CITY OF Salem AT YOUR SERVICE

MEMO

TO: Mayor and City Councilors

THROUGH: Steve Powers, City Manager

FROM: Robert D. Chandler, PhD, PE, Assistant Director
Public Works Department

DATE: June 22, 2018

SUBJECT: **Summary of Actions to Address Cyanotoxins in Salem's Water Supply**

Mayor and City Councilors:

The purpose of this memorandum is to provide for you an overview of the issues and actions taken to date to address the risks associated with cyanotoxins in Salem's water supply. It is organized in two parts:

Part 1 presents an assessment of the current situation and provides an update on our actions to address the presence of cyanotoxins in our drinking water supply.

Part 2 is background information on Salem's water supply, treatment system, and harmful algal blooms.

The information presented in this memorandum is deliberately at a high level and is provided so you can better address the questions and concerns of your constituents. It also reflects current information and conditions at the time of the memo. This remains a dynamic situation with a number of factors outside of our control and things may change with little or no notice. We are committed to continuing to keep you, our residents, and customers informed. For answers to more detailed questions specific to Salem's actions:

- Conducting water operations: Mark Becktel, AICP, Public Works Operations Manager
- Constructing enhanced water treatment facilities: Brian Martin, PE, City Engineer

For more general information on the issues, options, and challenges related to cyanotoxins in water supplies, I recommend: "A Water Utility Manager's Guide to Cyanotoxins" (2015). This 2015 reference is jointly produced by the American Water Works Association and the Water Research Federation. It is available at http://www.waterrf.org/PublicReportLibrary/4548b.pdf.

Additionally, the City of Salem website (see https://www.cityofsalem.net/water-advisory) continues to provide updated information on the water advisory, including answers to commonly asked questions, water quality sample results, monitoring status, and links to information from the Oregon Health Authority and Environmental Protection Agency.

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PART 1 – SITUATION ASSESSMENT AND ACTIONS

Summary: Cyanotoxins have been identified in the source waters and the water distribution system in Salem. As an intermediate solution to remove the toxins at the Geren Island Water Treatment Facility, we will install a pretreatment system on the island that uses powdered activated carbon (PAC). Laboratory testing, pilot testing, and demonstration testing using a single sand filter cell all must be satisfactorily completed before full scale implementation of the PAC system. As of the date of this memorandum, laboratory testing has been completed satisfactorily, pilot testing is underway and nearly completed, and acquiring the material and constructing the PAC system is in progress for the demonstration testing. Demonstration testing is expected to commence during the week of June 25 and full scale implementation the week of July 2.

REMOVING CYANOTOXINS FROM THE WATER SUPPLY.
Salem's slow sand filtration water treatment system at Geren Island does not remove cyanotoxins; in fact, as the cyanobacteria move through the biofilm, also called the "schmutzdecke," and sand layer, the cells can be lysed resulting in a further release of toxins. The professional literature on cyanotoxins and municipal water supply identifies a number of treatment methods, all of which vary in effectiveness, costs, and feasibility. Given the nature and constraints of our water treatment plant at Geren Island in Stayton, there are two means available to address cyanotoxins: oxidation and adsorption.

In the short term, we have increased our dosage rate of chlorination to oxidize any cyanotoxins. (Oxidation changes the molecular structure so it is no longer toxic.) In the intermediate term, we will be implementing a method that involves using activated carbon to remove the cyanotoxins by adsorption before the water enters our sand filters. (Adsorption is what happens on the molecular level when one component is attracted to another because they have opposite electrical charges.) In the long term, we are evaluating the merits of installing an ozonation treatment system at Geren Island that will oxidize cyanotoxins prior to the water entering the slow sand filtration system. The cities of Wilsonville, Medford, and Lake Oswego all utilize ozone systems for their potable water treatment. Our current, very rough estimate of the cost to install a permanent ozonation treatment system at Geren Island is $40M.

THE INTERMEDIATE SOLUTION: POWDERED ACTIVATED CARBON.
In general, the method of using powdered activated carbon to remove cyanotoxins from the source water involves five steps:

Step 1. Add powdered activated carbon (PAC) to the water in the inlet channel after it has been drawn from the North Santiam River.

