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State Water Resources Control Board

DRAFT

TO: Blue Ribbon Committee Technical Subcommittee Co-chairs

FROM: Amy Little
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DIVISION OF DRINKING WATER – MENDOCINO DISTRICT

DATE: April 19, 2019

SUBJECT: COMPILATION OF WATER QUALITY COLLECTED AT INTAKES OF PUBLIC WATER SYSTEMS IN CLEAR LAKE, CA

Introduction

The goal of this technical memo is to provide the Blue Ribbon Committee with new information potentially relevant to the rehabilitation of Clear Lake, CA. Specifically, this technical memo summarizes water quality data collected by public water systems and provides information on potential future surface water treatment challenges for utilities around Clear Lake, CA. Recommendations to support public water systems are included at the end of the technical memo.

There are 18 public water systems which rely on Clear Lake for source water to supply safe potable water to 38,000 people for surrounding communities in Lake County. Each water system is unique in its approach to surface water treatment to ensure the Safe Drinking Water Act is met.

There are conscientious and dedicated operators that oversee daily operations of complex water treatment systems to ensure safe potable drinking water is available on a continuous basis. Based on observations and discussions with operators, the following trends are emerging in general:

- Treatment is increasingly more complex
- Source water quality can be unpredictable
- It is difficult to support qualified operators in this environment
- Costs of treatment will likely increase to ensure disinfection byproduct (DBP) regulations are met
- Costs of treatment may increase to ensure future cyanotoxin regulations are met
- Increasing awareness by utility management and staff that Clear Lake is an impaired source

A Historical Look at Some Source Water Quality Constituents in Clear Lake from Drinking Water Intakes

Introduction

The information contained in this section of the report is a subset of the water quality collected by utilities from their respective intakes. Attempts were made to focus on relevant parameters, as 230 chemical constituents were sampled between 1984 and 2017. Table 1 and Table 2 summarize the chemical constituents that were not detected (N=163) and detected (N=67), respectively. Further, rather than highlight stressors for each individual system, much of the data is compiled as if all 18 surface water systems were one. It's important to recognize that each public water system intake is unique and different water quality challenges may surface at different times. Trends are discussed in the sections below.

pH

This water quality parameter is included because it impacts the coagulation/flocculation process, it is one of several critical parameters used to define the amount of disinfectant needed to inactivate pathogens, and it is a potential indicator of corrosivity for water distributed. The plot below (See Figure 1) depicts pH collected over time (collected annually) from 1984 to 2017 at each Clear Lake intake. This is not a high frequency data set for this parameter. For example, some utilities experience dramatic swings for pH within a given day. The average (avg), minimum (min), maximum (max), 95th percentile (95th perc) and 5th percentile (5th perc) were calculated and plotted to examine potential trends. The maximum pH increases in 2016 and 2017. The minimum pH line decreases with three spikes, pH of 5.1 (2002), pH of 4.8 (2008), and pH of 6.4 (2011). The public water systems likely have pH values that are collected daily. If needed, I could coordinate with a public water system to collect higher frequency data.

Turbidity

Turbidity measures the cloudiness in liquids and based on the plot below (Figure 2), it can fluctuate over time. Public water systems typically collect turbidity data every fifteen minutes at the source when monitored with online analyzers and the average (avg), minimum (min), and maximum (max) were calculated for a single utility on Clear Lake. The plot demonstrates that turbidity can fluctuate tremendously. Interestingly, when turbidity maximum values are lower, the turbidity minimum values increase.

For this utility, I believe the maximum range value is 100 NTU. The turbidity at an intake can fluctuate and, depending on the State Water Resources Control Board – Division of Drinking Water (Division) approved treatment approach, the utility must reduce turbidity below the corresponding performance standard. For example, based on current regulations, a conventional treatment plant must reduce turbidity below 0.3 NTU 95% of the time in a given month. This is one of many regulatory aspects of operating a water treatment plant in Clear Lake.

Total Organic Carbon (TOC)

Total organic carbon is a relevant water quality parameter because of the role it plays in forming disinfection byproducts (See section below). The graph in Figure 3 plots all the monthly total organic carbon data collected by the utilities in Clear Lake. Additionally, a dotted trendline is plotted to demonstrate a baseline increase over time. The plotted data suggests a baseline increase sometime in the fall of 2013. Averaging total organic carbon before and after September 1, 2013 yields the following:

Period	Average Total Organic Carbon, mg/L
Jan 1, 2002 – Aug 31, 2013	4.1
Sept 1, 2013 – May 31, 2017	5.4

The average concentration of total organic carbon since September 1, 2013 increased by 32%. The TOC shift may be related to the number of wildfires that have occurred in the watershed.

Microcystins

Cyanotoxins are an emerging contaminant of concern and a subset of proactive utilities in Clear Lake have participated in routine monitoring for microcystins at both the intake and in water delivered to customers. Monitoring typically begins with cyanobacteria bloom onsets and stops as winter approaches and concentrations are not detected.

Cyanotoxins are not regulated in drinking water but the U.S. Environmental Protection Agency established health advisories in 2015 for microcystins (0.3 µg/L for children pre-school age or younger) and cylindrospermopsin. Based on recreational monitoring conducted by Big Valley Band of Pomo Indians and a collaboration between Elem Indian Colony (analyses efforts) and Highlands Mutual Water Company (ELISA equipment contribution) to conduct drinking water monitoring, the primary constituent of concern at this time is microcystin. Recreational monitoring demonstrates that concentrations for microcystins near the shore can range between non-detection and 16,000 µg/L (September 2014). To date, through a combination of monitoring programs, there have been no detections of microcystin above the health advisory of 0.3 µg/L. The surface water treatment plants around Clear Lake have many various barriers in place to reduce microcystins but it is not known if microcystin concentrations exceed approximately 40 µg/L (highest microcystin level detected to date at an intake in Clear Lake) in source waters whether or not treatment plants can continue to perform.

Mercury

Between 1984 and 2017, the public water systems sampled for inorganic mercury 370 times with no detections. The public water systems in Clear Lake typically sample for inorganic mercury every year. The Office of Environmental Health Hazard Assessment reviewed the public health goal for inorganic mercury in 2005, indicating that it should remain at 1.2 ug/L.

Manganese

This water quality parameter is included because in the fall of 2017, there was a fish die off followed by unprecedented increases in ammonia and manganese concentrations. There was discoloration to the water supplied to customers. The graph depicted below (Figure 4) displays the minimum (min), average (avg), and maximum (max) values by year over time, beginning in 1984. The average manganese concentration remains below the aesthetics-based level of 50 µg/L. The maximum manganese concentrations spike periodically with the latest spike in 2014 at 2,100 µg/L. The 2017 event is not depicted in the graph. Please, contact Bryan Rinde, a water quality engineer with Golden State Water Company, for a comprehensive view of the challenges associated with that water quality event.

Ammonia

This water quality parameter is included because it can interfere with a critical treatment process, specifically primary disinfection, and it can also interfere with the method used to measure disinfection residuals. Due to recent ammonia events, some public water systems were required to develop disinfection plans to overcome elevated concentrations. There are five records for ammonia.

Date of Collection	Ammonia Concentration, mg/L
August 12, 2009	0.27 mg/L
August 10, 2011	0.85 mg/L
August 8, 2012	0.64 mg/L
February 13, 2013	Non-detect
February 12, 2014	Non-detect

Please, contact Bryan Rinde, a water quality engineer with Golden State Water Company, for additional information.

Sulfate

This water quality parameter is included because it was mentioned in a report that it is a potential driver of cyanobacteria growth. In this plot (See Figure 5), sulfate concentrations, in mg/L, are displayed as a minimum (min), average (avg), and maximum (max) over time. There are numerous spikes in sulfate concentration maximums between 1984 and 2004. More recent sulfate concentrations appear to be decreasing and stabilizing with time.

Activities by Public Water Systems to Improve Source Water Quality

Every five years, the public water systems are required to submit a watershed sanitary survey. For the 2017 Watershed Sanitary Survey for Clear Lake, CA, the public water systems proposed a special edition approved by the Division - Mendocino District office. The special nutrient report edition focused on obtaining funds to improve source water quality. The public water systems hired Corona Environmental Consultants (CEC) to complete the report and associated funding applications.

Tarrah Henrie, the lead project manager, and consultants provided some invaluable Clear Lake reports, bridging water system concerns with ecological knowledge of the Clear Lake system:

1. "Task 2" report is an assessment of proposed projects in Clear Lake; given that landscape, CEC proposed top projects for the water systems to tackle; finally, CEC compiled votes from the water systems and ranked the projects

2. "Golden State Water Company: Clear Lake Watershed Sanitary Survey Update - Source Water Quality Improvement Grant Applications" report is a comprehensive report that summarizes water quality challenges and provides details for the three projects selected in Task 2.

