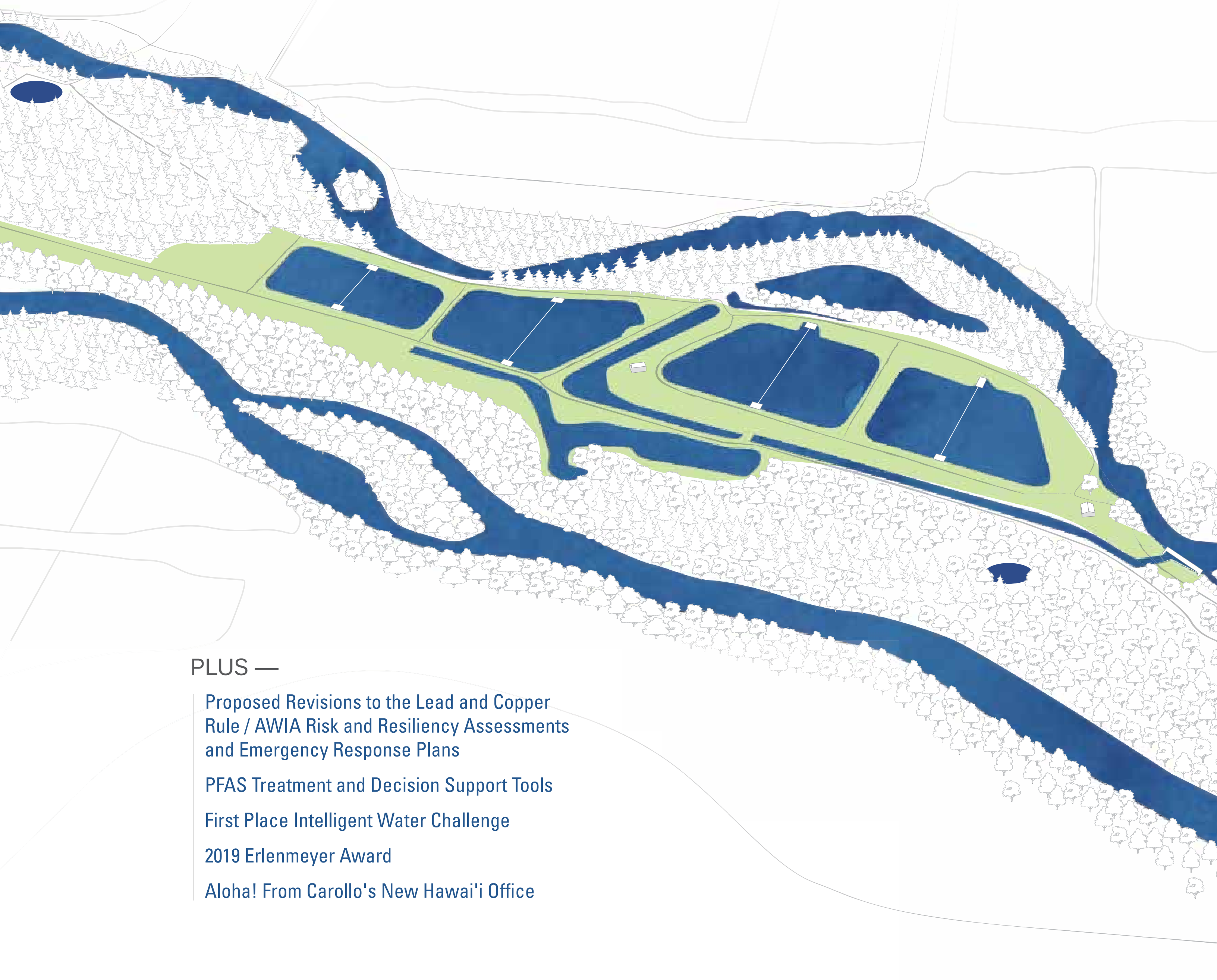
CAROLLO ENGINEERS | VOL 4 2019

currents

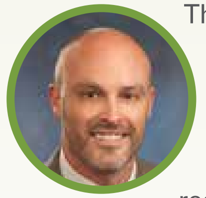
City of Salem
CYANOTOXIN EMERGENCY RESPONSE



PLUS —

THIS ISSUE'S Editorial

JESS BROWN, PhD, PE (jbrown@carollo.com)