Step 2. Provide sufficient mixing and contact time between the PAC and the water to ensure cyanotoxins are adsorbed.

Step 3. Through a combination of gravity and added compounds—a combination of cationic polymer and alum—cause most of the PAC to settle before the water enters our filtration system.

Step 4. Send the PAC-treated water first to a roughing filter to then to the slow sand filters.

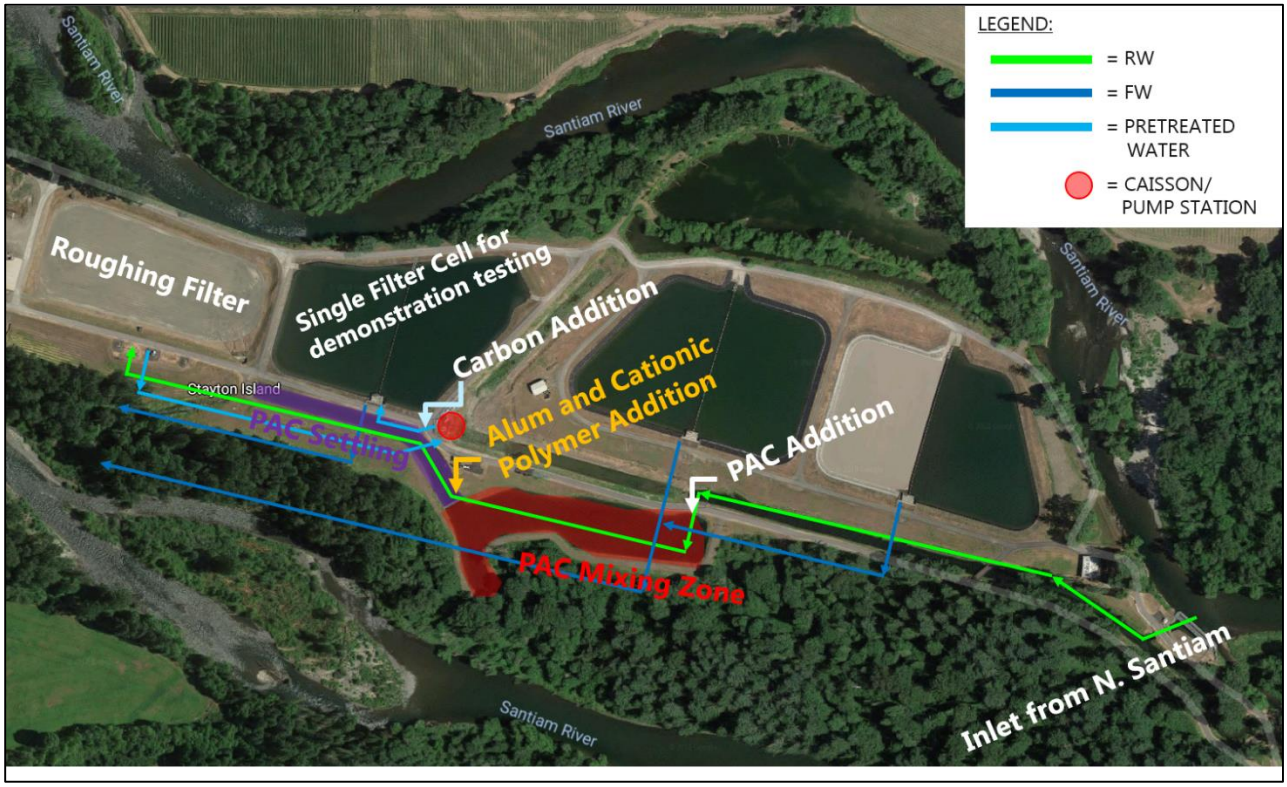
Step 5. Treat the water after the filters with chlorine and add, as necessary, a compound (we use soda ash) to maintain the proper pH. [Note that Step 5 is part of our normal, day-to-day drinking water treatment routine.]