I recommend reading these reports to gain a complete picture of downstream implications for the impaired source water quality as it impacts utilities. Excerpts from the reports include the following:

> *"Recognizing a shared interest and urgency in addressing the water quality issues that plague Clear Lake, the local water utilities are working collaboratively to find effective and holistic solutions to reduce nutrient inputs and mitigate the impacts of cyanobacteria blooms. The water systems are seeking funding assistance to support three such projects:*
>
> 1. *Phosphorus Loading Study,*
> 2. *Physical Treatment of Cyanobacteria Blooms, and*
> 3. *Green-infrastructure and Road Improvements for Stormwater Management"*

> *"Efforts aiming to reduce phosphorus alone have not worked to reduce nuisance blooms in Clear Lake. Several studies of Clear Lake have indicated that there may be other factors that are affecting cyanobacteria blooms including iron (Horne, 1975; Richardson et al., 1994), sulfate (Richerson et al., 2008), changes in the dominant nitrogen sources (Winder et al., 2010), and food chain changes (Winder et al., 2010)."*

> *"The intracellular and extracellular organic matter from cyanobacteria cells can serve as a DBP precursor (Cheung et al., 2013; Wert and Rosario-Ortiz, 2013)."*

> *"Several of the water systems on Clear Lake have reported that manganese is increasing in the source water (Clear Lake Watershed Sanitary Update 2012)"*

> *"The issue becomes worse when large mats of floating cyanobacteria begin to decay and release taste and odor compounds."*
>
> *"Several of the water utilities on Clear Lake have reported rapidly changing raw water conditions in the summer, including ammonia and pH fluctuations, that can lead to significant spikes in chlorine demand. Under these circumstances, it has been more difficult for some systems to maintain a free chlorine residual at maximum chlorine dosing, making it more challenging to meet pathogen inactivation requirements."*
>
> *"Poor control caused by source water issues like high levels of cyanobacteria leads to higher chemical costs and can result in serious challenges complying with water quality standards that are intended to ensure the safety of drinking water."*
>
> *"Yes, despite these efforts, phosphorus levels in Clear Lake have not changed significantly and cyanobacteria blooms seem to be worsening."*
>
> *"The recovery period following a phosphorus loading reduction depends on the loading history and the accumulation of phosphorus in the sediment, but in some lakes significant improvements may take decades (Søndergaard et al., 2003)."*

Recent wildfire activity and Potential Water Quality Impacts

David Cowan, Director of Lake County Water Resources Department, stated that approximately 60% of the county has burned in the last four years. The recent wildfire activity in Lake County potentially impacting water quality in Clear Lake include the following: Mendocino Complex (2018; 450,000 acres), Sulphur (2017; 2,207 acres), Valley (2015; 76,067 acres), Clayton (2016; 3,929 acres), and others (CAL FIRE statistics).

Recent research conducted by Dr. Amanda Hohner (Water Research Foundation, Web Report #4590) in post-wildfire conditions suggests that higher levels of natural organic matter in source water quality may lead to disinfection byproduct compliance issues. Further, Dr. Hohner indicates that a "thorough investigation of post-fire treatment challenges is needed to help utilities make informed management decisions and develop mitigation approaches." By reviewing the total organic carbon plot (Figure 3), there appears to be an increase in total organic carbon at the end of 2013 in the timeseries data from the public water systems. We anticipate another increase in total organic carbon (and corresponding disinfection byproducts) given 2018 wildfire activity in the northwest region of Clear Lake.

Does the recent wildfire activity result in a potential increase in cyanobacteria and associated cyanotoxins in source water? I have not found any supporting literature to support this overall concept but based on the following, we have concerns:

- Clear Lake is a phosphate limited system (CalEPA RWQCB Central Valley report, Page 4)
- Burned vegetation releases nitrate, ammonia, and phosphate (Water Research Foundation & EPA Web Report #4482)
- N:P ratios play a role in cyanobacteria composition (CalEPA RWQCB Central Valley report, Page 7)

Recent wildfire activity may further increase organic loads on the Clear Lake system and lead to elevated HAA5s in the distribution system and possibly other unregulated contaminants, which leads to more treatment, increased costs, and increased plant complexity.

Ensuring Safe Drinking Water with an Impaired Source

The State Water Resources Control Board's Division of Drinking Water (Division) shares a responsibility to ensure all public water systems throughout California have access to clean, potable water at all times. The Division achieves this objective by inspecting and evaluating the ability of public water systems to meet state and federal drinking water standards; providing technical and funding assistance; and, at times, relying on industry, academic and government partnerships to address new technological advances and current public health concerns.

One of our activities included our office co-hosting our first water quality failure workshop in May 2018. This workshop was planned, in part, due to the increasing demands on the water treatment plants. Four water quality failures were considered:

(1) cyanotoxins present in finish drinking water,
(2) filters are unable to meet turbidity performance standards,
(3) manganese and ammonia at high concentrations in source water quality, and
(4) a system-wide pressure loss event.

Industry partners came together to facilitate a discussion of steps involved to minimize impacts to communities if faced with one of these water quality challenges. Another possible water quality challenge that may benefit a Clear Lake public water system includes preparing for an ongoing elevated disinfection byproduct maximum contaminant level violation.

A look at water quality in the distribution system

Disinfection Byproducts

Disinfection byproducts (DBPs) can form when a pre-oxidant or disinfectant combines with naturally occurring materials in source water (EPA Factsheet). Public water systems were required to collect two groups of disinfection products (four total trihalomethanes and five haloacetic acids) in their distribution systems beginning in 2004 to comply with state and federal regulations.

Depicted below are total trihalomethanes (TTHM) and haloacetic acids (HAA5) concentrations over time (see Figure 6 and Figure 7) in distribution systems for Clear Lake public water systems. The maximum contaminant level for TTHM and HAA5 is 80 ug/L and 60 ug/L, respectively. Due to the large volume (N=2,480) and sporadic nature of the data set (samples are collected quarterly), the minimum is shown for the year as the 5th percentile (min (5%)) and the maximum is shown for the year as the 95th percentile (max(95%)). The data is also averaged annually (avg) to consider potential long term trends.

Public water systems installed GAC media, installed aeration systems, practice enhanced coagulation, flush distribution systems, and modified many treatment units to reduce organics in order to remain in compliance.

TTHM trend

In addition to other strategies, aeration systems have been able to largely reduce the chloroform component for TTHMs. From Figure 6, the Systems average has remained below the maximum contaminant level for TTHMs. However, there are some systems that are experiencing high TTHMs (in 2018 the 95th percentile was 84.1 ug/L, above the maximum contaminant level).

HAA5 trend

Typically, reducing organics before a chlorine-based oxidant is injected is a widely known treatment adjustment to contend with DBPs, including HAA5s. Many of the public water systems have granular activated carbon (GAC) to reduce organics before applying a disinfectant. It is the recent rise of HAA5s (see Figure 7), historical trends of total organic carbon levels, compounded by the Mendocino Complex fire and associated introduction of increased organics that brings concern. It is possible public water systems will have to install additional upgrades to ensure compliance. **The average concentration of HAA5 spiked 40% from 29.8 ug/L to 41.7 ug/L system-wide, signaling a potential problem.**

Future regulations - nitrogenous based disinfection byproducts and cyanotoxins

There are unregulated disinfection byproducts that may be regulated in the future. To learn more, read a factsheet released by the Water Research Foundation. Proactive public water systems will likely engage in monitoring to learn more about the presence of nitrogenous based disinfection byproducts and potential treatment solutions, if warranted.

A look at operations

Through discussions with operators, it is difficult to retain T3 operators in this challenging work environment. A T3 operator faces long hours, less comparable pay to adjacent regions, and treatment challenges due to source water quality changes.

A look at changes in a primary coagulant at a public water system on Clear Lake

INSERT PLOT OF ONE SYSTEM'S COAGULANT DOSAGE OVER TIME

Through ingenuity, planning, engineering and perseverance, below is a list of public water systems serving the Clear Lake, CA communities (in alphabetical order), providing safe potable water on a continuous basis.