Thank you for perusing the 2019 *Currents Volume 4!* In our last issue, we discussed the basics of per- and polyfluoroalkyl substances (PFAS): what they are, why they're so important in the water industry, and where regulations on them stand. We continue the PFAS discussion in this issue, focusing on treatment and testing/modeling tools that support the design and operation of PFAS facilities. Our feature story covers another hot issue in the industry: cyanotoxins. We detail the City of Salem's 2018 cyanotoxin event, their emergency response strategy, and their multi-barrier approach to the 2019 cyanotoxin season. You'll also meet the winning team for the 2nd annual LIFT Intelligent Water Systems Challenge and read about the 2019 Emerald Erlenmeyer Award winner, a recognition of exemplary contributions, initiative, and dedication to the mission of the AWWA Water Science & Research Division. And, finally, we'll introduce you to our latest office in Honolulu, Hawai'i. As always, I hope you enjoy this issue, and please let me or the primary authors know if you have any questions or comments.

Aloha and mahalo!

IN THIS ISSUE

Carollo Engineers...Working Wonders With Water®

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EPA UPDATE: Proposed Revisions to the Lead and Copper Rule and AWIA Risk and Resiliency Assessments and Emergency Response Plans

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DEREK SWARTZENDRUBER

GEORGE WHITTEN, PE

DAVE SOBECK, PE

As an engineering firm focused on water, an important aspect of what we do is to help our clients address current drinking water regulations and prepare for any future compliance implications. This article focuses on two recent regulatory actions issued by the United States Environmental Protection Agency (USEPA) that will affect public water systems nationwide: the proposed Lead and Copper Rule Revisions (LCRR) and America's Water Infrastructure Act (AWIA) of 2018.

LEAD AND COPPER RULE REVISIONS

The USEPA Administrator announced the proposed LCRR on October 10, 2019. The proposed rule, which focuses on the six key areas listed in Table 1, was published in the Federal Register on November 13, 2019. Notably, the LCRR includes a new 10 microgram per liter (µg/L) trigger level. If water systems measure 90th percentile lead concentrations above the trigger level, they will be required to optimize their existing corrosion prevention strategy. If no corrosion treatment exists, systems will be required to conduct a corrosion control treatment (CCT) study.

Carollo continues to assist utilities across the country as they address current LCR requirements and is factoring in the impact of the revised rule to help utilities plan for long-term compliance. Caroline Russell, Principal Technologist in Carollo's Austin office, can be contacted for more information (crussell@carollo.com, 512-427-8109).

Table 1. Key Proposed Revisions to the Lead and Copper Rule

Focus Area	Key LCRR Requirements
Identifying the Most Impacted Area	▸ Lead service line (LSL) inventories must be submitted within 3 years after rule promulgation. Systems without LSLs must demonstrate their absence.
Strengthening Treatment Requirements	▸ A 10 µg/L trigger level(1) has been established. The 15 µg/L action level (AL) remains unchanged. ▸ If the trigger level is exceeded, systems must optimize CCT or conduct a study if CCT is not currently in place. ▸ Calcium hardness adjustment is no longer a lead CCT option and phosphate inhibitors must be orthophosphate. ▸ Calcium, conductivity, and temperature analyses are no longer required as part of water quality parameter (WQP) sampling. ▸ If a tap sample exceeds the AL, systems must collect a follow-up sample, conduct WQP monitoring at or near the site, and perform a corrective action.
Replacing Lead Service Lines	▸ Systems with lead above the trigger level must develop a goal for LSL replacement; systems with lead above the AL must replace 3% of LSLs every year. ▸ No more partial LSL replacements will be allowed. ▸ Utilities must replace their portion of an LSL within 45 days if the customer replaces their portion.
Increasing Sample Reliability	▸ Samples must now be collected in wide mouth bottles, and recommendations for aerator cleaning/removal and pre-stagnation flushing prior to sample collection are prohibited. ▸ Systems must collect all samples from sites served by LSLs, if available.
Improving Risk Communication	▸ Utilities must inform customers served by an LSL or a service line of unknown material. ▸ Consumer Confidence Reports must provide updated health effects language and information regarding LSL replacement programs. ▸ Systems must notify customers of lead AL exceedance within 24 hours. ▸ Systems must improve public access to lead information, including LSL locations, and respond to requests for LSL information, deliver educational materials to customers during water-related work that could disturb LSLs, and provide increased information to health care providers. ▸ Provide lead consumer notice to customers whose individual tap sample is > 15 µg/L within 24 hours.
Better Protection of Children in Schools and Childcare Facilities	▸ Utilities must conduct lead testing at 20% of K-12 schools and licensed childcare facilities in their service area every year (excludes facilities built after January 2014). ▸ Sample results must be provided to each sampled site, Primary Agency, and local or state health department.

