 2022 at the same frequency as drinking water samples at the following sites:

- Ringold Boat Launch
- Leslie Groves Park Swimming Area
- Howard Amon Park Swim Dock
- Chiawana Park Boat Launch
- Pasco Boat Basin
- Two Rivers Park

Additional sample locations may be added during the warmer months, if needed, at the following sites or other sites based upon any complaints received:

- Columbia Point Boat Launch
- Bateman Island Boat Launch
- Columbia Park Marina
- Plymouth Park
- Crow Butte State Park
- Scooteney Reservoir

The additional sites likely will not be sampled on a routine basis. Once any monitoring site detects cyanotoxins, samples will be sent to the King County Environmental Lab for analysis. Once a detection occurs, BFHD will continue the same sampling methods at specific locations until sampling falls below the advisory levels.

Raw Water

DOH Office of Drinking Water recommends sampling the raw water twice monthly for anatoxin-a and microcystins at each of the Cities six intake facilities during the bloom season of March through October. Samples will be collected by the Cities every Second and fourth other Monday and deliver the samples to the Benton-Franklin Health District. This baseline sampling is planned for approximately 16 times regardless of if there are detections or not. Per DOH's QAPP (DOH, February 2022), the recommended sampling sites for the Cities raw water sources are as shown in **Table 3-3**.

Table 3-3

Raw Water Sampling Sites
[Excerpted from Table 2 of DOH QAPP]

Facility	Sample Location
Kennewick Membrane Plant Intake	Raw Water Sample Tap
Kennewick Ranney Well Collector 5	Pump Wet Well
Pasco Butterfield WTP Intake	Raw Water Sample Tap
Pasco WPWTP Membrane Intake	Raw Water Sample Tap
Richland WTP River Intake	Raw Water Sample Tap
Richland Wellfield Pond	Dip Sample from End of Pond
Richland Wellfield Pump Discharge	Upstream from UV Reactor

If HABs or cyanobacteria indicators have been detected in the source water above .20 micrograms per liter (µg/L) on the BFHD enzyme-linked immunosorbent assay (ELISA) test, confirmation samples will be sent off to a certified lab within 24 hours. If samples from a certified lab have confirmed the presence of cyanotoxins above the 0.2µg/L, raw water sampling will increase to twice per week, along with finished water sampling as discussed in the following section. If cyanotoxins are not detected, but a bloom is observed near one of the intakes, raw water sampling shall continue to be sent to a certified lab twice per week until the bloom is gone. If cyanotoxins are not detected for two consecutive samples and the observed bloom near the intake is gone, raw water sampling can be reduced; however, source water monitoring and observations could continue.

Finished Water

Finished water monitoring should begin within 24 hours of a treatment plant intake raw water sample result from a certified lab that detects cyanotoxins at or above recommended Health Advisory Levels (HALs). A raw water sample should be collected and shipped simultaneously to fulfill the comparison requirements listed in **Table 3.5**. Finished water sampling should begin according to the schedule shown in **Table 3-4**. The Cities should consider collecting a confirmation sample within 24 hours of the initial finished water sample without waiting for initial results to shorten response times during an HAB event.

Table 3-4

Initial Finished Water Sampling Schedule
[Excerpted from Table 5 of DOH Guidance 331-654]

Sample Location	Frequency	Result - Cyanotoxins Detected	Result - Cyanotoxins Detected in Raw but Not Finished Water	Result - No Cyanotoxins Detected in Raw or Finished Water
Distribution system entry point	2 times per week	Collect confirmation sample as soon as possible and within 24 hours. **If confirmed, proceed with follow-up sampling per Table 3-5**	Continue raw and finished water sampling at KCEL or another lab 2 times per week until cyanotoxins are not detected in raw water	Continue **raw water** sampling at BFHD 2 times per week until bloom is gone (discontinue finished water sampling)

* Report analytical results to DOH within 24 hours of receipt.

If the Cities initial finished water sampling detects cyanotoxins, they should continue finished water monitoring according to the schedule shown in **Table 3-5**.

Table 3-5

Follow-Up Finished Water Sampling Schedule
[Excerpted from Table 6 of DOH Guidance 331-654]

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

* 0.3 µg/L for microcystins; 0.7 µg/L for cylindrospermopsin; 0.3 µg/L for anatoxin-a

Laboratories

Once samples have been obtained from the sites in **Table 3-3**, they should be stored appropriately and shipped to a laboratory for analysis. Testing for cyanobacteria and cyanotoxins can be performed at the King County Environmental Lab (KCEL).

Both laboratories will automatically report their results electronically to the Cities and DOH when the testing is complete.

Benton-Franklin Health District

BFHD has a lab in Kennewick, Washington that performs testing on potable and non-potable water. BFHD has ELISA analytical capabilities for anatoxin-a and microcystins. ELISA is a quantitative test that indicates total toxin for microcystins, anatoxin-a, cylindrospermopsin, and saxitoxins. However, ELISA requires a separate test be performed for each toxin. Detection levels have been set at .02 micrograms per liter (µg/L). BFHD will perform screening level analysis of raw water samples for cyanotoxins.

King County Environmental Lab

KCEL in Seattle, Washington, is an accredited lab by Ecology for analyzing cyanotoxins. When one of the Cities' screening raw water samples detects cyanotoxins at or above 0.2 µg/L, KCEL will be perform a further analysis. KCEL uses both ELISA and EPA-approved mass spectrometry (LC-MS/MS) analysis for microcystins and anatoxin-a. LC-MS/MS is a more accurate version based on EPA Methods 544 and 545.

COMMUNICATIONS PLAN

If a raw or finished water sample results in cyanotoxin levels above recommended HALs, the Cities will need a communications plan for notifying and advising the public and their customers about the event. Sample communication letters for HAB events can be found in **Appendix B**. The Cities also should consider and create a plan for any communications that they might have with customers if cyanotoxins are detected but not confirmed, or are confirmed below the HAL. At a minimum, sample detection results below HALs should be communicated in the Cities annual Consumer Confidence Reports.

If any cyanotoxin concentration from an entry point sample exceeds an HAL, the Cities and any suppliers that purchase water from the Cities must issue a health advisory as soon as possible, but no later than 24 hours after receipt of results, stating that the water is not safe to drink. If a do not drink advisory is issued during the algal bloom event, **Appendix B** also includes a sample notification letter for when the bloom event has cleared and it is safe to resume drinking the Cities' distribution system water.

If cyanotoxins are detected in a raw or finished water sample, the Cities should follow the recommendations in **Table 3-6** for issuing a health advisory, as recommended in DOH Guidance 331-654.

Table 3-6

Recommended Health Advisories for Detection of Cyanotoxins
[Excerpted from Table 7 of DOH Guidance 331-654]

Location	Cyanotoxin Level	Health Advisory	Followup
Raw Water Only	Above detection limit	Not recommended*	Continue raw water monitoring.
Finished Water	Below HALs	Not recommended*	Continue finished water monitoring. Include detection in Consumer Confidence Report.
Finished Water (initial sample)	At or above HALs	Not recommended*	Monitor according to **Tables 3-4** and **3-5**.
Finished Water (Confirmed)	At or above HALs	Issue Do Not Drink advisory within 24 hours of receiving sample results	Issue a second notice to remove the advisory after two consecutive finished water samples are below HALs.

* Communicate results to customers per the Cities communication plans.

It should be noted, "Do Not Drink" advisories do not allow customers to boil or treat their water; they must obtain bottled water for cooking and drinking.

In addition to notification letters, the Cities should also consider local cell phone distribution messaging (i.e. CodeRED integrated Public Alert Warning System) or other media outlets that can be used for rapid and widespread distribution of notices, including TV, social media, etc. If the Cities serve customers that speak any non-English language that exceeds 5 percent of the population (i.e. Spanish), the sample letters in **Appendix B** also may need to be translated into those languages to reach as many customers as possible.

Notifications

Raw Water Detection

If cyanotoxins are detected in a raw water sample below the HAL, Cities (except West Richland) should notify the following staff:

- Water treatment and water resources staff.
- Water operations and engineering supervisors email group.
- City Manager, communications, and marketing staff.

If cyanotoxins are detected in a raw water sample at levels greater than or equal to the HALs, Cities should make the following notifications:

- DOH within 1 business day.
- Water treatment and water resources staff.
- Purchasing water systems (if applicable).
- All managers and supervisors.
- City Manager and other leadership.

Finished Water Detection

If a finished water sample detects any cyanotoxins, the following staff should be notified:

- Water treatment and water resources staff.
    - Include results with notification so a treatment program can be determined.
- Water operations and engineering supervisors email group.
- City leadership and DOH.