WATER SYSTEM PROFILES

(Alphabetical Order) Water treatment plant name – connections, population served, flow capacity, treatment classification, disadvantage status, treatment processes, planned future upgrades, source water quality issues/concerns, other concerns, including treatment, system representative, business #
Buckingham Park Water District – 457 c, 1,501 p, 300 gpm, T3, Economically distressed community, pre-oxidation, coagulant & polymer addition, flocculation/sedimentation, multimedia filtration, granular activated carbon filtration, disinfection, Nakia Foskett/Alan Mitchell, 707-279-8568
Cache Creek Mobile Home Park – 45 c, 150 p, 21 gpm, T3, severely disadvantaged community, pre-oxidation; coagulation; rapid mix; contact clarification/filtration; corrosion control; disinfection, Dave Stein, 707-245-7716

Clear Water Mutual Water Company – 93 c, 263 p, 45 gpm, T3, economically distressed community, pre-oxidation; coagulation; rapid mix; flocculation/sedimentation; filtration; granular activated carbon contactors; disinfection, Michael Ruest, 707-279-1207

Clearlake Oaks County Water District – 1,797 c, 2,359 p, 864 gpm, T3, severely disadvantaged community, pre-oxidation; coagulation; rapid mix; flocculation/sedimentation; filtration; granular activated carbon contactors; disinfection; corrosion control, Dianna Mann/Dan Larson, 707-998-3322

Crescent Bay Improvement Company – 24 c, 27 p, 20 gpm, T2, economically distressed community, coagulation/filter aid; filtration; disinfection, planned future upgrades: DBP remediation, source water quality concerns: “high NTUs during storm runoff and summers, times when ammonia is high and CL2 demand is way up, requiring hand dosing of storage tanks, times when the water charge is positive rather than negative according to charge analyzer bench test.”, planned future upgrades: DBP remediation per corrective action plan. If approved, perhaps in bank filtration; we hopt to consolidate/sell, Mary Benson, 707-994-1005

Golden State Water Company (Clear Lake) – Sonoma Water Treatment Plant: 2,074 c, 4,047 p, 1.03 MGD, T3, severely disadvantaged community, pre-oxidation; coagulation; rapid mix; flocculation/sedimentation; filtration; GAC contactors; corrosion control; disinfection, planned future upgrades: variable frequency drive pumps and generators; source water quality concerns: “the large organic concentration in Clear Lake has historically caused rapid degradation of source water quality. These events put utilities in a challenging technical and financial situation to maintain compliance with disinfection, maximum contaminant levels (i.e. DBPs), and secondary maximum contaminant levels (i.e. manganese)”, Bryan Rinde, 916-853-3632/Keith Ahart, 707-994-0930

Harbor View Mutual Water Company – 246 c, 550 p, 170 gpm, T3, economically distressed community, pre-oxidation; pH adjustment; coagulation; rapid mix; flocculation/dissolved air flotation; filtration; granular activated carbon contactors; disinfection, Jeremiah Fossa, 707-279-4143

Highlands Mutual Water Company – 2,877 c, 6,169 p, 1,600 gpm, T4, severely disadvantaged community, pre-oxidation, coagulation, seasonal powdered activated carbon, rapid mix, flocculation/sedimentation, filtration, granular activated carbon contactors, corrosion control, disinfection, Jeff Davis/Norm Birdsey, 707-994-8676

Konocti County Water District – 1,796 c, 4,425 p, 0.96 MGD, T4, severely disadvantaged community, pre-oxidation; coagulation; rapid mix; pH adjustment; flocculation/sedimentation; filtration; granular activated carbon contactors; corrosion control; disinfection, Frank Costner/Tom Parks, 707-994-2561

Konocti Harbor Resort & Spa – 33 c, 115 p, 250 gpm, T2, economically distressed area, pre-oxidation; coagulation; rapid mix; flocculation/solid contactor; filtration; granular activated carbon contactors; filtration; disinfection, not active at this time

Lake County CSA 20 (Soda Bay) – 643 c, 1,792 p, 350 gpm, T3, economically distressed community, coagulation; rapid mix; flocculation/solid contactor; filtration; granular activated carbon contactors; disinfection, Robert Saderlund, 707-263-8279

Lake County CSA 21 (North Lakeport) – 1,220 c, 2,733 p, 900 gpm, T3, economically distressed community, pre-filtration; pre-oxidation; coagulation; rapid mix; flocculation/solid contactor; filtration; granular activated carbon contactors; disinfection, Robert Saderlund, 707-263-8279

Lakeport, City of – 2,348 c, 5,400 p, 1.73 MGD, T4, disadvantaged community, pre-oxidation; coagulation; rapid mix; flocculation/solids contactor; filtration; oxidation; granular activated carbon contactors; disinfection, Paul Harris, 707-263-3578

Lucerne California Water Service Company – 1,199 c, 2,305 p, 1.0 MGD, T4, severely disadvantaged community, pre-oxidation; coagulation; flocculation; sedimentation; pre-

filtration; microfiltration; advanced oxidation system; disinfection; corrosion control, Donny Breedlove, 707-274-6624
Mt. Konocti Mutual Water Company – 1,567 c, 3,150 p, 1,110 gpm, T3, economically distressed community, pre-oxidation; coagulation; flocculation/sedimentation; filtration; granular activated carbon contactors; disinfection; corrosion control, Alan Farr/Keith Wesselhoff, 707-277-7466
Nice Mutual Water Company – 1,064 c, 2,500 p, 637 gpm, T4, severely disadvantage community, coagulation; rapid mix; pre-oxidation; flocculation/sedimentation; filtration; granular activated carbon contactors; disinfection, David Fultz, 707-274-1149
Richmond Park Resort – 30 c, 34 p, 8 gpm, T3, economically distressed area, pre-oxidation; coagulation; rapid mix; flocculation/sedimentation; filtration; granular activated carbon contactor; disinfection, David Fultz, 707-274-1149
Westwind Mobile Home Park – 38 c, 104 p, 10 gpm, T2, economically distressed area, pre-oxidation; coagulation; rapid mix; flocculation/solids contactor; filtration; disinfection, Craig Shields, 707-245-4809

gpm – gallons per minute, MGD – million gallons per day

Conclusion

It is my hope that the historical source water quality parameters, the motivation displayed by the public water systems to identify source water quality improvement projects, and a look at water quality parameters downstream, would convey this message: in general, there are increasing pressures on the water treatment systems around Clear Lake due to degrading source water quality. Please, consider the recommendations below to support the public water systems.

Recommendations

Identify funding to support the following:

1. Support funding to find effective and holistic solutions to reduce nutrient inputs and mitigate the impacts of cyanobacteria blooms. “The proposed projects take a multi-pronged approach towards improving water quality in Clear Lake. These projects seek to address some of the most pressing issues on Clear Lake towards meeting the nutrient TMDL, improving source water quality and reliability, and improving knowledge of phosphorus dynamics in Clear Lake to support on-going management strategies.” Three priority projects were identified by Corona Environmental Consulting that would accomplish the above:

    - Phosphorus loading study ($386,000)
    - Physical treatment: aeration/ultrasonic installation and study ($500,000)
    - Green Infrastructure and Road Improvements for Stormwater Management ($880,000)

2. Support match funding needed to conduct a project that will support utilities in identifying ways to reduce organics and corresponding disinfection byproducts. Dr. Amanda Hohner, an assistant professor at Washington State University, would be the principal investigator on a Water Research Foundation project that would do the following:

    - Describe source water characteristics, specifically the organic composition

- Optimize organic reductions by examining which combination of pre-oxidants yields the lowest disinfection products
- Examine the conversion of granular activated carbon filters into biofilters; recent research suggests ozone with biologically active granular active carbon filters can enhance organic reductions

3. Provide Clear Lake public water systems an update on efforts underway to improve source water quality on an annual basis.

4. Support the development of a strong learning-based operator program with local educational institutions. Contact Paul Harris, Utilities Superintendent for City of Lakeport, to learn about current efforts underway.

5. Provide financial assistance to a Clear Lake operator recruitment and retention program. The program would support Clear Lake surface water system operators by paying for "contact hours" which is required for treatment certification and all certification exams and advertising to increase job visibility.

6. Consider a mentor program that involves an operator (with a certification of at least T4/T5 for five years) paired with an apprentice operator (any level) residing or employed in Lake County. The Division could assist (need to verify) by providing both parties with contact hours (maximum 12 hours earned; three 4-hour sessions) and developing the topics that would be discussed and reviewed (e.g. safety, chemical dosage calculations, optimizing unit treatment processes).

7. Provide financial assistance to Clear Lake public water systems that would support monitoring or optimizing for current and emerging contaminants. Examples of eligible support would allow public water systems to apply for funds in order to do the following:

    a. Monitor for microcystins or nitrogenous based disinfection byproducts
    b. Purchase equipment to verify treatment processes are optimized to reduce organics (e.g. bench top equipment that measures UV transmissivity or laboratory charge analyzer)
    c. Install or upgrade a treatment process to reduce organics or emerging contaminant

8. Support table top emergency exercises for water quality failures every two years for Clear Lake public water systems.

9. Consider including total organic carbon in future watershed models to assist public water systems.

Sources of Information

2019 Clear Lake Public Water System Survey, State Water Resources Control Board – Division of Drinking Water – Water Quality Database, Corona Environmental Consulting reports, including 2018 Task 2 final report and Golden State Water Company: Clear Lake Watershed Sanitary Survey Update – Source Water Quality Improvement Grant Applications, Water Research Foundation Emerging DBPs Factsheet, Water Research Foundation Web Report #4590 *Wildfire Impacts on Drinking Water Treatment Process Performance: Development of Evaluation Protocols and Management Practices*, CA EPA Regional Water Quality Control

Board – Central Valley Region *Clear Lake Nutrient Total Maximum Daily Load Control Program 5-Year Update (2012)*, *Effects of Wildfire on Drinking Water Utilities and Best Practices for Wildfire Risk Reduction and Mitigation, WRF & EPA, Web Report #4482 (2013),* CALFIRE web-based statistical reports, Big Valley Band of Pomo Indians Clear Lake water quality dashboard and Clear Lake public water system permit reports.

cc: Sue Keydel, US EPA, Region 9
Meredith Howard, SWRCB

Table 1. Chemical constituents not detected in Clear Lake, CA source waters by public water systems, specifically at their intakes.