Throughout the process and at various stages in the treatment train, water quality samples are taken to ensure toxins are removed and safe drinking water is delivered to our customers.

To ensure the PAC method will be effective at removing cyanotoxins, we have been working with Carollo Engineers, a nationwide environmental engineering firm. We have contracted with Carollo for many years of projects involving both water and wastewater treatment systems and they have on their staff recognized experts in slow sand filtration systems and cyanotoxins. Bench testing at the Carollo laboratory in Boise has shown PAC can be highly effective at removing cyanotoxins from drinking water. We are in the process of conducting a pilot test at Geren Island, the results of which will be used to evaluate the appropriate type of PAC (there are several) and ways to optimize settling of the PAC. The photos below show pilot testing in progress at Geren Island.

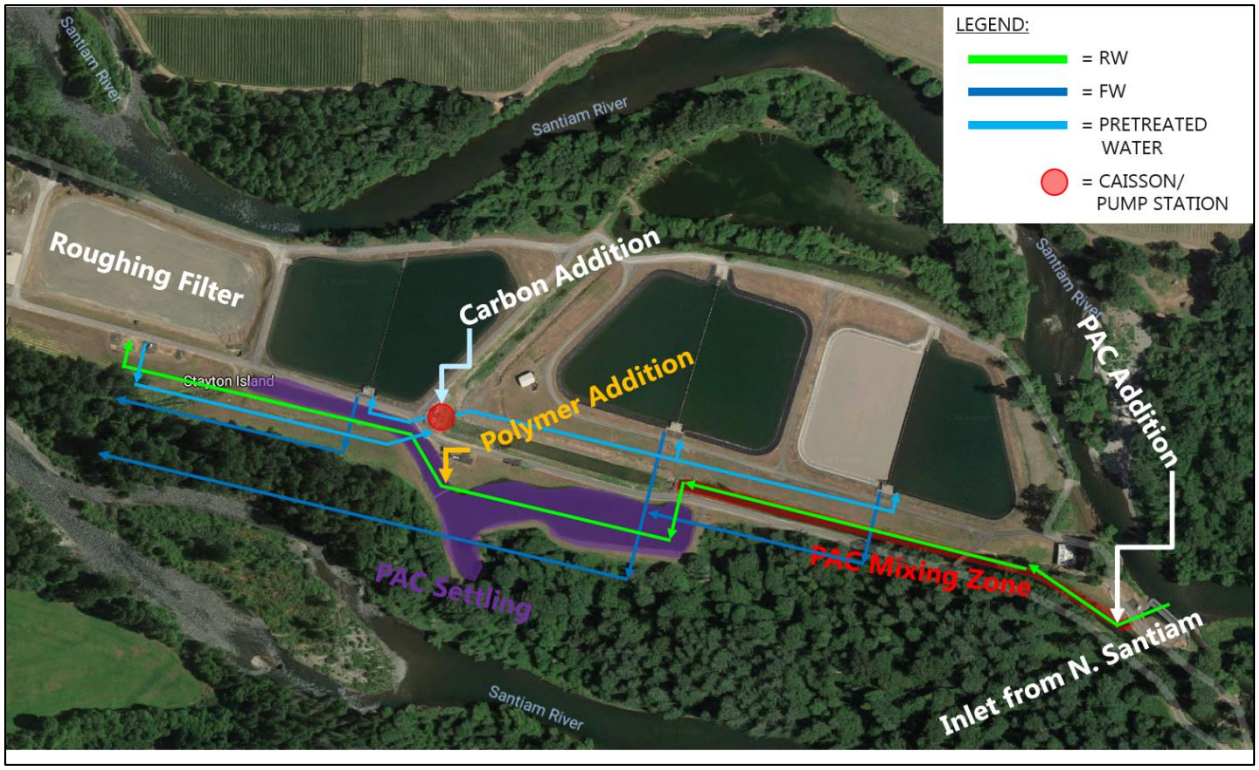
Pilot testing PAC injection and settling at Geren Island Water Treatment Plant.