Entry Point Detection

Entry point detections (source water exiting the treatment plant and entering the distribution system) at least 50 percent of the HAL will require initiation of the Cities’ Incident Command System (ICS), as discussed in **Chapter 4**.

If an entry point detects any cyanotoxins, the following notifications should be made:

- DOH within 1 business day.
- Water treatment and water resources staff.
- Purchasing water systems (if applicable).

- Water operations and engineering supervisors email group.
- Initiate ICS to manage customer notifications and the media, as outlined in the **Level 1 Emergency** section in **Chapter 4**.

If a confirmed entry point sample detects cyanotoxins at or above the HALs for sensitive groups (.03 µg/L), Cities (except West Richland) should make the following notifications:

- DOH as soon as possible, but no later than 24 hours after receipt of the results.
- Water treatment and water resources staff.
- Purchasing water systems within 24 hours (if applicable).
  - Explain that confirmation sampling is in process.
- ICS, as outlined in the **Level 2 Emergency** section of **Chapter 4**.

If an entry point sample results in a confirmed detection of cyanotoxins at or above the HALs for all users (1.6µg/L), the following notifications should be made:

- DOH as soon as possible, but in general no later than 8 hours.
- Water treatment and water resources staff.
- Purchasing water systems within 8 hours (if applicable).
  - Purchasing systems will need to coordinate with DOH to determine their requirements.
- ICS as outlined in the **Level 3 Emergency** section of **Chapter 4**.

Entry Point High Color Detection

If potassium permanganate is fed to mitigate cyanotoxins and the permanganate sensor(s) downstream of the clearwell and/or distribution entry is higher than normal, resulting in water with a tint of pink color. The Cities or BFHD should be ready to notify customers that the water should be safe to drink with a slight pink tint and that boiling the water may accelerate the dissolving of pink color into the water.

Agency Contacts

The following local and state agencies are available to provide technical assistance or support to the Cities during a harmful algal bloom event:

- DOH Office of Drinking Water, Eastern Regional Office: (509) 329-2100.
- DOH Office of Environmental Public Health Sciences: (360) 236-3359.
- Washington State Department of Ecology, Central Regional Office (for Benton County): (509) 575-2490
- Washington State Department of Ecology, Eastern Regional Office (for Franklin County): (509) 329-3400.
- Benton-Franklin Health District: (509) 460-4200 or (509) 547-9737.

4 | LONG-TERM PLANNING

INTRODUCTION

In addition to planning for a potential harmful algal bloom (HAB) event in the near term, the Cities (Richland, West Richland, Pasco, and Kennewick) should be evaluating long-term efforts to protect their water sources and customers. This chapter of the Algal Bloom Management and Response Plan will discuss the capital improvements needed to optimize treatment for a bloom event consisting of microcystins or anatoxin-a, as well as long-term water system planning and Emergency Response Plan efforts.

CAPITAL IMPROVEMENT PLAN

The capital improvement projects that follow identify improvements needed at the Cities' Columbia River source facilities to effectively treat for anatoxin-a and microcystins. **Chapter 2** includes more detailed information about the Cities' existing treatment plants and processes.

City of Kennewick

Water Treatment Plant

To date, no finished water samples from the City of Kennewick (Kennewick) Columbia River surface Water Treatment Plant (WTP) have indicated an anatoxin-a breakthrough while permanganate was actively being injected; therefore, no major process improvements are recommended at this time. However, Kennewick should plan to continue monitoring and injecting permanganate as part of normal operations. It is recommended that during a HAB event, additional samples be collected downstream of the inclined plates to evaluate the implications of dosing permanganate upstream of chlorine.

Ranney Wells

In the event that cyanobacteria/cyanotoxins sampling upstream and downstream of the wells shows that the riverbank is not effective at filtering out bacteria then additional treatment will be necessary. The Ranney wells rely upon ultraviolet light (UV) disinfection systems and chlorine residual, which alone are reportedly ineffective at comprehensive cyanotoxin removal. It is recommended to install an additional tote tank or batch mixer chemical feed system upstream of the UV reactors for increased operational flexibility. An added chemical feed point upstream of the reactors provides opportunity for operators to add UV-catalyzed advanced oxidation processes (AOPs) that may prove useful in mitigating the effects of a HAB. Installation of the additional chemical feed equipment is estimated to cost approximately $200,000. No treatment or monitoring is required after the AOP, but cyanobacteria samples can be collected to verify inactivation.

City of Pasco

Butterfield Water Treatment Plant

The City of Pasco's (Pasco) Butterfield WTP currently injects permanganate and chlorine at the head of the plant. Relocating the point of permanganate or chlorine injection upstream of the plant, closer to the raw water intake, would yield significantly increased contact time. The Butterfield WTP filter backwash retention basins and drying bed are located on a separate Pasco-owned property along S 12th Avenue, upstream of the Butterfield WTP. Installation of an additional chemical injection facility at this location could yield up to an additional 1,600 feet of contact piping. The facility could consist of a pre-fabricated building with space for a tote tank or batch mixers and a metering pump. Pasco could experiment with dosing oxidants at this location. For example, increased permanganate doses could be injected without color breakthrough concerns or pre-chlorination could occur significantly upstream of the permanganate dosing. The location also could serve to test additional oxidants as more insight is gained into the best solution to HAB mitigation. The proposed location has frontage along the existing raw water line, as well as an existing water service and convenient access to nearby power, as shown on **Figure 3**. This approach is recommended as the preferred long-term alternative for the Butterfield WTP and is estimated to cost approximately $250,000, which includes the pre-fabricated building, mechanical metering pump, pipe, and fittings, electrical power and communications conduit and wiring, and supervisory control and data acquisition (SCADA) control improvements.

West Pasco Water Treatment Plant

Pasco's West Pasco Water Treatment Plant (WPWTP) is considered the Cities most vulnerable treatment facility during a HAB. The WPWTP does not currently include an active chemical feed system that would effectively treat for anatoxin-a or microcystins, nor does it include conventional flocculation/sedimentation upstream of its membranes. The short-term cyanotoxin mitigation improvements should be implemented (described in **Chapter 2**), which include a permanganate feed system (tote tank or batch mixers and metering pump) that injects upstream of the membrane filters and one online permanganate sensor downstream of the clearwell as shown on **Figure 4**. Pasco is currently working with its membrane manufacturer to run small scale tests to determine the impacts permanganate may have on the membrane fibers, if any. Process recommendations will be provided once the testing results are available. Installation of the permanent chemical feed equipment is estimated to cost approximately $100,000, which includes the mechanical metering pump, pipe, and fittings, electrical power and communications conduit and wiring, and SCADA control improvements. Another cyanotoxin treatment process to consider for long-term planning is implementing an ozone feed system.

City of Richland

Columbia River Water Treatment Plant

The City of Richland's (Richland) Columbia River WTP currently injects sodium permanganate at the head of the plant and does not provide adequate mixing and contact time to alleviate color breakthrough at high doses. Relocating the point of injection upstream of the plant, to the raw water intake property on Snyder Street, would yield significantly increased contact time. Installation of an additional chemical injection facility at this location could yield up to an additional 1,500 feet of contact piping. The facility could consist of a small modular building with space for a tote tank or batch mixers and a metering pump. Richland could experiment with dosing oxidants at this location. For example, increased permanganate doses could be injected without color breakthrough concerns. The location could also serve to test additional oxidants as more insight is gained into the best solution to HAB mitigation. The proposed location has frontage along the existing raw water line, as well as an existing water service and power, as shown on **Figure 5**. Installation of the additional injection facility is estimated to cost approximately $250,000, which includes the pre-fabricated building, mechanical metering pump, pipe, and fittings, electrical power and communications conduit and wiring, and SCADA control improvements. The City also should plan on feeding permanganate downstream of filtration.

North Richland Wellfield

In the event that cyanobacteria/cyanotoxins are detected downstream of the infiltration basins, additional treatment will be necessary. The North Richland Wellfield relies upon UV disinfection systems and chlorine residual, which alone are reportedly ineffective at comprehensive cyanotoxin removal. It is recommended to install permanganate feed systems at the Snyder Street Intake, as well as downstream of filtration, for increased operational flexibility. An added injection point upstream of the reactors provides opportunity for operators to leverage UV-catalyzed AOPs that may prove useful in mitigating the effects of a HAB. It is recommended that one real-time permanganate sensor be installed upstream of chlorination. The SCADA system should be programmed to accept data from the analyzer and provide feedback control to the permanganate metering pump to maintain a setpoint dose. Installation of the additional injection equipment and analyzer is estimated to cost approximately $125,000, which includes the mechanical metering pump, pipe, and fittings, electrical power and communications conduit and wiring, and SCADA control improvements.