Constituent	MDRL	Years Sampled
1,1,1,2-TETRACHLOROETHANE	0.5 ug/L	1989-2017
1,1,1-TRICHLOROETHANE	0.5 ug/L	1989-2017
1,1,2,2-TETRACHLOROETHANE	0.5 ug/L	1989-2017
1,1,2-TRICHLOROETHANE	0.5 ug/L	1989-2017
1,1-DICHLOROETHANE	0.5 ug/L	1989-2017
1,1-DICHLOROETHYLENE	0.3 - 0.5 ug/L	1989-2017
1,1-DICHLOROPROPENE	0.5 ug/L	1989-2017
1,2,3-TRICHLOROBENZENE	0.5 ug/L	1989-2017
1,2,3-TRICHLOROPROPANE (1,2,3,-TCP)	0.005 - 0.5 ug/L	1989-2016
1,2,4-TRICHLOROBENZENE	0.5 ug/L	1989-2017
1,2,4-TRIMETHYLBENZENE	0.5 ug/L	1989-2017
1,2-DICHLOROBENZENE	0.5 ug/L	1989-2017
1,2-DICHLOROETHANE	0.5 ug/L	1989-2017
1,2-DICHLOROPROPANE	0.5 ug/L	1989-2017
1,3,5-TRICHLOROBENZENE	NRA	1998
1,3,5-TRIMETHYLBENZENE	0.5 ug/L	1989-2017
1,3-DICHLOROBENZENE	0.5 ug/L	1989-2017
1,3-DICHLOROPROPANE	0.5 ug/L	1989-2017
1,3-DICHLOROPROPENE (TOTAL)	0.5 ug/L	1989-2017
1,4-DICHLOROBENZENE	0.5 ug/L	1989-2017
2,2-DICHLOROPROPANE	0.5 ug/L	1989-2017
2,4,5-T	0.5 - 2 ug/L	2002-2017
2,4,5-TP (SILVEX)	0.1-10 ug/L	1984-2017
2,4-D	0.1-10 ug/L	1984-2017
2,4-DB	5-10 ug/L	2002-2015
2-CHLOROETHYLVINYL ETHER	NRA	19899-2015
2-CHLOROTOLUENE	0.5 ug/L	1989-2017
2-METHYLPHENOL	NRA	2003
3-HYDROXYCARBOFURAN	3 ug/L	1995-2017
4,4-DDD	0.01-0.05 ug/L	2002-2014
4,4-DDE	0.01-0.05 ug/L	2002-2014
4,4-DDT	0.02-0.04 ug/L	2002-2014
4-CHLOROTOLUENE	0.5 ug/L	1989-2017
4-NITROPHENOL	0.4 - 5 ug/L	2002-2015
ACIFLURFEN	0.2-1 ug/L	2002-2015
ACROLEIN	NRA	2002-2003
ACRYLONITRILE	5 ug/L	2002-2014
ALACHLOR	0.2-4 ug/L	1995-2017
ALDICARB	3 ug/L	1995-2017
ALDICARB SULFONE	2-4 ug/L	1995-2017
ALDICARB SULFOXIDE	3-4 ug/L	1995-2017
ALDRIN	0.01-0.075 ug/L	1998-2016
ALPHA-BHC	0.01-0.05 ug/L	2002-2014
AMIBEN	NRA	2002-2003
ANTIMONY	0.5-6 ug/L	1994-2017
ATRAZINE	0.1-1 ug/L	1989-2017

Constituent	MDRL	Years Sampled
Bentazon	0.4-2 ug/L	1998-2017
Benzene	0.3-0.5 ug/L	1989-2017
BENZO (A) PYRENE	0.1 ug/L	1996-2016
BERYLLIUM	.002-1.2 ug/L	1994-2017
Beta-BHC	0.05 ug/L	2002-2014
BIS (2-CHLOROETHYL) ETHER	NRA	1993 - 2003
BROMACIL	10 - 0.5 ug/L	1995 - 2017
BROMOBENZENE	0.5 ug/L	1989 - 2017
BROMOCHLOROMETHANE	0.5 ug/L	1989 - 2017
BROMOMETHANE	0.5 ug/L	1989 - 2015
BUTACHLOR	0.38 - 3.8 ug/L	1995 - 2016
Cadmium	0.1 - 10 ug/L	1984 - 2017
CARBARYL	5 ug/L	1995 - 2017
CARBOFURAN	1 - 5 ug/L	1989 - 2017
CARBON TETRACHLORIDE	0.5 ug/L	1989 - 2017
CHLORDANE	0.05 - 0.1 ug/L	1989 - 2017
CHLOROBENZILATE	5 ug/L	2002 - 2014
CHLOROETHANE	0.5 ug/L	1989 - 2015
CHLORONEB	0.5 ug/L	2002 - 2014
CHLOROTHALONIL	0.1 - 5 ug/L	1995 - 2014
CHROMIUM, HEXAVALENT	0.2 - 1 ug/L	2002 - 2017
CIS-1,2-DICHLOROETHYLENE	0.5 ug/L	1989 - 2017
CIS-1,3-DICHLOROPROPENE	0.5 ug/L	2005 - 2014
CIS-PERMETHRIN	0.2 ug/L	2002 - 2014
CYANIDE	0.005 - 100 ug/L	1995 - 2017
DACTHAL	0.04 ug/L	2002 - 2014
DALAPON	6 - 10 ug/L	1995 - 2017
DCPA (TOTAL DI & MONO ACID DEGRADATES)	0.04 - 2 ug/L	2002 - 2016
DELTA-BHC	0.05 ug/L	2002 - 2014
DI(2-ETHYLHEXYL)ADIPATE	5 ug/L	1996 - 2006
DIAZINON	0.025 -2 ug/L	1995 - 2017
DIBROMOCHLOROPROPANE (DBCP)	0.01 ug/L	1996 - 2017
DIBROMOMETHANE	0.5 ug/L	1989 - 2017
DICAMBA	0.4 - 1.5 ug/L	1996 - 2016
DICHLORODIFLUOROMETHANE (FREON 12)	0.5 ug/L	1989 - 2017
DICHLOROMETHANE	0.5 ug/L	1989 - 2017
DICHLORPROP	1 ug/L	2002 - 2015
DIELDRIN	0.01 - 0.02 ug/L	1998 - 2016
DIISOPROPYL ETHER	3 - 5 ug/L	2000 - 2017
DIMETHOATE	1 - 10 ug/L	1995 - 2017
DINOSEB	1 - 2 ug/L	1995 - 2017
DIURON	1 ug/L	1995 - 1998
ENDOSULFAN I	0.01 - 0.05 ug/L	2002 - 2014
ENDOSULFAN II	0.01 - 0.05 ug/L	2002 - 2014
ENDOSULFAN SULFATE	0.02 - 0.05 ug/L	2002 - 2014
ENDOTHALL	40 - 45 ug/L	1995 - 2017
ENDRIN	0.02 - 1 ug/L	1994 - 2017
ENDRIN ALDEHYDE	0.05 ug/L	2002 - 2014
ETHYLBENZENE	0.5 ug/L	1989 - 2017