Once we are satisfied with the results of the pilot tests, we will implement PAC treatment in two phases. The first phase is a single filter cell test. In this test, a portion of the raw water (RW) entering from North Santiam at the inlet is directed from the intake channel to the PAC mixing zone, which is located in the south channel. PAC is added as the flow enters the mixing zone, which is followed by the settling basin where alum and cationic polymer is added to aid in the settling process. The flow is then routed to the roughing filter where the more PAC can settle. [Our roughing filter is a sand filtration cell without a biofilm/schmutzdecke.] The remaining PAC will be removed as the water infiltrates through the roughing filter. The water that infiltrates into the ground water collection system (caisson) is then pumped to the single filter cell. Carbon in the form of ascetic acid will be added if necessary to provide the necessary nutrition for the biofilm at the surface of the sand filter. Finish water (FW) from the filter will be chlorinated and enter the water distribution system.



Geren Island Water Treatment Facility – First Phase of Demonstration Testing.

The second and final phase involves full implementation of the PAC treatment process involving all our filters and the full production system. Raw water (RW) enters from North Santiam at the inlet. PAC is injected and maintained in suspension as the water flows in the mixing zone in the intake channel. The water then enters the PAC settling zone in the south channel, where alum and cationic polymer are added to aid in the settling process. From the settling basin, the flow is directed to the roughing filter. From the roughing filter, the water will infiltrate into the caisson groundwater collection system to be pumped onto the slow sand filter system. Carbon, in the form of ascetic acid, can be added at the pump station as needed to provide nutrients for the sand filters biofilm. Upon leaving the sand filter(s), finish water (FW) will be treated with chlorine and enter the water distribution system.



Geren Island Water Treatment Facility – Full-scale implementation.

In addition to satisfactorily completing the pilot and demonstration phases of assurance testing, a number of items must be completed and in place prior to full implementation. Most of the below have been completed; final delivery of the last few items needed for full scale implementation is expected next week.

- Channel cleaning and dredging;
- PAC storage facility and PAC injection system;
- All treatment materials, including PAC, alum, cationic polymer, and ascetic acid (which will be used if necessary to provide nutrients for the health of the filter biofilm;
- Solar-powered, floating, portable mixing and circulation system to keep the PAC in suspension (we're using a system called SolarBee®);

- Cationic polymer and alum injection system to cause the PAC to settle;
- Backup generators for injection systems;
- Testing and calibration of system components; and
- Various piping, pumping, and wiring to support the operations.

Lastly, the Oregon Health Authority (OHA) will provide a conditional letter of approval to proceed with full scale implementation. We will submit a technical report to OHA early in the week of June 25 and expect to receive approval within one or two days.

CURRENT STATUS

As of noon on June 22: The powdered activated carbon (PAC) implementation at Geren Island is progressing well. We are currently pilot testing PAC on small controlled test filters at the island that replicate our actual sand filters. The pilot testing began last Friday, June 15, and will continue to run throughout the overall implementation process. The Pilot study is helping test the health of our sand filters after the toxins and other organics are removed, as well as determine carbon settling rates with and without polymer additives. Our testing has confirmed that polymers and alum will be required to settle the carbon before the water flows into our filters. These additives were incorporated into the pilot testing on Wednesday (6/20) and we will be fine tuning the optimal concentrations through the weekend.

Materials and equipment for the demonstration filter implementation arrived to the island this week and have been installed. We began testing the equipment today (6/22) and will continue to test and calibrate through the weekend so that the first phase (the roughing filter and single filter cell test) can begin on Monday, June 25.

Materials and equipment for the full implementation have been ordered and are either received or on their way to the Island. The last components for the full implementation are scheduled to arrive Thursday, June 28. Meanwhile, contractors have been at the island clearing the settling basins, building pads for the equipment, constructing secondary containment structures, and placing shelters for material storage.