(1) Based on 90th percentile lead concentration.

AWIA RISK AND RESILIENCY

The concept of completing a formal vulnerability assessment (VA) and emergency response plan (ERP) for a community's water system dates back to the Bioterrorism Act of 2002. Early VAs and ERPs were typically developed using a terrorism threat basis, while more likely threats were often not considered, and resiliency was ignored entirely. With the adoption of the AWIA, which was codified in 2018, the EPA is establishing the need for a new holistic, all-hazards approach to water system resilience. The Act requires communities serving more than 3,300 customers to complete a comprehensive risk and resilience assessment (RRA), followed by updates to their ERP. The RRA and ERP updates must consider and address physical security, operational procedures, water system configuration, cybersecurity, natural hazards, and other relevant factors that contribute to the overall reliability and resiliency of a water system. If qualifying utilities do not complete the RRA and ERP by the designated dates (shown in Table 2), they could face significant fines and risk increasing their liability should an event occur. The efforts and collaboration required are significant and call for a team with the resources, tools, and AWIA experience to efficiently complete the work. Carollo's team leverages its experience with key AWWA guidance documents and follows a well-planned systematic approach to help our clients successfully complete compliant RRA and ERPs.

Table 2. Deadlines for Water Systems to Confirm Completion of RRAs and ERPs by Certified Letter to EPA

Utility Size	Risk & Resilience Assessment	Emergency Response Plan
>100k	March 31, 2020	September 30, 2020
50k-100k	December 31, 2020	June 30, 2021
3,300-50k	June 30, 2021	December 30, 2021

The USEPA website includes fact sheets and additional information on the LCRR.

City of Salem CYANOTOXIN EMERGENCY RESPONSE

TIMOTHY ENGLISH, PE (tenglish@carollo.com) ■ NICOLE WILLIAMS, PE ■ CAROLLO'S WATER PRACTICE AND SUPPORT TEAM

INTRODUCTION AND BACKGROUND

The Geren Island Water Treatment Plant (GIWTP) started supplying potable water to the City of Salem, Oregon, in 1937. The raw water intake for the GIWTP is downstream of Detroit Lake, a large reservoir impounded by the Detroit Dam. Historically, the City's rigorous water quality monitoring program has shown effective cyanotoxin removal through the sole treatment process: biologically active slow sand filtration.

On May 23, 2018, 7 μg/L of cylindrospermopsin and low levels of microcystin were detected in the raw water much earlier in the season, and at much higher concentrations, than in past years. Unfortunately, these detections occurred before the filters could acclimate to the cyanotoxins, and the existing GIWTP failed to reduce the concentrations to below health advisory (HA) levels. Over the next several days, increased monitoring confirmed the presence of microcystin and trace amounts of cylindrospermopsin and anatoxin-a in the distribution system, leading to a "do not drink" advisory for vulnerable people on May 29. The advisory was lifted on June 2 after a series of non-detects. On June 6, microcystin was detected above HA levels at the distribution system point-of-entry (POE), and a second advisory was issued. This advisory was lifted on July 2, after 12 consecutive days of cyanotoxin concentrations below the HA levels—the longest such advisory in US history.

Immediately after the first water advisory, the City retained Carollo to help support its public outreach efforts while aggressively pursuing implementation of a near-term solution and planning for long-term treatment enhancements to mitigate the risk of future cyanotoxin events. The near-term approach involved a 3-week period devoted to developing and vetting alternative mitigation strategies. These strategies included:

- Conducting a literature review to identify cyanotoxin treatment technologies for consideration for either near- or long-term implementation at GIWTP.
- Conducting bench-testing at Water ARC® of several treatment methods on raw water samples from the GIWTP.
- Retrofitting a pilot that was already at GIWTP to facilitate a quick pilot-scale evaluation of powered activated carbon (PAC) addition.
- Pilot testing followed by demonstration-scale testing (10 mgd) and then full-scale (50 mgd) implementation.

Carollo is currently designing the long-term solution: two-stage filtration with intermediate ozonation. This article will review the findings, challenges, and lessons learned from this experience.

2018 Cyanotoxin Response Strategy

Within the first week of Carollo's involvement, the Water ARC® completed bench-scale testing of GIWTP source water for the removal or destruction of the cyanotoxins. The tests found that:

- Chlorination is effective at oxidizing microcystin, but at concentrations greater than typically used in the GIWTP-treated water.
- PAC removed cyanotoxins, including microcystin.
- PAC is difficult to settle when alum and polymer dosages are not optimized.
- Ozone oxidizes both microcystin and cylindrospermopsin.