Constituent	MDRL	Years Sampled
ETHYLENE DIBROMIDE (EDB)	0.02 ug/L	1989 - 2017
ETHYL-TERT-BUTYL ETHER	0.5 - 3 ug/L	1999 - 2017
GLYPHOSATE	4 - 25 ug/L	1989 - 2014
HEPTACHLOR	0.01 - 0.02 ug/L	1989 - 2017
HEXACHLOROBENZENE	0.04 - 0.5 ug/L	1998 - 2017
HEXACHLOROBUTADIENE	0.5 ug/L	1989 - 2017
HEXACHLOROCYCLOPENTADIENE	0.4 - 1 ug/L	1998 - 2017
HYDROXIDE ALKALINITY	1 - 5 mg/L	1986 - 2017
ISOPROPYLBENZENE	0.5 ug/L	1989 - 2017
LINDANE	0.01 - 1 ug/L	1984 - 2017
M,P-XYLENE	0.5 ug/L	1989 - 2017
MERCURY	.001 - 5 ug/L	1984 - 2017
METHIOCARB	0.5 - 5 ug/L	1995 - 2015
METHOMYL	2 ug/L	1995 - 2017
METHOXYCHLOR	.02 - 10 ug/L	1984 - 2017
METHYL ETHYL KETONE	1 - 5 ug/L	1992 - 2017
METHYL ISOBUTYL KETONE	1 - 5 ug/L	1992 - 2017
METOLACHLOR	0.5 - 5 ug/L	1995 - 2017
METRIBUZIN	0.1 - 2.5 ug/L	1995 - 2017
MOLINATE	0.25 - 2.5 ug/L	1995 - 2017
MONOBROMOACETIC ACID (MBAA)	1 ug/L	2002 - 2007
MONOCHLOROACETIC ACID (MCAA)	2 - 3.1 ug/L	2002 - 2007
MONOCHLOROBENZENE	0.5 ug/L	1989 - 2017
M-XYLENE	NRA	1998 - 2015
NAPHTHALENE	0.5 ug/L	1989 - 2017
N-BUTYLBENZENE	0.5 ug/L	1989 - 2017
NITRATE + NITRITE (AS N)	0.4 - 400 ug/L	1993 - 2017
NITROBENZENE	NRA	2002 - 2003
N-PROPYLBENZENE	0.5 ug/L	1989 - 2017
OXAMYL	5 - 20 ug/L	1995 - 2017
O-XYLENE	0.5 ug/L	1989 - 2017
PARAQUAT	20 ug/L	2005 - 20011
PCB-1016 (AS DECACHLOROBIPHENYL (DCB))	0.5 ug/L	2002 - 2017
PCB-1221 (AS DCB)	0.5 ug/L	2002 - 2017
PCB-1232 (AS DCB)	0.5 ug/L	2002 - 2017
PCB-1242 (AS DCB)	0.5 ug/L	2002 - 2017
PCB-1248 (AS DCB)	0.5 ug/L	2002 - 2017
PCB-1254 (AS DCB)	0.5 ug/L	2002 - 2017
PCB-1260 (AS DCB)	0.5 ug/L	2002 - 2017
PENTACHLOROPHENOL	0.1 - 0.25 ug/L	1995 - 2017
PERCHLORATE	4 ug/L	2002 - 2017
PERMETHRIN	NRA	2002 - 2003
PICLORAM	0.2 - 1 ug/L	1995 - 2017
P-ISOPROPYLTOLUENE	0.5 ug/L	1989 - 2017
POLYCHLORINATED BIPHENYLS, TOTAL, AS DCB	0.5 ug/L	1998 - 2017
PROMETRYN	0.15 - 2 ug/L	1995 - 2017
PROPACHLOR	0.2 - 2.5 ug/L	1995 - 2016
PROPOXUR	0.5 - 5 ug/L	1995 - 2015
P-XYLENE	NRA	1998 - 2015

Constituent	MDRL	Years Sampled
SEC-BUTYLBENZENE	0.5 ug/L	1989 - 2017
STYRENE	0.5 - 1 ug/L	1989 - 2017
TERT-AMYL-METHYL ETHER	0.5 - 5 ug/L	1999 - 2017
TERT-BUTYL ALCOHOL (TBA)	NRA	2002 - 2015
TERT-BUTYLBENZENE	0.5 ug/L	1989 - 2017
TETRACHLOROETHYLENE	0.5 ug/L	1989 - 2017
THALLIUM	0.001 - 2 ug/L	1994 - 2017
THIOBENCARB	0.25 - 2.5 ug/L	1994 - 2017
TOXAPHENE	0.1 - 10.5 ug/L	1984 - 2017
TRANS-1,2-DICHLOROETHYLENE	0.5 ug/L	1989 - 2017
TRANS-1,3-DICHLOROPROPENE	0.5 ug/L	2005 - 2014
TRANS-PERMETHRIN	0.2 ug/L	2002 - 2014
TRICHLOROACETIC ACID (TCAA)	1 ug/L	2004 - 2007
TRICHLOROETHYLENE	0.5 ug/L	1989 - 2017
TRICHLOROFLUOROMETHANE	0.5 - 5 ug/L	1989 - 2017
TRICHLOROTRIFLUOROETHANE (FREON 113)	0.5 - 10 ug/L	1989 - 2017
TRIFLURALIN	0.04 ug/L	2002 - 2014
VINYL ACETATE	NRA	2002 - 2003
VINYL CHLORIDE	0.5 ug/L	1989 - 2017

MDRL – Minimum detection reporting limit

Table 2. Chemical constituents detected in Clear Lake, CA source waters by public water system, specifically at their intakes.

Constituent	MDRL	Concentration Range	MCL	Years Sampled	
Acetone	5 ug/L	ND - 7.9 ug/L	-	2002 - 2011	
ALKALINITY (TOTAL) AS CACO3	NRA	34 - 330 mg/L	-	1984 - 2017	
ALUMINUM	50 - 120 ug/L	ND - 22,000 ug/L	1000 ug/L, 200	1989 - 2017	
Ammonia	NRA	0.27 - 0.85 ug/L	-	2009 - 2012	
Arsenic	0.01 - 50 ug/L	ND - 11 ug/L	10 ug/L***	1984 - 2017	
Asbestos	0.2 MFL	ND - 0.4	7 MFL	1995 - 2016	
Barium	0.1 - 140 ug/L	ND - 890 ug/L	1,000 ug/L***	1985 - 2016	
BICARBONATE ALKALINITY	NRA	39 - 1,900 mg/L	-	1984 - 2017	
Boron	100 ug/L	ND - 4,100 ug/L	1,000 ug/L**	2002 - 2016	
Bromate	0.005 - 5 ug/L	ND - 0.029 ug/L	10 ug/L	2004 - 2016	
BROMODICHLOROMETHANE (THM)	0.5 - 1 ug/L	ND - 11.1 ug/L	comp	1989 - 2017	
BROMOFORM (THM)	0.5 - 1 ug/L	ND - 15.5 ug/L	comp	1989 - 2017	
CALCIUM	NRA	0.65 - 138 mg/l	-	1984 - 2017	
CARBON DIOXIDE	NRA	3,900 - 8,700 ug/L	-	2008 - 2009	
CARBON DISULFIDE	0.5 ug/L	ND - 0.83 ug/L	160 ug/L**	2005 - 2014	
CARBONATE ALKALINITY	1 - 5 mg/L	ND - 43 mg/L	-	1984 - 2017	
Chloride	0.5 ug/L	ND - 606 mg/L	500 mg/L*	1984 - 2017	
CHLOROFORM (THM)	0.5 - 1 ug/L	ND - 44 ug/L	comp	1989 - 2017	
CHLOROMETHANE	0.5 ug/L	ND - 2.3 ug/L	-	1989 - 2015	
CHROMIUM (TOTAL)	0.5 - 50 ug/L	ND - 37 ug/L	50 ug/L	1984 - 2017	
Color	3 - 5 units	ND - 90 units	15 units*	1985 - 2017	
Copper	0.01 - 50 ug/L	ND - 110 ug/L	1,000 ug/L*,	1984 - 2017	
DI(2-ETHYLHEXYL)PHTHALATE	3 - 5 ug/L	ND - 7.7 ug/L	4 ug/L	1989 - 2006	FN1
DIBROMOACETIC ACID (DBAA)	1 ug/L	ND - 1.1 ug/L	comp	2002 - 2007	
DIBROMOCHLOROMETHANE (THM)	0.5 - 1 ug/L	ND - 13.4 ug/L	comp	1989 - 2017	
DICHLOROACETIC ACID (DCAA)	1 ug/L	ND - 26 ug/L	comp	2002 - 2007	
DIQUAT	0.4 - 4 ug/L	ND - 1.2 ug/L	20 ug/L	1995 - 2017	
FLUORIDE (F) (NATURAL-SOURCE)	0.1 - 0.18 mg/L	ND - 1.6 mg/L	2.0 mg/L	1984 - 2017	
FOAMING AGENTS (MBAS)	0.05 - 0.1 ug/L	ND - 70 ug/L	50 ug/L*	1984 - 2017	
GROSS ALPHA	1 - 3 pCi/L	ND - 8.72 pCi/L	15 pCi/L	1994 - 2016	
GROSS BETA	4 pCi/L	ND - 5 pCi/L	calc	1995 - 2011	
HALOACETIC ACIDS (5) (HAA5)	1 ug/L	ND - 1.1 ug/L	60 ug/L	2004 - 2007	
HARDNESS (TOTAL) AS CACO3	3 mg/L	ND - 280 mg/L	-	1984 - 2017	
HEPTACHLOR EPOXIDE	0.01 ug/L	0.1 ug/L	0.01 ug/L	1989 - 2017	FN2
IRON	50 - 100 ug/L	ND - 4,800 ug/L	300 ug/L*	1984 - 2017	
LEAD	0.005 - 50 ug/L	ND - 50 ug/L	AL	1984 - 2017	
MAGNESIUM	NRA	9.8 - 173 ug/L	-	1984 - 2017	
MANGANESE	*10 - 50 ug/L*	*0.011 - 2,100 ug/L*	*50 ug/L*, 500*	*1984 - 2017*	
METHYL-TERT-BUTYL-ETHER (MTBE)	0.5 - 5 ug/L	ND - 4.5 ug/L	5 ug/L	1997 - 2017	
NICKEL	0.01 - 10 ug/L	ND - 33 ug/L	100 ug/L	1994 - 2017	
NITRATE (as N)	0.4 mg/L	ND - 1 mg/L	10 mg/L	2015 - 2017	
NITRATE (AS NO3)	0.04 - 4.5 mg/L	ND - 8.2 mg/L	45 mg/L	1984 - 2015	
NITRITE (AS N)	0.02 - 400 ug/L	ND - 84 ug/L	1,000 ug/L	1993 - 2017	
ODOR THRESHOLD @ 60 C	1 - 17 TON	ND - 570	3 TON*	1984 - 2017	
PH, FIELD	*NRA*	*0.6 - 9.1*	-	*2007 - 2017*	