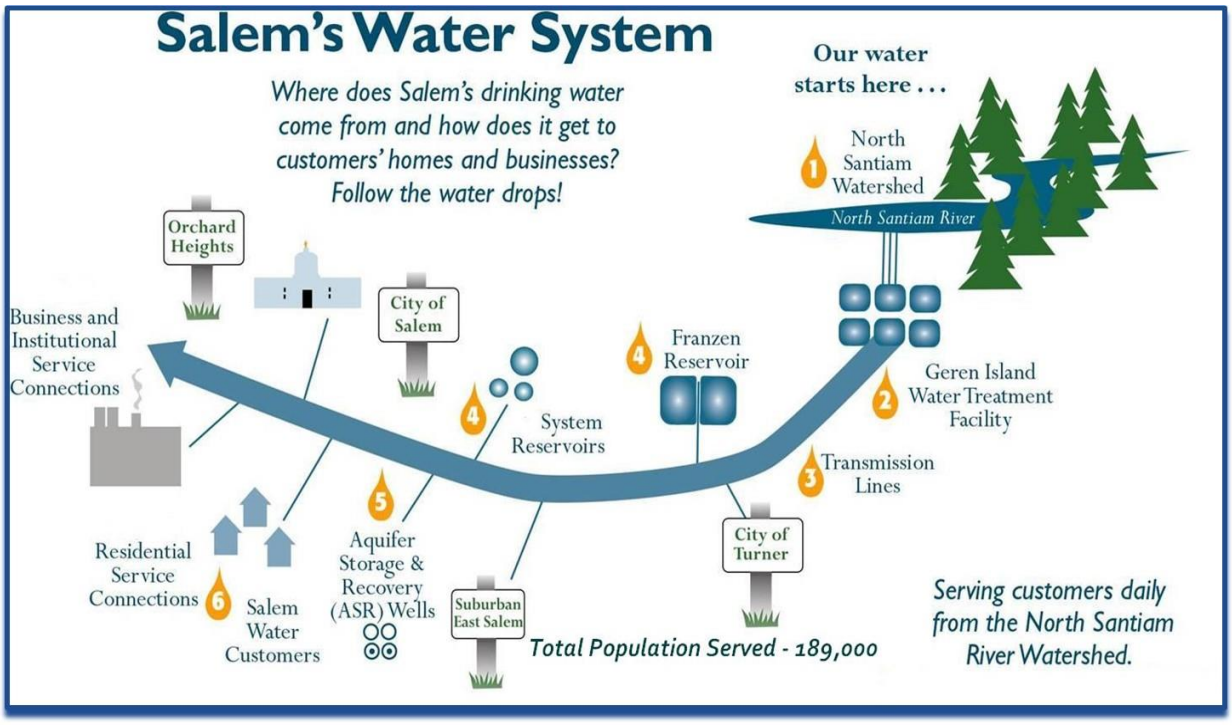
We will begin testing and calibrating equipment for the full implementation on Friday, June 29, and work through the weekend to reconfigure the system so that full implementation can begin on Monday, July 2. This will allow the demonstration filter to operate for one week before we apply PAC treated water to all of the filters.

PART 2 –SALEM WATER SYSTEM, ALGAE, AND ONGOING ACTIONS

Summary: Salem's water supply comes from the North Santiam River and the water is treated using a slow sand filtration system. Certain types of algae can release toxins known as cyanotoxins that cannot be removed by sand filtration systems. We test for cyanotoxins in the water, it is difficult to use the data to identify causes, correlations, or trends, even for samples taken at the same location on consecutive days. Even as we are implementing the science, engineering, and technology needed to address cyanobacteria and cyanotoxins, we are continuing to conduct a robust public information program, to meet the needs of our water customers, and to coordinate with other local, state, and federal jurisdictions.

OVERVIEW OF SALEM WATER SYSTEM

Salem's water comes from Mount Jefferson watershed in the Oregon Cascades. The water is stored behind Detroit Dam and released into the North Santiam River. We draw our source water from the river, treat it at our plant on Geren Island, and transmit the finished water to customers in Salem, Turner, Orchard Heights, and Suburban East Salem Water District. Because the water in the North Santiam River is typically of very high quality, we use a water treatment process called Slow Sand Filtration. This process involves passing the water through a biofilm (also called a "schmutzdecke") that rests on top of a layer of sand. The biofilm consists of bacteria, fungi, protozoa, and other components and the film removes particles, organic material, and other contaminants. After passing through the biofilm, the water infiltrates through the sand layer where it is collected, further treated with chlorine, and sent through transmission lines to our customers.