Pilot components (from left to right): South Channel's pilot influent pump, PAC mixing and settling tanks, and pilot roughing filter and slow-sand filter.

The City needed to immediately execute a treatment strategy to remove the "do not drink" advisory, and the PAC was the only feasible option for implementation during the 2018 algal bloom season.

The next 2 weeks were spent testing the impacts of two-stage filtration and PAC dosing on cyanotoxin removal and determining operational challenges at GIWTP, first on a pilot that Carollo happened to already be operating on-site for another project, and then at a larger demonstration scale. The preexisting pilot was extensively modified with the addition of pickle drums to mimic the settling conditions of the plant's intake channels and basins.

PAC, alum, and polymer were injected at the corresponding locations on the pilot while cyanotoxin concentrations and turbidity were monitored. A 10-mgd demonstration-scale test of PAC, alum, and polymer was then run for one week.

Upon completion of the tests, a more robust PAC dosing system with Solarbee® mixers was installed in the intake of GIWTP for full-scale treatment. On July 4, the new 50-mgd cyanotoxin treatment system was brought online. For the next month, the plant was operated and monitored by the City and Carollo staff 24 hours a day. As shown in Figure 1 on the right, the microcystin concentrations entering the GIWTP (Middle Intake) were above HA levels, but the water leaving the facility (Aldersgate POE) was non-detect.

As predicted by the pilot and demonstration tests, creating alum floc to settle PAC prior to first stage filtration was very difficult to maintain, even with extensive jar testing and alum/polymer dose adjustments. During this time, there was also a bloom of fragilaria, a type of filter-clogging algae. As a result, the first stage filter had to be drained and scraped every few days. However, it was determined later that the PAC contributed very little to the filter headloss, and that filter runs could go for a week or longer without the addition of alum or polymer.

PAC pre-treatment system components installed for demonstration-scale and full-scale operation included PAC-feed hopper (as shown on the left, being loaded by the City Operator) and PAC injection via a Solarbee® (right).

2019 Treatment Strategy

During the 2019 algal bloom season, the City measured microcystin concentrations similar to the 2018 season. However, cyanotoxins in the distribution system were well below the HA limit, and no advisories were issued. This was because the City implemented a detailed monitoring and response plan using the lessons learned in 2018. As part of this plan, several treatment modifications were made to implement a multi-barrier approach, including:

1. Dosing 10-40 mg/L PAC when cyanotoxins were detected at the GIWTP intake.
   a. During the winter, Carollo worked with the City to install new intake flow meters that more accurately dose PAC and expand the settling basin to give more contact and settling time prior to filtration.
2. Increasing the chlorine dose from 1.5 mg/L to 3 mg/L and then using a newly designed and constructed dechlorination facility to bring chlorine concentration levels back to normal levels.
3. Monitoring and responding to changing conditions as they occurred.

The sustained efforts of the City and Carollo resulted in a robust treatment system that successfully treated high levels of microcystin through the summer, making for a highly satisfied client and a relieved response team. The PAC system removed about 50% of toxins, with the rest removed by biological filtration. Carollo is now working with the City to design a new ozone facility at GIWTP that will produce high quality water for years to come.