Constituent	MDRL	Concentration Range	MCL	Years Sampled	
PH, LABORATORY	*NRA*	*4.8 - 11*	-	*1984 - 2017*	FN3
POTASSIUM	1.8 - 2 mg/L	ND - 12 mg/L	-	1987 - 2017	
RADIUM 226	NRA	ND - 1.16 pCi/L	5 piC/L^	2006 - 2011	
RADIUM 228	1 pCi/L	ND - 4.76 pCi/L	5 piC/L^	2004 - 2016	
SELENIUM	0.001 - 12 ug/L	ND - 13 ug/L	50 ug/L	1984 - 2017	
SILVER	0.01 - 50 ug/L	ND - 12 ug/L	100 ug/L	1984 - 2017	
SIMAZINE	0.07 - 4 ug/L	ND - 0.17 ug/L	4 ug/L	1989 - 2017	
SODIUM	NRA	3.3 - 146 mg/L	-	1984 - 2017	
SODIUM ABSORPTION RATIO	NRA	21	-	2002	
SOURCE TEMPERATURE C	NRA	9.1 - 39 degC	-	1994 - 2017	
SPECIFIC CONDUCTANCE	NRA	159 - 4,500 uS/cm	1,600 uS/cm*	1984 - 2017	
SULFATE	*NRA*	*1.2 - 100 mg/L*		*1984 - 2017*	
TOLUENE	0.5 ug/L	ND - 0.81 ug/L	150 ug/L	1989 - 2017	
TOTAL DISSOLVED SOLIDS	NRA	78 - 9,100 mg/L	1,000 mg/L*	1984 - 2017	
TOTAL ORGANIC CARBON (TOC)	*NRA*	*0.72 - 17 mg/L*	*TT*	*2002 - 2017*	
TOTAL TRIHALOMETHANES	0.5 - 1 ug/L	ND - 52 ug/L	80 ug/L	1989 - 2017	
TRITIUM	NRA	145 piC/L	20,000 pCi/L	1995	
TURBIDITY, LABORATORY	*NRA*	*ND - 60 NTU*	*TT*	*1984 - 2017*	
URANIUM	1 pCi/L	ND - 1.12 pCi/L	20 pCi/L	1993 - 2011	
VANADIUM	3 - 10 ug/L	ND - 4 ug/L	50 ug/L**	2002 - 2012	
XYLENES (TOTAL)	0.5 - 1.5 ug/L	ND - 0.56 ug/L	1,750 ug/L	1989 - 2017	
ZINC	0.05 - 50 ug/L	ND - 560 ug/L	5,000 ug/L	1984 - 2017	

** Secondary Standard*

^ combined MCL with Radium 226/228

NRA - not readily available

TT - treatment technique

AL - action level in distribution system

calc - running annual average of (gross beta particle activity - naturally occuring potassium-40 beta particle activity) is less than 50 pCi/L

comp - component of an overall MCL

** - no MCL; CA notification limit

*** - based on a running annual average

FN1 - One detection occurred in June 1991; confirmation sample required within 7 days; Nov 1991 sample demonstrates no detection.

FN2 - One detection occurred in Dec 1990; confirmation sample required within 7 days; Jun 1991 sample demonstrates no detection.

FN3 - three pH values greater than 14 were removed from this data set.

FIGURES

Figure 1. pH measured in Clear Lake source water (1984 – 2017) (N=701)

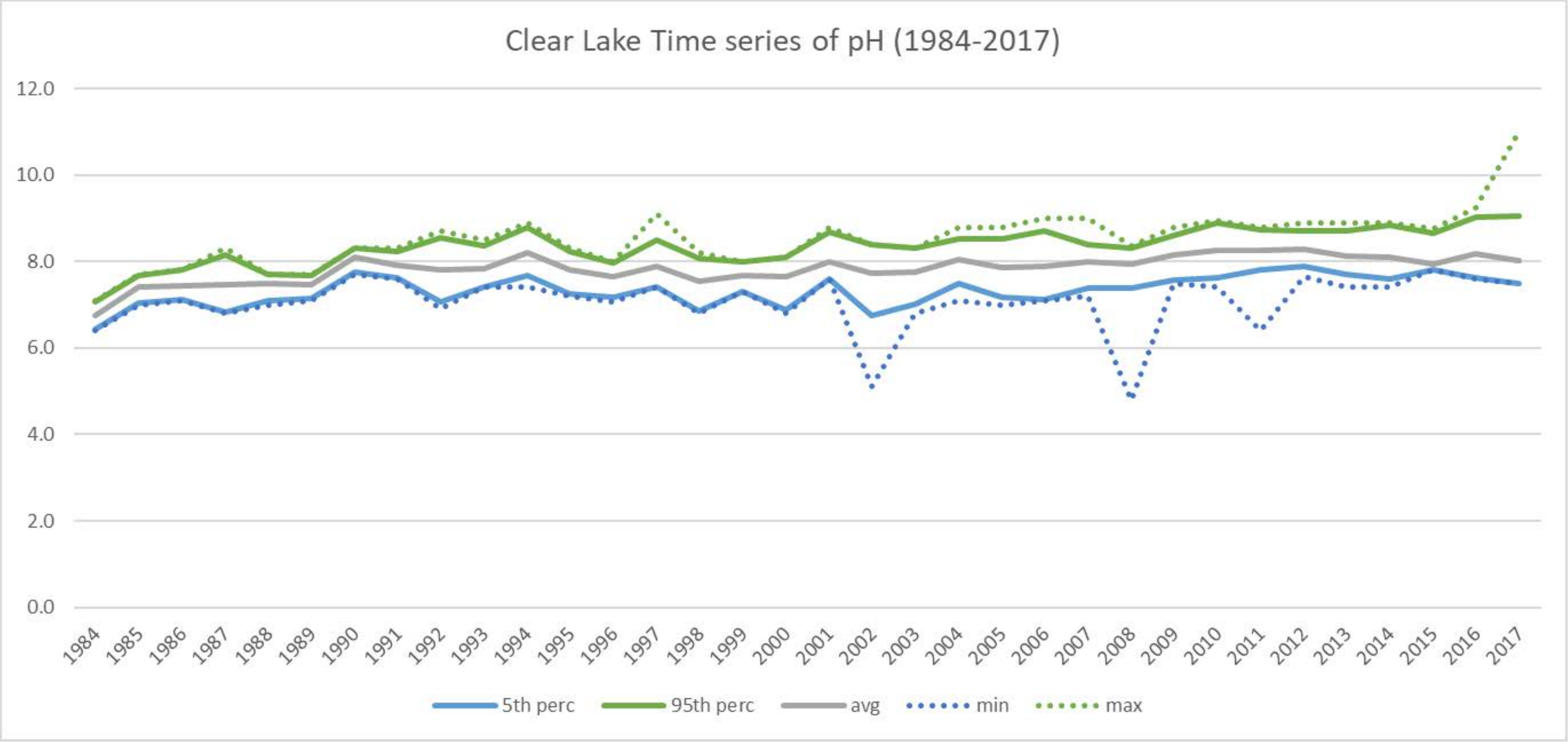

Figure 2. Monthly turbidity values, NTU, in Clear Lake source water over time (2016 – 2018; max 100 NTU); turbidity is typically collected every 15-minutes by public water systems. (N=102,144)