FUTURE WATER SYSTEM PLANNING EFFORTS

In addition to implementing the **Capital Improvement Plan** projects, the Cities should be considering long-term planning efforts that may assist with detecting, mitigating, and/or preventing future algal bloom events, which may include the need to treat different cyanobacteria (e.g., cylindrospermopsin or saxitoxins).

Longer term measures that may help mitigate or reduce algal bloom events in the Cities source water include adjusting the depths of source water intakes to draw from multiple intake depths or providing spatially separated intakes in the river. The Cities should work with the Washington State Departments of Health (DOH) and Ecology (Ecology), as needed, to determine if these improvements would prove helpful in a river source.

The Cities also should coordinate with Ecology and the U.S. Environmental Protection Agency (EPA) to continue investigating source pollution that may be creating HAB events in the Columbia River should it be determined that the pollution could be prevented and/or corrected, thereby lessening the likelihood of future algal bloom events. This effort is being planned with an unknown implementation schedule and outcome. The Cities can coordinate investigative samples in areas of interest to assess impacts from local activities.

If further measures are determined necessary, the Cities should include these elements in their future Water System Plan efforts and capital improvement budgets to ensure that the appropriate financing and resources are available to implement these efforts. It is recommended that the Cities review this Algal Bloom Management and Response Plan, the monitoring results, and recommendations from other agencies on a yearly basis to adjust and modify the approach over time as more information is developed and understood.

EMERGENCY RESPONSE PLAN

As discussed in the **Communications Plan** in **Chapter 3**, some HAB events may require the Cities to implement and notify their Incident Command System. As part of the recent America's Water Infrastructure Act, the Cities had to update their Emergency Response Plans (ERPs) and will need to continually do so on a 5-year schedule. The Cities should include algal bloom events in their next ERP update so that Incident Command and water system personnel will know how to respond in an emergency situation.

Incident Command System

During an emergency, it may be necessary to initiate the Cities' Incident Command System (ICS). ICS will manage agency coordination, informing the public and media, and other communications as deemed necessary for each emergency event. ICS will remain in place until entry point results have returned to "not detected."

The following cyanotoxin or cyanobacteria events may require activating the Cities' incident command. City staff should determine which type of HAB event requires notifying ICS and initiating emergency response protocols. City staff will review and update this plan as part of their next ERP updates.

Level 1 Emergency

If an entry point sample (treated water exiting the treatment facility and entering the distribution system), detects cyanotoxins below health advisory levels (HALs), then ICS should be notified to manage customer notifications and the media, as needed. This is considered a Level 1 Emergency, and does not present a health concern to the public at this time. A sample notification letter can be found in **Appendix B**.

Level 2 Emergency

If an entry point sample has a result greater than 0.3 micrograms per liter (µg/L) for total microcystins or anatoxin-a, then ICS should be notified. This is considered a Level 2 Emergency, as it presents a health concern to infants, children under 6 years of age, and susceptible adults (pregnant women, nursing mothers, immunocompromised, and dialysis patients). A sample notification letter can be found in **Appendix B**.

Level 3 Emergency

If an entry point sample has a confirmed anatoxin-a or microcystins result greater than or equal to their health advisory level, ICS should be notified to initiate the proper public notifications as soon as possible, but no later than 24 hours after receipt of the sample results. This is considered a Level 3 Emergency because it is a health concern to all customers. A sample notification letter can be found in **Appendix B**.

At this point, the notification letter will include a Do Not Drink advisory for all customers. It should be noted, customers will not be allowed to boil water to make it safe for drinking/cooking. The Cities should evaluate whether alternate emergency water sources will be made available to customers and include this language in the notification letters.

ICS will remain in place until two consecutive entry point samples have returned results that are below the HALs. At this point, the Cities should send out notification to their customers that is safe to resume drinking distribution system water (**Appendix B**).

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Figures

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FIGURE 1
KENNEWICK WATER TREATMENT PLANT