Overview of City of Salem water system.

Aerial photo of the Water Treatment Plant at Geren Island.

ABOUT ALGAE, BLOOMS, AND CYANOTOXINS

Algae are a single-cell bacteria and are found naturally in all fresh and salt water bodies throughout the world. Algae thrive most when there is an abundance of food—typically one or more forms of phosphates and nitrates—sunlight, and warmth weather. This is why most blooms occur during the summer months, when the weather is warmest and the days are longest.

Detroit Lake is currently experiencing increased levels of algae, including a type that is known to be hazardous at high concentrations. Commonly known as blue-green algae, cyanobacteria ("cyano" is derived from Greek for dark blue) can release toxins in the water that can be a human health concern. Generally, toxins are released when the cell membrane is ruptured, which is also known as "lysing." Once released into the water and depending on the concentrations, ingesting "cyanotoxins" can affect the liver, nervous system, and gastrointestinal system. However, the short-term and long term (i.e., acute and chronic) exposure levels of concern are still not well understood, particularly at lower concentrations. Among cyanotoxins there are many variants and we monitor for four types in our water supply: microsystin, anatoxin-a, cylindrospermopsin, and saxitoxin, each of which has a different biochemical structure.

Cyanotoxin-producing blooms—also called "Harmful Algal Blooms" or HABs—are monitored and reported by the Oregon Health Authority (OHA). In 2017, OHA issued 12 algal bloom advisories. As of the date of this memo, the Oregon Health Authority has issued algal bloom advisories in 2018 for: South Umpqua River, Detroit Reservoir, Dorena Reservoir, and Upper Klamath Lake.

HARMFUL ALGAL BLOOMS: CHALLENGES AND RESPONSES

Monitoring, Sampling, and Analysis. To evaluate the levels and trends of cyanotoxins, the Public Works Department takes samples every day at locations that include: Detroit Reservoir, in the North Santiam River, at the intake to the water treatment plant at Geren Island, at a location after the treatment plant at the point of entry to the water distribution system, and at four locations within our distribution system in Salem. There are several different laboratory processes available for identifying the presence and concentrations of cyanotoxins, all of which vary in analytical procedures, duration of the test, and sensitivity of the results.

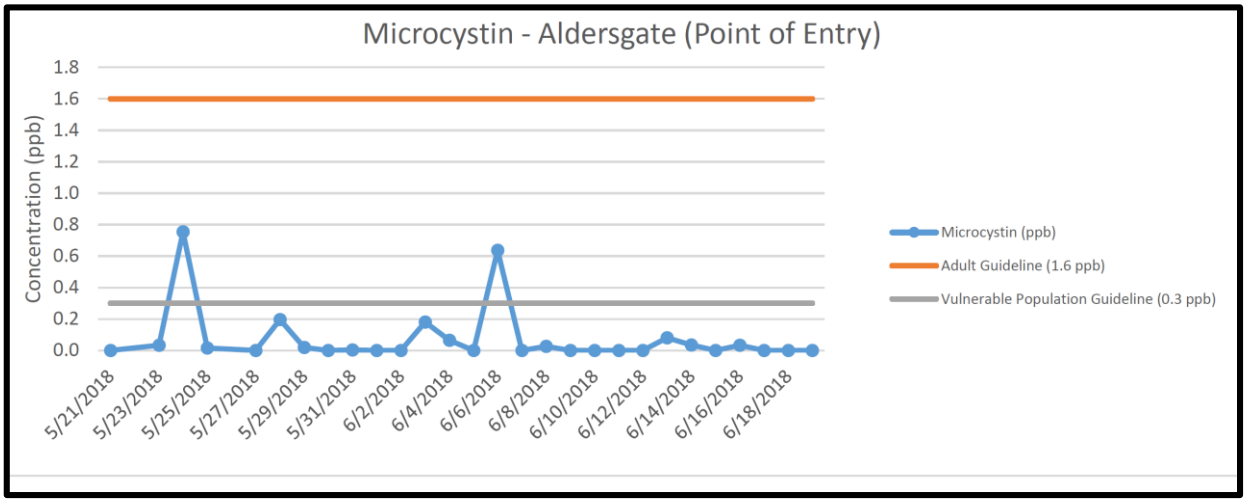
The CAAS: Cyanotoxic Automated Assay System, installed this week at the Public Works laboratory at Willow Lake Water Pollution Control Facility. After the samples are prepared, this device prepares runs the Enzyme-linked Immunosorbent Assay (ELISA) analysis for toxins in water.