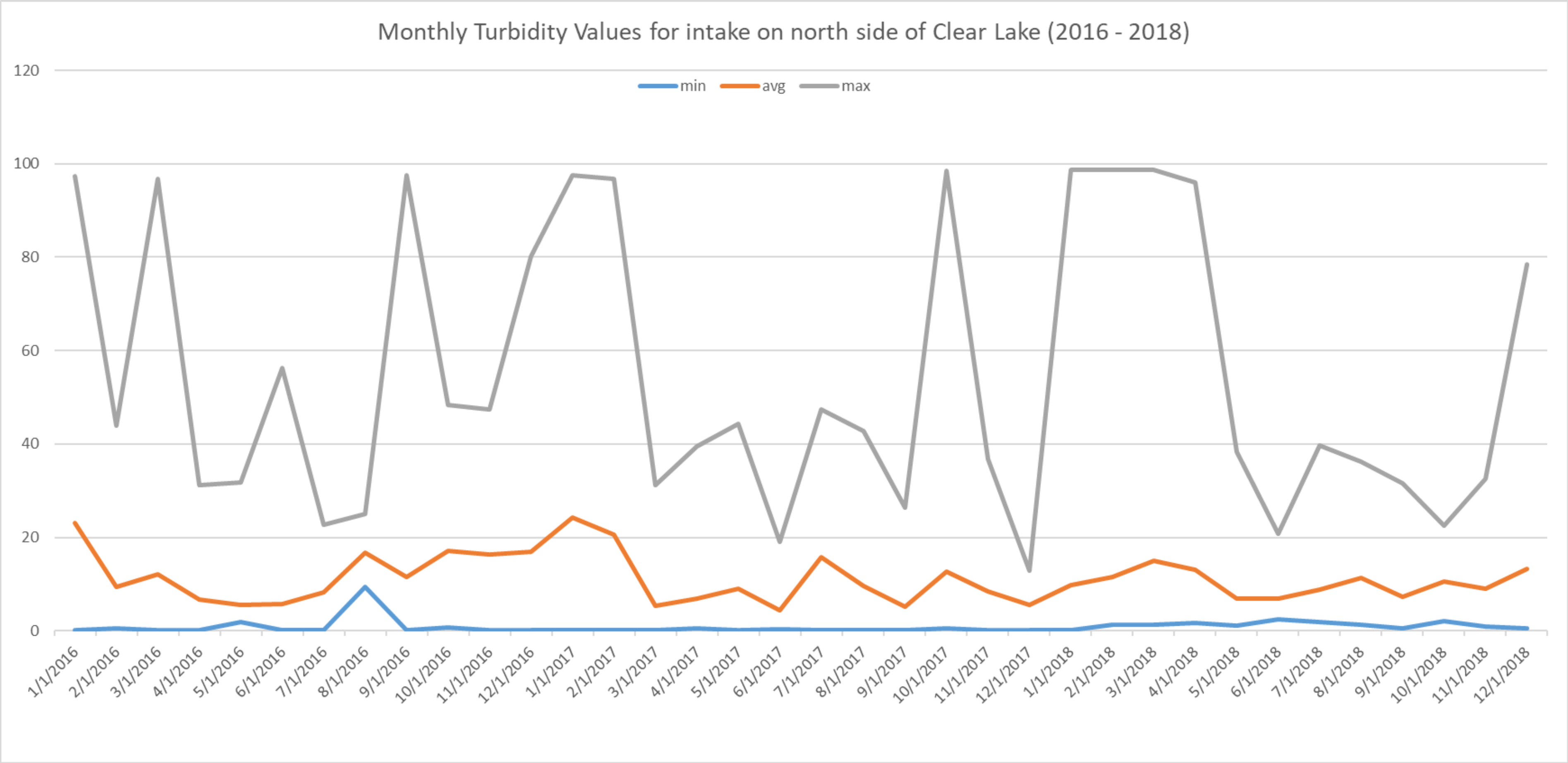

Figure 3. Total organic carbon concentrations, mg/L, in Clear Lake source water over time (1984 – 2017); total organic carbon is typically collected monthly by water systems. (N=1,469)

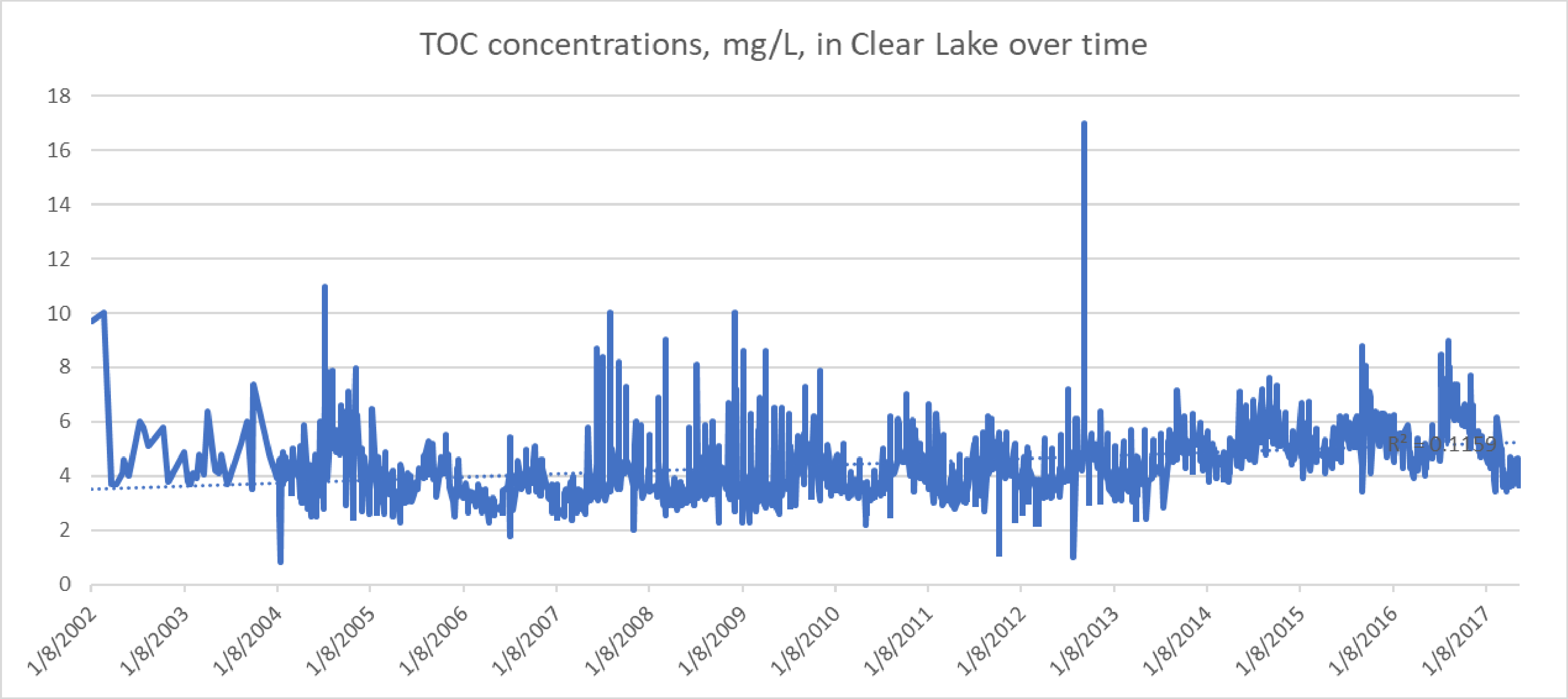

Figure 4. Manganese concentrations in Clear Lake source water over time (1984 – 2017); manganese is typically collected annually by water systems.(N=497)

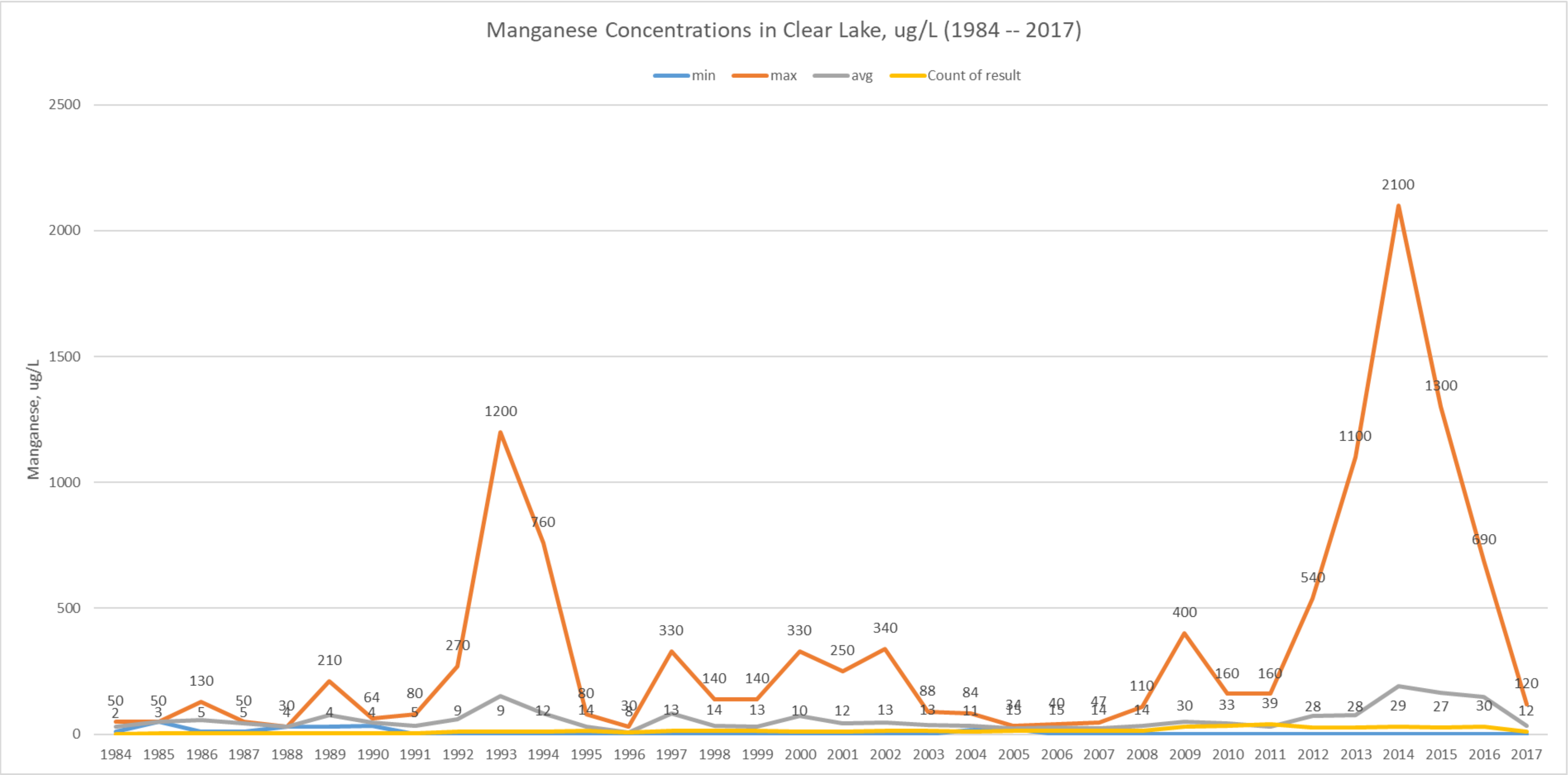

Figure 5. Sulfate concentrations, mg/L, in Clear Lake source water over time (1989 – 2017) (N=369)