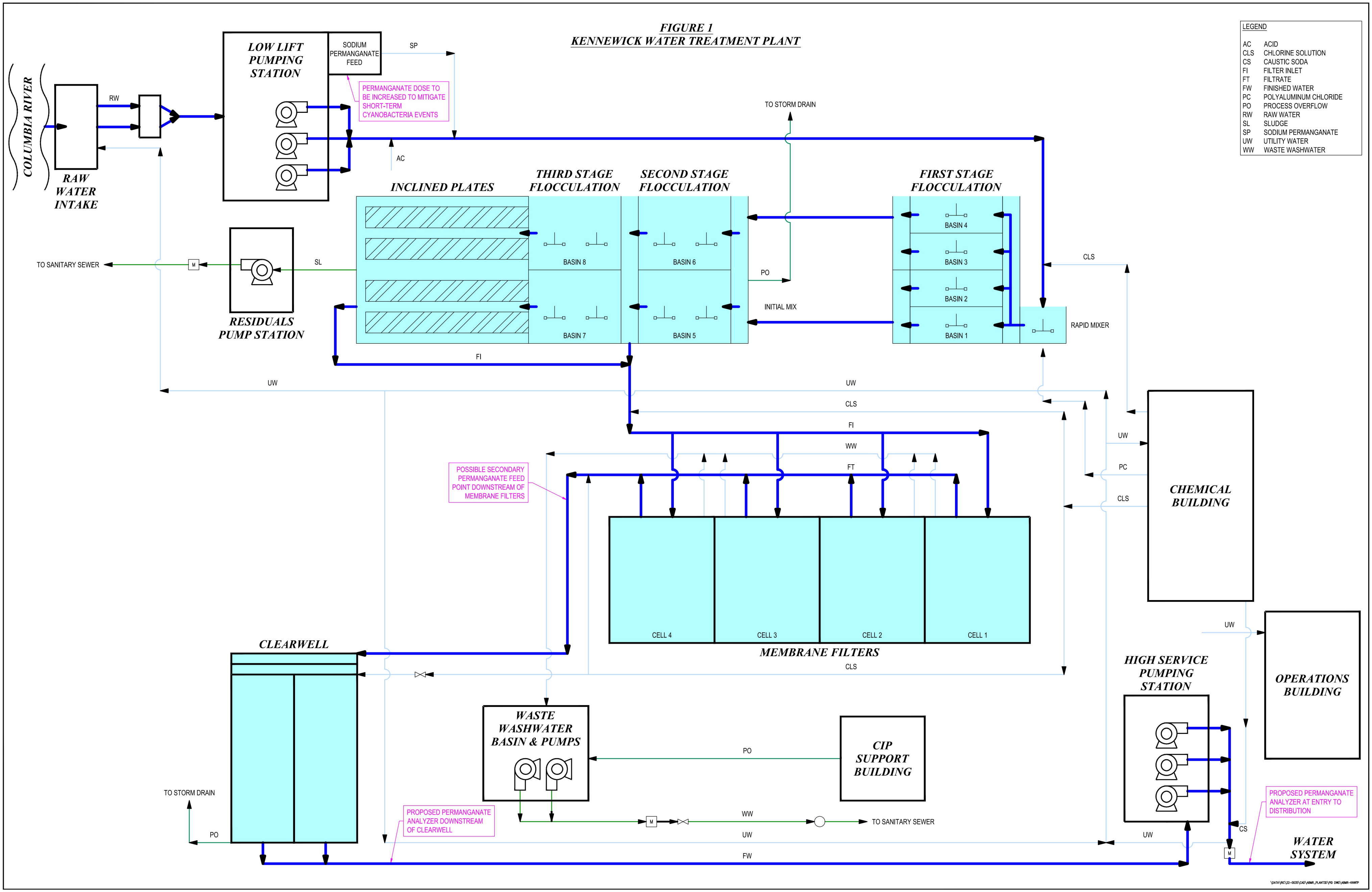


FIGURE 2
KENNEWICK RANNEY COLLECTOR NO. 5

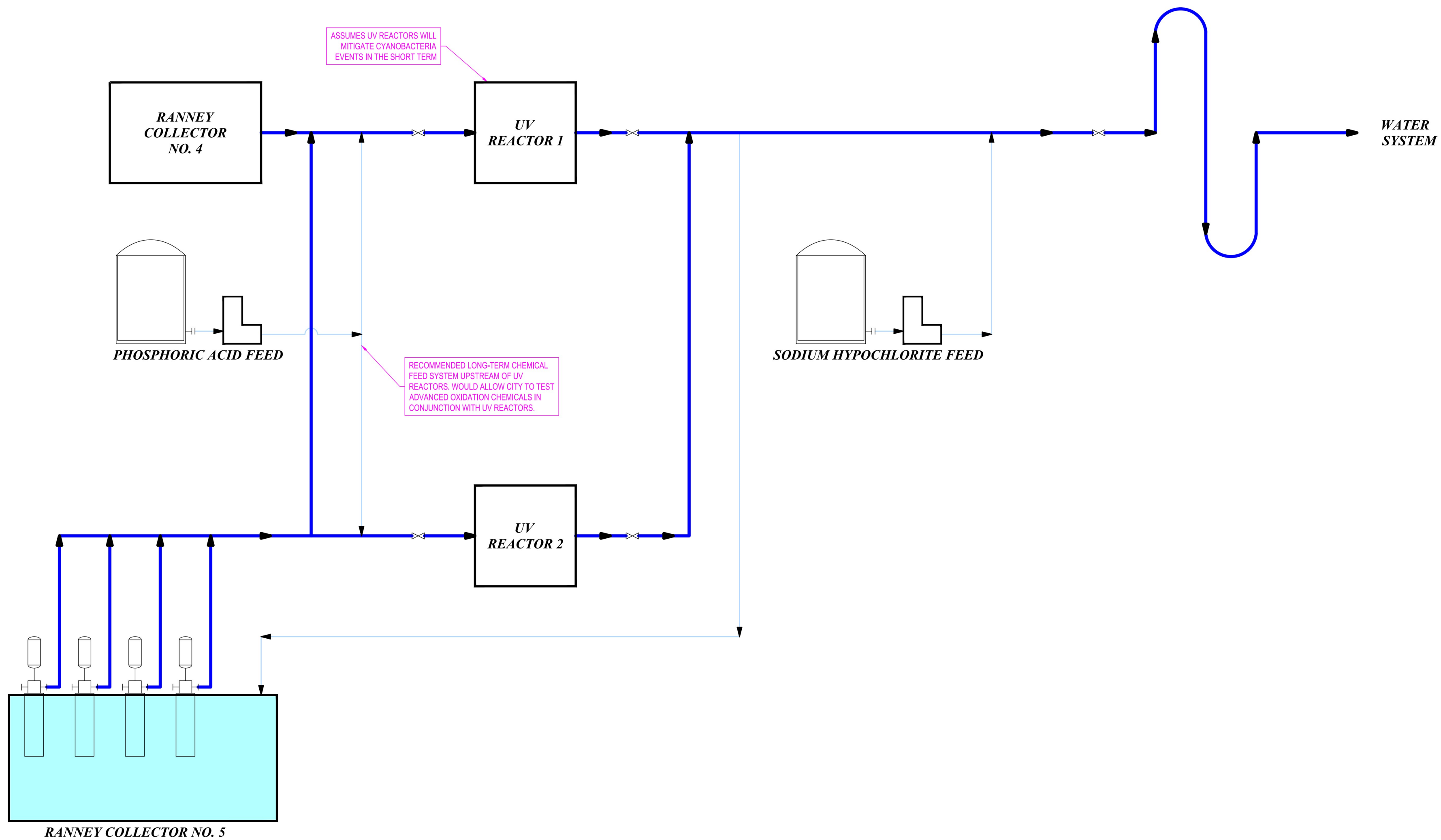


FIGURE 3
PASCO BUTTERFIELD WATER TREATMENT PLANT

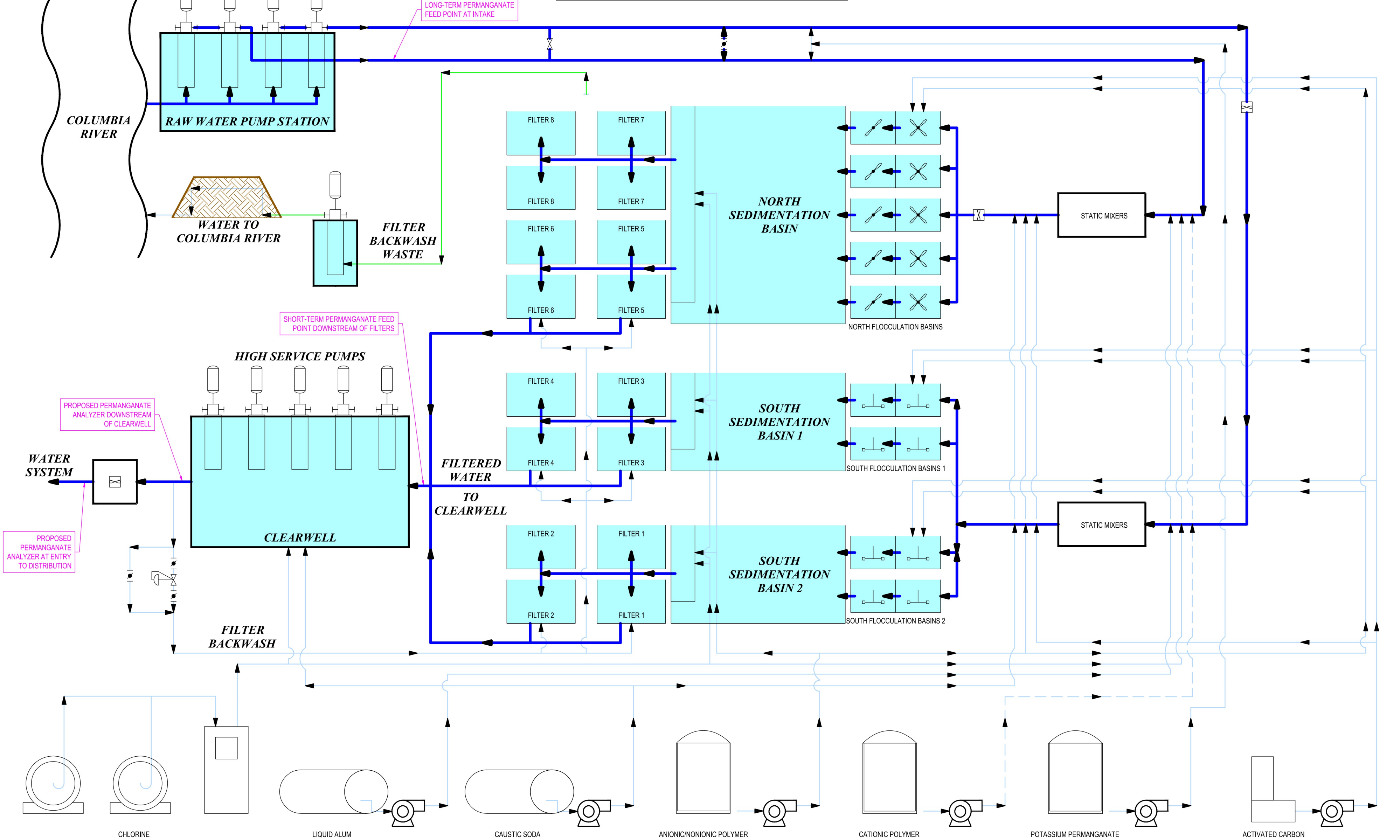