Very generally, all processes deliberately lyse the cells and then employ a combination of liquids, chemicals, electricity, and light to separate the components of the cells and then to determine their respective mass and electric charges. Depending on the methods, the results can be used to identify the presence or absence of toxins, molecular structures, classify the toxins, and calculate the concentrations. Conducting detailed analysis requires specialized equipment and highly trained technicians; we send our samples to a laboratory out of state where the Liquid Chromatography-Mass Spectrometry analysis (LCMSMS or LC-tandem MS) is conducted. This process has a 48-hour turnaround time for the results.

We are obtaining the necessary equipment and training for our staff so we can begin doing our own analysis, the results of which will be available within hours and can be used to screen for the presence of cyanotoxins. The equipment is a Cyanotoxic Automated Assay System (CAAS) that prepares samples and analyzes them using the EPA-approved Enzyme-linked Immunosorbent Assay (ELISA) methodology.

Predicting the Risks. Identifying and tracking cyanotoxins in our water system is challenging, largely because algae are living organisms that are capable, in a *very* short time, of rapidly multiplying, changing depth, being relocated by currents and circulation patters, and dying. This means sampling results from the same location can vary dramatically from day to day. To illustrate, during the week of June 11 we had two samples taken 24 hours apart at the same location; one sample was 350 times higher than the sample taken the next day. Later samples during that week were all much lower than the first and a week later a sample from this same location had a concentration about 35,000 times lower than the first high reading.

An additional challenge is that the fate and transport of algae is not well understood. A high concentration at one location in Detroit Reservoir does not necessarily mean we can later expect a high reading at another location in the reservoir *or* in the North Santiam River *or* in our water system. Further, we have had sampling results taken at the same location that showed consecutive days of very low to non-detectable concentrations of cyanotoxins, then one daily sample that spiked high followed by more days with low/non-detectable concentrations. The figure below shows 15 days of sample results taken at the point of entry of treated water into our system, which had 24 samples at low or non-detectable concentrations, two samples of slightly elevated levels, and two high readings. Overall, and despite hundreds of data points at a dozen or more locations, we have yet to successfully identify consistent causes, predicable effects, or reliable correlations.



Sample results taken at Aldersgate, the point of entry for finish water to enter the water transmission system.

Keeping our Customers Informed. While wisely implementing the science, engineering, and technology related to cyanobacteria and cyanotoxins can be challenging, we believe the most important component of our response is how we inform and engage our drinking water customers. Confidence in the quality of the water and trust in the organization that provides the water is of inestimable value. As of the date of this memo, a summary of the measures in place would include:

- City of Salem website specific to the water advisory that includes answers to commonly asked questions, water quality sample results, monitoring status, and links to information from the Oregon Health Authority and Environmental Protection Agency. Information is available in English and Spanish.

- Daily press releases with an update on the water advisory and the latest sampling results.

- A Joint Information Center established to respond to telephone, email, and social media questions and concerns, with information available in both English and Spanish.

- Routine updates with local, state, and federal agencies, including Marion County, Oregon Health Authority, Oregon Emergency Management, Oregon National Guard, the Environmental Protection Agency, the Army Corps of Engineers, and others.

- Water distributions sites at nine locations in Salem, Turner, and unincorporated Marion County, providing water at no charge to customers who bring their own containers. The source of the water is from the City of Keizer, which uses well water that is unaffected by cyanotoxins in Salem's source water.

- Drinking water delivery to residents affected by the water advisory who are unable to go to a water distribution site.

cc:

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