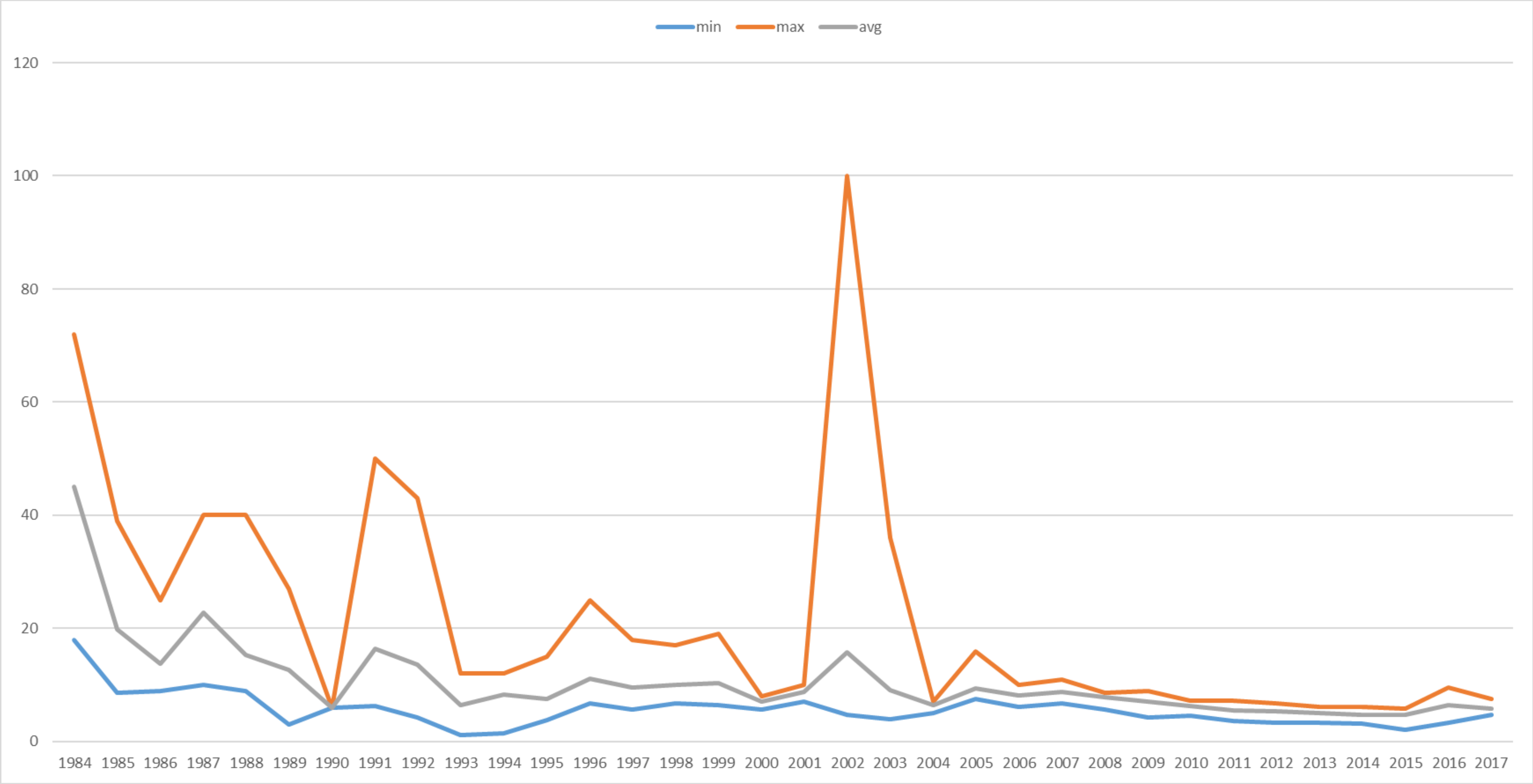

Figure 6. TTHM concentrations in Clear Lake distribution systems over time (2003 – 2018). (N=1,246)

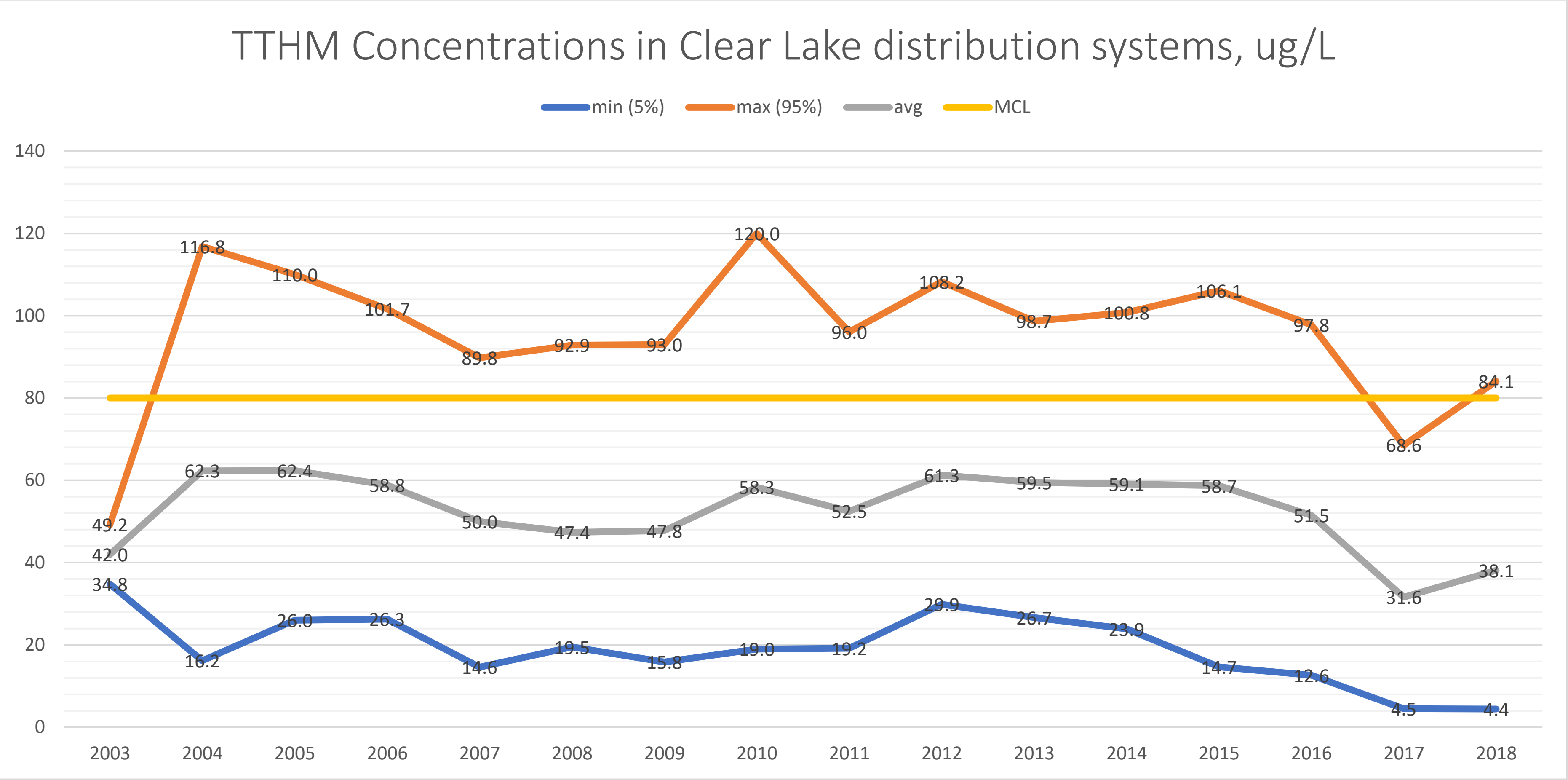

Figure 7. HAA5 concentrations in Clear Lake distribution systems over time (2003 – 2018) (N=1,234)