FIGURE 4
WEST PASCO WATER TREATMENT PLANT

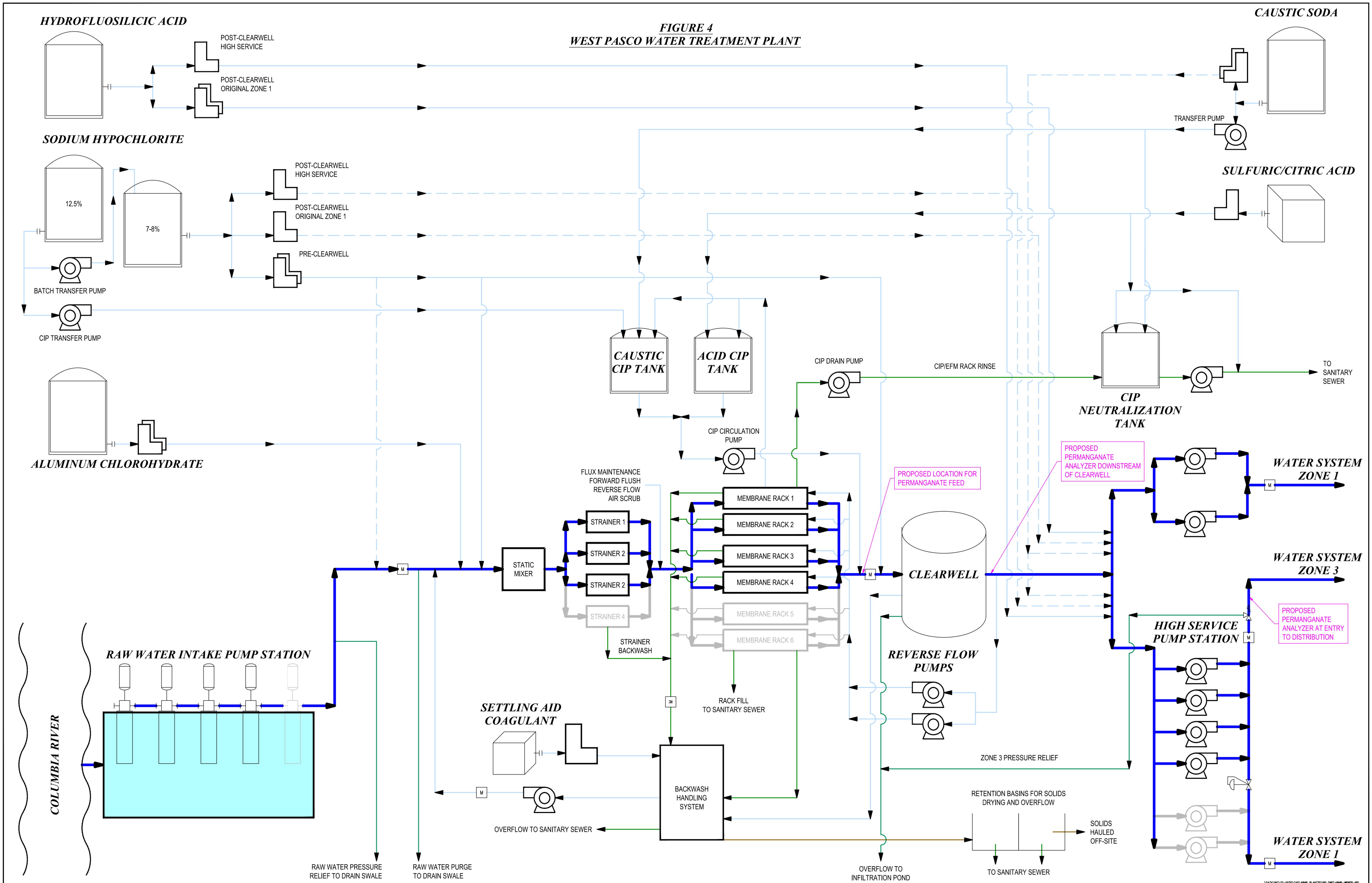


FIGURE 5
RICHLAND COLUMBIA WATER TREATMENT PLANT

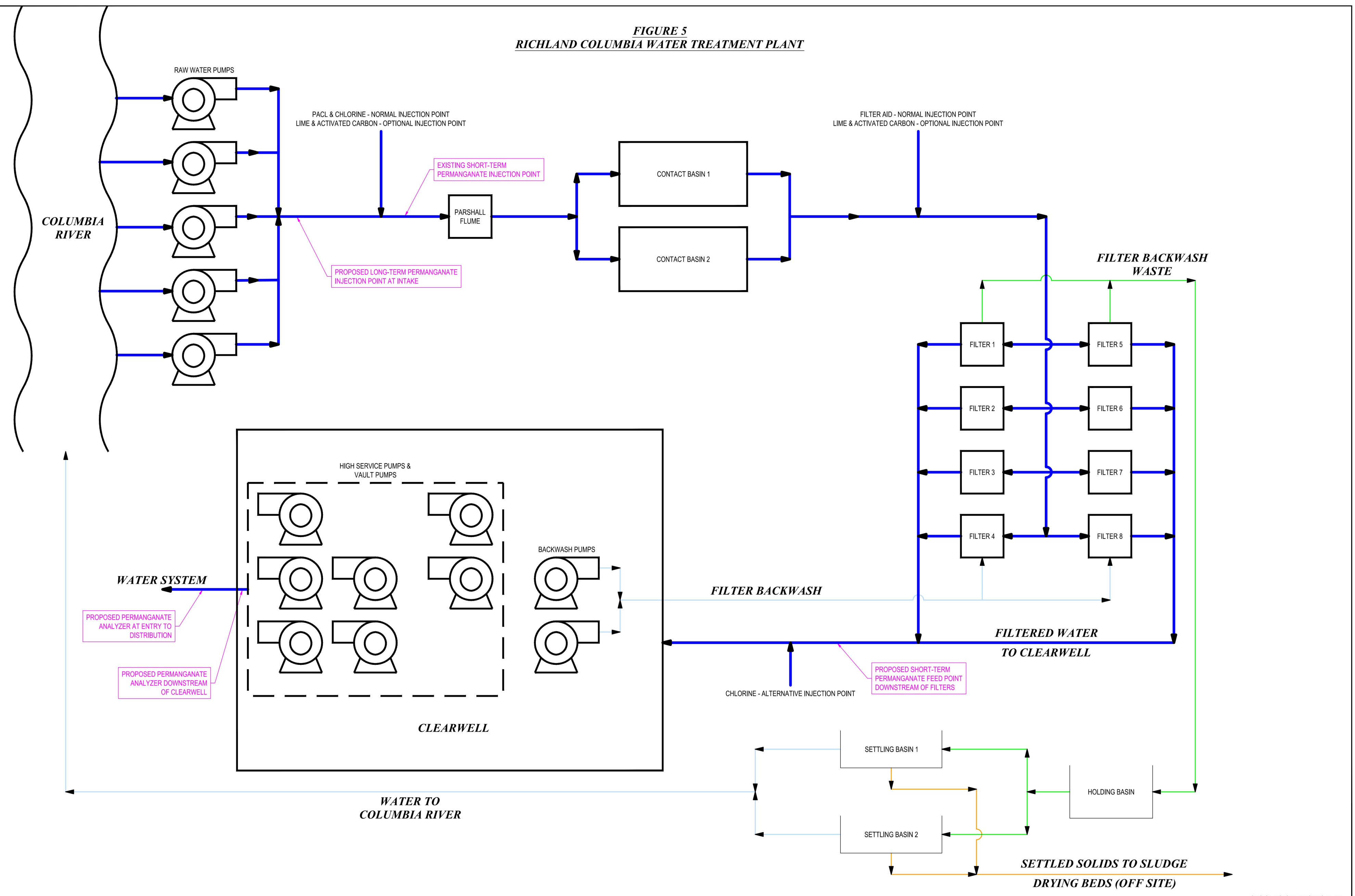
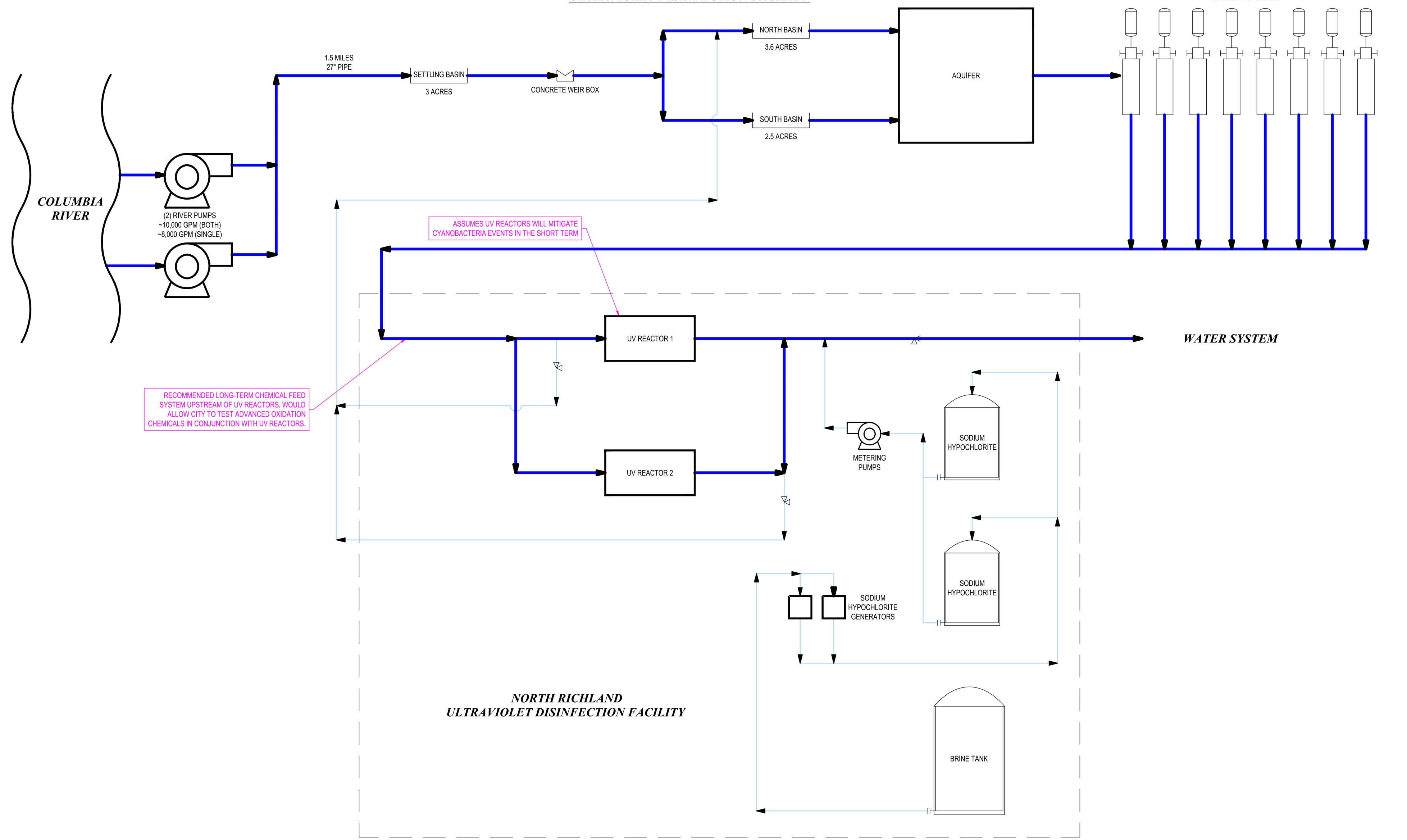


FIGURE 6
NORTH RICHLAND WELL FIELD
ULTRAVIOLET DISINFECTION FACILITY



Appendix A

Online Permanganate Analyzers

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PERMANGANATE SENSOR

PML SERIES

WATER QUALITY MONITORING SOLUTIONS

RH2 Note: This product is locally represented by TMG Services out of Tacoma, WA. RealTech has one ongoing successful application in Mississippi and hope to have more installs throughout the country soon. RealTech can provide a 30-day free trial to interested customers who pays for shipping of the system and provides a conditional purchase order for the ultimate purchase, if successful.

FEATURES & BENEFITS

- Affordable, real-time permanganate monitoring
- Outputs as permanganate (mg/L or µg/L)
- Operator friendly, low maintenance design
- Quick and simple optical measurements
- Long life LED technology
- Reagent free operation

REAL-TIME MONITORING SOLUTION

Permanganate Sensor

Real Tech's bypass Permanganate sensor has a very low detection limit that provides an early warning of overdosing, well before residual permanganate is visible in water. Designed with LED technology, this practical and affordable sensor measures permanganate continuously in real time.

Controllers and Accessories

Our innovative modular product platform ensures our clients gain the real-time water quality monitoring system that meets their specific demands and budget. With multiple controller and accessory options available such as automatic chemical cleaning systems that lower maintenance while improving system performance, Real Tech provides a total solution for all of your unique water quality needs.

Liquid Ai Compatible

Our Liquid Ai data services complement our real-time water quality monitoring systems. Our Remote Monitoring platform is a powerful data management and visualization tool that enables access to data anywhere, anytime.

MEASUREMENT PRINCIPLE

Real Tech's Permanganate sensor uses the absorbance of light at multiple wavelengths to accurately detect permanganate levels. Compounds that may interfere with measurement, such as particles, are compensated for using additional reference wavelengths. The sensor uses a unique long path length measurement cell which enables the detection levels and sensitivity required in drinking water applications. The result is reliable, low-cost, real-time measurement of permanganate in water.

PERMANGANATE SENSOR SPECIFICATIONS

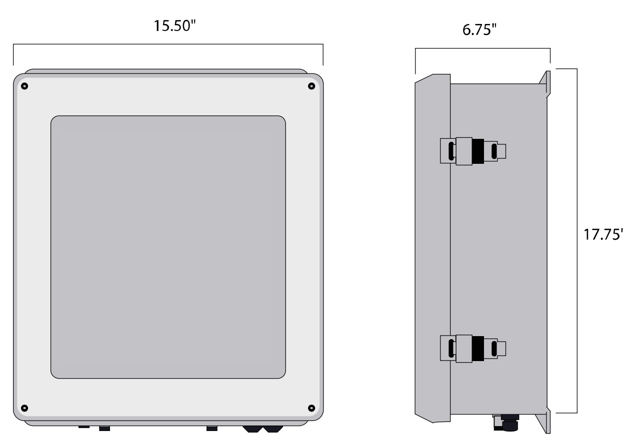
CHARACTERISTIC	TECHNICAL DATA			
MODEL	**PML4025**	**PML4050**	**PML4100**	**PML4150**
Path Length	25 mm	50 mm	100 mm	150 mm
Parameter	Permanganate			
Range	Depends on model selected. Refer to range chart on page 4.			
Units	mg/L, ug/L, ppm, ppb			
Sampling Time	30 seconds			
Calibration	Factory calibrated. Field adjustment of calibration is possible.			
Cleaning	In-situ chemical cleaning makes cleaning quick and easy. Automatic chemical cleaning is optional.			
Self-Diagnostics	Detection and diagnosis of internal system fault			
Alarms	Dry contact terminals allow for operator configurable alarms for: high and low set points, low lamp output, leaks, system fault, etc.			
Humidity Control	Humidity sensor with large plug-in regenerating desiccant system			
Wavelength	Multiple wavelengths			
Light Source	LED			
Flow Rate	300-1000 mL/min			
Pressure Rating	20 PSI maximum			
Fluid Connections	1/4” OD tube push-in fittings			
Electrical/Comm.	From controller			
Storage Temp.	-20 to 60°C (-4 to 140°F)			
Operating Temp.	0 to 45°C (32 to 113°F)			
Enclosure	NEMA 4X, wall mountable			
Weight	24 lb			
Dimensions	17.75”H x 15.5”W x 6.75”D			
Warranty	2-year limited warranty (Extended care packages available)			
Sensor Upgrades	High Temp. Upgrade II			

* Technical Specifications are subject to change without notice.

DIMENSIONS

The permanganate sensors is a bypass cabinet instrument installed directly on a wall, railing or system backboard. Sample is supplied to the sensor from either a pressurized source.

DIMENSIONS FOR PERMANGANATE SENSOR



SENSOR MODELS & RANGE

Includes permanganate sensor, flow cell, calibration bottle and dehumidifier.
Controller and accessories sold separately.

MODEL#	PATH LENGTH	PERMANGANATE (mg/L)	PERMANGANATE (µg/L)
PML4025	25 mm	0.1 - 20	100 - 20,000
PML4050	50 mm	0.05 - 10	50 - 10,000
PML4100	100 mm	0.025 - 5	25 - 5,000
PML4150	150 mm	0.02 - 3.5	20 - 3,500

* Stated ranges are approximate, dependent on industry, site and application - contact Real Tech to confirm model selection.

CONTROLLERS

PRODUCT #	NAME	DESCRIPTION
S-169000	Real Controller	Wall mounted controller with 4-line x 20-character back lit LCD display for sensors
S-11TPC	Real Controller Pro	Wall mounted controller with touch panel PC interface (PC inside cabinet model)
S-11TPCD	Real Controller Pro	Wall mounted controller with touch panel PC interface (PC external on door model)

ACCESSORIES

PRODUCT #	NAME	DESCRIPTION
UVT-118010	Real Clean System II	Automatic chemical cleaning system for use with 4000 series models
S-1789121	Dual Feed II	Dual feed option includes Digital I/O module for use with controllers

Real Tech Inc.
1150 Champlain Court,
Whitby, Ontario L1N 6K9 Canada
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info@realtechwater.com

REAL TECH INC.

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REAL CONTROLLER

WATER QUALITY
MONITORING
SOLUTIONS

FEATURES & BENEFITS

- Simple to operate and control
- 4 line x 20 character backlit LCD
- Comprehensive hierarchical menu system
- Multiple sensor and accessory integration
- Modbus (RS485) and 4-20 mA output standard
- Optional WiFi, additional 4-20 mA, Modbus TCP, cell modem

OVERVIEW

The plug and play Real Controller provides a simplified version of the Real Controller Pro. Featuring a character LCD display, hierarchical menu system and correlation software. A single Real Tech sensor or multiple sensors and peripheral accessory devices can easily be controlled and configured from one location. Modbus RS485 and 4-20 mA are standard. Additional 4-20 mA, Dry contacts, WIFI module, Modbus TCP, and Cell module optional.

OPTIONAL UPGRADES

PRODUCT #	NAME	DESCRIPTION
S-164110	WIFI for Real Controller	WIFI module for remote connectivity
S-168111	4-20 mA input (4)	4-20 mA input module, four channel
S-178113	4-20 mA output (1)	4-20 mA output module, one channel
S-178114	4-20 mA output (2)	4-20 mA output module, two channel
S-178115	4-20 mA output (4)	4-20 mA output module, four channel
S-168120	Digital I/O dry contact module	4 input and 4 output dry contacts
S-164120	Modbus TCP	Modbus TCP (ethernet) for Real Controller
S-214101	Cell Modem	Connectivity via cell connection for any Real Tech Controller

REALTECH INC.

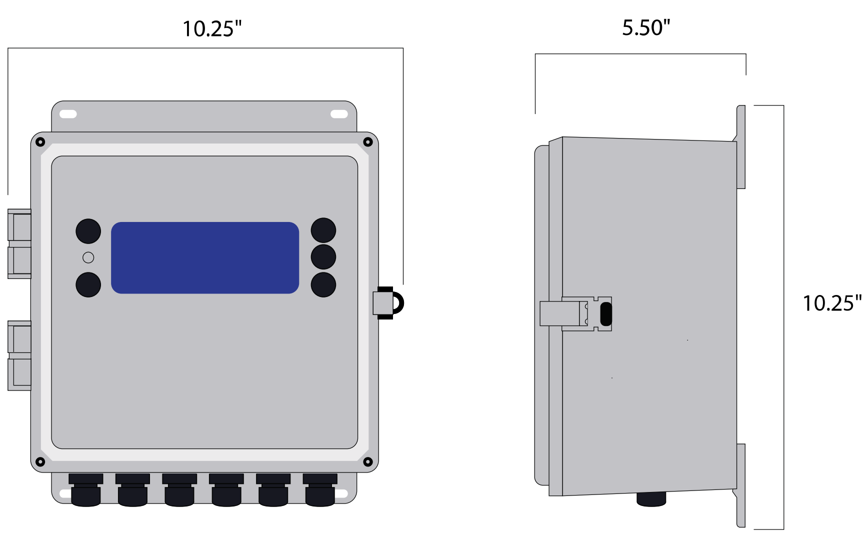
SPECIFICATIONS

CHARACTERISTIC	TECHNICAL DATA
Product #	S-169000
Compatibility	All sensors, except PL series sensor
Display	4 line x 20 character backlit LCD with LED indicator
Operator Interface	Five push buttons to control a comprehensive hierarchical menu system
Inputs	Proprietary inputs for Real Tech sensors and accessories. Optional 4-20 mA inputs for plug and play sensors, dry contact inputs.
Alarms	Display of sensor specific alarms.
Communication	Modbus (RS485) and 4-20 mA standard. Additional 4-20 mA input and output, Digital I/O expansions, Modbus TCP and WIFI optional.
Data Logging	Onboard. 6-month nominal (configuration dependent). Optional remote data logging. Export data via USB.
Electrical	24VDC 13.4A power adapter (accepts 90-250VAC 50/60Hz)
Enclosure	NEMA 4, wall mountable
Dimensions	10.25"H x 10.25"W x 5.5"D
Operating Temp	0 to 45°C (32 to 113°F)
Storage Temp	-20 to 60°C (-4 to 140°F)
Weight	8 lb
Warranty	2-year limited warranty

* Technical Specifications are subject to change without notice.

DIMENSIONS

The Real Controller is installed directly on a wall, railing or system backboard.



Real Tech Inc.
1150 Champlain Court,
Whitby, Ontario L1N 6K9 Canada
TF: 1.877.779.2888 T: 1.905.665.6888
info@realtechwater.com

REALTECH INC.

CLEAN SYSTEMS

WATER QUALITY
MONITORING
SOLUTIONS

FEATURES & BENEFITS

- Saves time and lowers maintenance
- Limits flow cell fouling and enhances performance
- User configurable automatic cleaning cycle
- Recapture feature recycles cleaning fluid
- Long life peristaltic chemical pump

OVERVIEW

Real Tech's automatic chemical cleaning systems offer the most effective method for cleaning optical sensors. Cleaning fluid and frequency can be set to site specific needs, ensuring the target fouling agents are removed effectively and measurement drift is minimized.
The automatic cleaning cycles save time and lower maintenance while improving overall operation and accuracy of the instrument.

MODELS

PRODUCT #	NAME	DESCRIPTION
UVT-078130	Real Clean System I	Automatic chemical cleaning system for use with 2000 and 3000 series models
UVT-118010	Real Clean System II	Automatic chemical cleaning system for use with 4000 series models

The Real Clean systems are designed for use with pressurized sample water (300-1000 mL/min) and minimal solids in the sample stream (<10 mg/L TSS).

REALTECH INC.

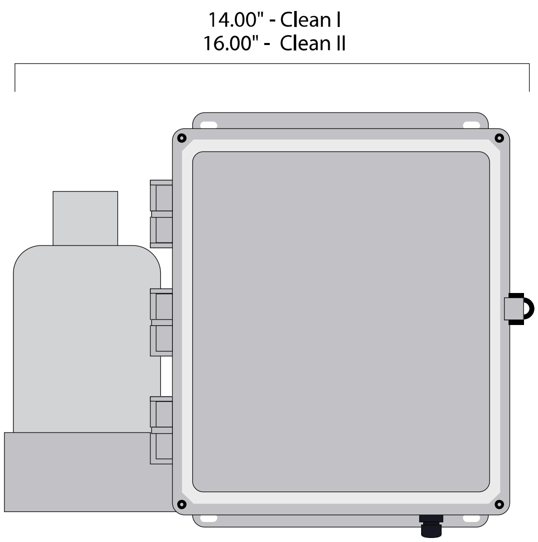
SPECIFICATIONS

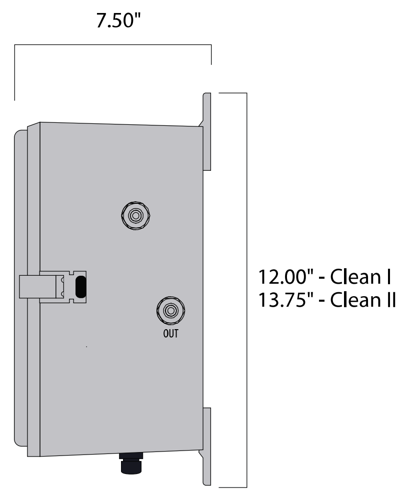
CHARACTERISTIC	TECHNICAL DATA
Cleaning Frequency	User configurable
Cleaning Capacity	1L storage container, cleaning fluid recapture feature reduces fluid replenishment frequency
Min Flow Rate	300mL/min
Max Flow Rate	1000mL/min
Max Pressure	20 PSI
Alarms	Leak, Cleaning Fluid Low, Cleaning Fluid Empty
Electrical/Communication	From controller/ analyzer
Dimensions	12.0"H x 14.0"W x 7.5"D (Real Clean System I) or 13.75"H x 16.0"W x 7.5"D (Real Clean System II)
Enclosure	NEMA 4, wall mountable
Fluid Connections	1/4" tube push-in fittings
Storage Temp.	-20 to 60°C (-4 to 140°F)
Operating Temp.	0 to 45°C (32 to 113°F)
Weight	10 lb
Warranty	2-year limited warranty

* Technical Specifications are subject to change without notice.

DIMENSIONS

The Real Clean systems are installed directly on a wall, railing or system backboard.





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Appendix B

Sample Health Advisory Letters

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DRINKING WATER WARNING

Microcystins Health Advisory

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

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

> Bottle-fed infants and children younger than six years old, pregnant women, nursing mothers, those with pre-existing liver conditions, those receiving dialysis treatment, the elderly, and immune-compromised individuals.

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

What should I do?

Alternative water, such as commercially-available bottled water, should be used for drinking, making infant formula, making ice, brushing teeth, and preparing food for bottle-fed infants, children younger than six years old, pregnant women, nursing mothers, those with pre-existing liver conditions, those receiving dialysis treatment, the elderly, and immune-compromised individuals.

Healthy children above the age of six and adults not in the categories listed above may drink the water. Water may be used by all individuals for bathing, washing hands, washing dishes, doing laundry, and flushing toilets. Children younger than 6 years of age must be supervised while bathing to prevent accidental ingestion of water. After bathing provide a final rinse of skin with uncontaminated water for people with open wounds or skin conditions such as eczema.

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

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

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

What happened? What is being done?

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

For more information, please contact ___________________________at____________________.

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

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

DRINKING WATER WARNING

Microcystins Health Advisory

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

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

Consuming water containing concentrations of microcystins over the action level may result in abnormal liver function, diarrhea, vomiting, nausea, numbness or dizziness. Children younger than six years of age, pregnant women, nursing mothers, the elderly, immune-compromised individuals, those with pre-existing liver conditions and those receiving dialysis treatment may be more susceptible than the general population to the health effects of microcystins. Seek medical attention if you or anyone in your family is experiencing any of these symptoms.

What should I do?

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

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

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

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

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

What happened? What is being done?

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For more information, please contact ___________________________at____________________.

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

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

Insert Date

For More Information Contact:
First Name, Last Name, (509) XXX-XXXX
City of ____________

City of _____ Detects Low Levels of Toxins in Drinking Water

The City of ____________ has detected low levels of cyanotoxin in our tap water – well below established health advisory levels -- and is notifying all customers out of an abundance of caution.

The City routinely monitors for the presence of contaminants in our treated drinking water that is provided through our [**surface water source name**] and delivered to your home or business via our water distribution system. Confirmed results on [**date**] detected [**toxin detected**]. The detection value of [**value]** is below regulatory health advisory levels of [**value**] parts per billion for vulnerable populations, and below limits of [**value**] parts per billion for healthy adults.

The [**microcystin/cylindrospermopsin**] is a by-product of certain algae species that naturally grow in water. The City regularly monitors at the water treatment plant intake as well as [**add other sampling locations**] within the Columbia River watershed for toxic algae blooms.

Although results are below levels considered dangerous by state and federal health authorities, as our customers, you have a right to know that [**toxin**] has been detected in extremely low levels, what you should do, and what we are doing to proactively address this situation.

What does this mean?
At the current levels detected, there are no health concerns with consuming the water.

What is being done?
The City continues to work with the Washington State Department of Health to monitor and test the water treatment plant intake and treated drinking water exiting the plant for cyanotoxins on a [**daily**] basis. In addition, the City continues to adjust our treatment process to mitigate the presence of cyanotoxins. If your water is slightly pink in color at this time that is due to additional disinfectant added to destroy the cyanotoxins. Boiling colored water should remove the pink color and make it more safe to drink. [**Daily**] testing will continue until we detect no toxins in the treated drinking water. The City updates its website daily as new test results are received to make sure our customers have the most up to date information.

For more information, go to [**web address**].

Insert Date

For More Information Contact:
First Name, Last Name, (509) XXX-XXXX
City of ____________

City of _____ Issues Do Not Drink Water Advisory for Vulnerable Populations

The City of ____________ has detected levels of cyanotoxin in our tap water above regulatory health advisory levels for infants, children under the age of 6, nursing mothers, pregnant women, those with pre-existing liver conditions and those receiving dialysis treatments. The City is asking those customers not to drink tap water. <u>Boiling water **does not** make it safe to drink for these vulnerable populations.</u>

The City routinely monitors for the presence of contaminants in our treated drinking water that is provided through our [**surface water source name**] and delivered to your home or business via our water distribution system. Confirmed results on [**date**] exceeded the Washington State Department of Health's toxicity value for the cyanotoxin [**microcystin/cylindrospermopsin**] for vulnerable populations. The detection value of [**value]** is above DOH limits of [**value**] for vulnerable populations. The water is considered safe for healthy adults.

The [**microcystin/cylindrospermopsin**] is a by-product of certain algae species that naturally grow in water. This cyanotoxin eluded the City's treatment process to enter into the tap water at levels that pose a health threat to vulnerable populations resulting in this do not drink advisory for that select portion of the population.

What should I do?

Drinking water above the acute toxicity value of [x] ug/L of [toxin] is not advised for vulnerable populations. You should use an alternative (e.g., bottled) water supply. If you have specific health concerns, consult your doctor. Tap water can continue to be used for non-consumptive activities like bathing and washing clothes.

What does this mean?

Consuming water containing concentrations of cyanotoxins over the health advisory level for more than 10 days may result in upset stomach, diarrhea, vomiting, as well as liver or kidney damage. Seek medical attention if you or your family members experience illness.

What is being done?

The City continues to work with DOH to monitor and test the water treatment plant intake, treated drinking water exiting the plant, and throughout the distribution system for cyanotoxins on a [**daily**] basis. In addition, the City continues to adjust our treatment process to mitigate the presence of cyanotoxins. The City is providing alternative sources of drinking water for our vulnerable customers. Please check [**web address**] for water station locations near you. [**Daily**] testing will continue until we detect no toxins in the distribution system that delivers drinking water to your house. The City updates its website daily with water station locations and as new test results are received to make sure our customers have the most up to date information.

For more information, go to [**web address**].

Insert Date

For More Information Contact:
First Name, Last Name, (509) XXX-XXXX
City of ____________

City of _____ Issues Do Not Drink/Do Not Boil Water Advisory for All Customers

The City of ____________ has detected levels of cyanotoxin above regulatory health advisory levels in our tap water and is asking all customers to avoid drinking tap water. <u>Boiling water does not make it safe to drink.</u>

The City routinely monitors for the presence of contaminants in our treated drinking water that is provided through our [**surface water source name**] and delivered to your home or business via our water distribution system. Confirmed results on [**date**] exceeded the Washington State Department of Health's acute toxicity value for the cyanotoxin [**microcystin/cylindrospermopsin**]. The detection value of [**value]** is above DOH health limits of [**value**].

The [**microcystin/cylindrospermopsin**] is a by-product of certain algae species that naturally grow in water. This cyanotoxin eluded the City's treatment process to enter into the tap water at levels that pose a health threat to anyone consuming the water, resulting in this do not drink advisory for all City customers.

What should I do?

Drinking water above the acute toxicity value of [x] ug/L of [toxin] is not advised for any person, pet, or livestock. You should use an alternative (e.g., bottled) water supply. If you have specific health concerns, consult your doctor. Tap water can continue to be used for non-consumptive activities like bathing and washing clothes.

What does this mean?

Consuming water containing concentrations of cyanotoxins over the health advisory level for more than 10 days may result in upset stomach, diarrhea, vomiting, as well as liver or kidney damage. Seek medical attention if you or your family members experience illness.

What is being done?

The City continues to work with DOH to monitor and test the water treatment plant intake, treated drinking water exiting the plant, and throughout the distribution system for cyanotoxins on a [**daily**] basis. In addition, the City continues to adjust our treatment process to mitigate the presence of cyanotoxins. The City is providing alternative sources of drinking water for our customers. Please check [**web address**] for water station locations near you. [**Daily**] testing will continue until we detect no toxins in the distribution system that delivers drinking water to your house. The City updates its website daily with water station locations and as new test results are received to make sure our customers have the most up to date information.

For more information, go to [**web address**].

Insert Date

For More Information Contact:
First Name, Last Name, (509) XXX-XXXX
City of ____________

City of _____ Lifts Do Not Drink/Do Not Boil Water Advisory

The City of ____________ on [**date/time**] lifted the Do Not Drink and Do Not Boil drinking water advisory for [residents; or infants, young children under the age of six and other vulnerable populations].

Confirmed results on [**date**] were below the Washington State Department of Health's toxicity value for the cyanotoxin [**microcystin/cylindrospermopsin**] for [all customers/vulnerable populations]. The detection value of [**value]** was below DOH health advisory limits of [**value**] for [all customers/vulnerable populations]. The water is considered safe for [healthy adults/all customers].

Residents may resume using tap water for all purposes. Customers should flush their household water systems for [**10 minutes**] to ensure any trace amounts of the cyanotoxin are expunged.

[**Microcystin/Cylindrospermopsin**], a toxin produced by cyanobacteria (formerly known as blue-green algae), was detected in the tap water at [**value**] on [**dates**], exceeding state regulatory levels for [all customers/vulnerable populations] that is set at [**value**]. A drinking water advisory was in place for [**# days**].

The City, working with DOH, quickly responded to mitigate the presence of [**microcystin/cylindrospermopsin**] by adjusting our treatment process.

The City will continue to regularly monitor at the water treatment plant intake as well as [**add other sampling locations**] within the Columbia River watershed for toxic algae blooms and presence of cyanotoxins. Please go to [**web address**] for the latest monitoring results.

For more information, go to [**web address**].