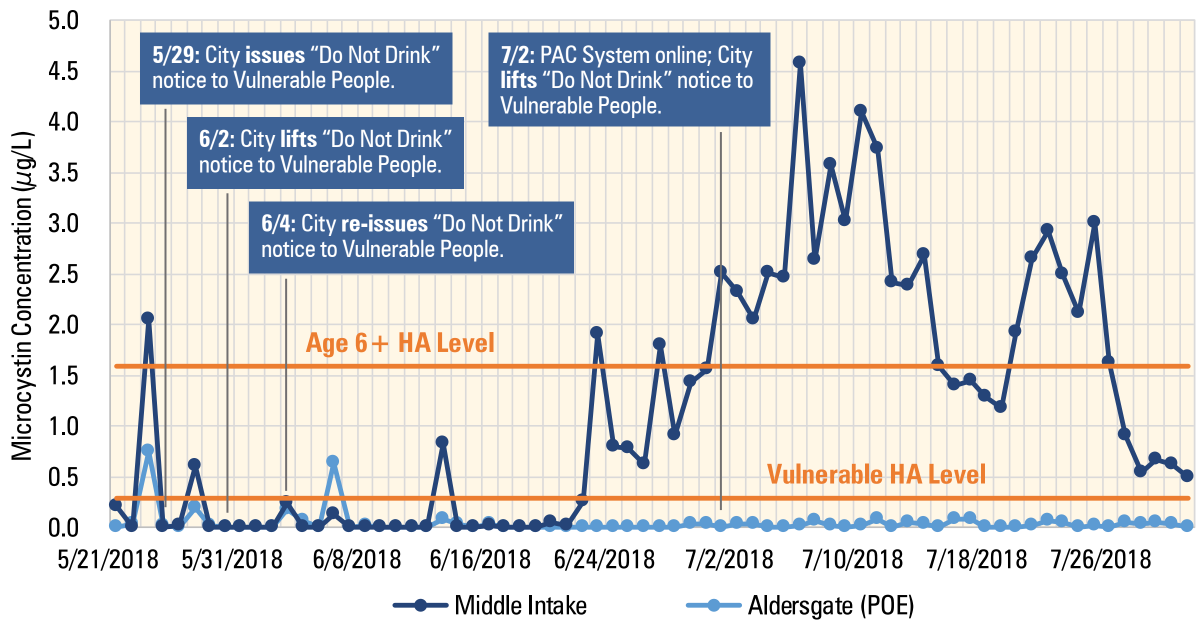
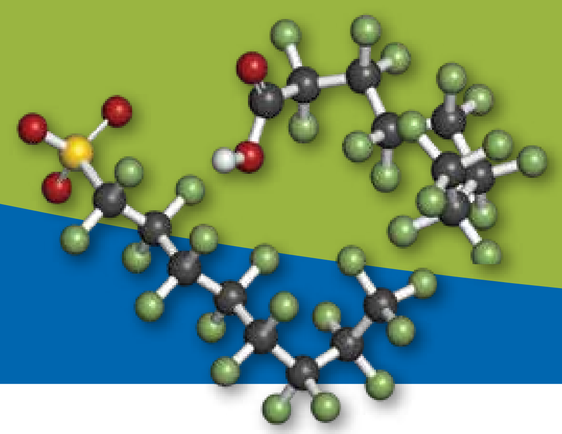


Figure 1. Microcystin concentrations at the GIWTP intake and Aldersgate (POE) through the 2018 cyanotoxin season.



PFAS Treatment AND DECISION SUPPORT TOOLS

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This article is a continuation of the PFAS article in *Currents Volume 3* and provides information on advancements in PFAS treatment, advanced modeling tools, and techniques that Carollo has developed. Please refer to *Volume 3* for general information on PFAS regulations and specific PFAS project details.

How are PFAS Treated?

Per- and polyfluoroalkyl substances, known as PFAS, have been used in many industries since the 1940s and are known to cause adverse health effects. Unfortunately, conventional water and wastewater treatment processes, such as coagulation, flocculation, sedimentation, filtration, or activated sludge processes, are mostly ineffective at removing PFAS from drinking water. Even ozonation and most advanced oxidation processes (AOP) do not remove PFAS efficiently.

Presently, several innovative AOP technologies are being developed to attack C-F bonds and destroy PFAS, but are still in the research stage. Granular activated carbon (GAC) adsorption, ion exchange (IX), reverse osmosis (RO), and nanofiltration (NF) have demonstrated to effectively remove PFOA and PFOS with some limitations associated with each of these technologies, as shown in Table 1 below.

A Retrofittable System

To cope with the impacts of changing water quality on PFAS treatment and the uncertainties of changing regulations, Carollo developed the concept of a "retrofittable system" that can accommodate both carbon and resin with just very minor or no modifications to the vessels. This approach considers the differences between the design parameters for GAC or IX, such as surface loading rates, EBCT, and media depth, and accommodates both.

Both GAC and IX systems use pressure vessels and are typically designed in either lead-and-lag or parallel-staged configurations, helping to maximize the system's removal capacity, improve product water quality, and maximize operations flexibility. The retrofittable system uses the same standardized vessel design, but incorporates an innovative underdrain system that considers the differences in GAC and IX design parameters. It includes a backwash system as well, which is normally required for GAC, and uses 5-μm bag filters as a pretreatment for IX, which should not be backwashed during operation.

Table 1. Advantages and Disadvantages of IX, RO, and NF at Removing PFAS

	Advantages	Disadvantages
GAC	• Can be easily implemented. • Effective at removing PFOA and PFOS. • Good option if the source water also contains other organic contaminants that could be removed simultaneously.	• Not very effective at removing short-chain compounds.
IX	• Can be easily implemented. • Highly effective at selectively removing both long- and short-chain compounds. • Has higher PFAS removal capacity and lasts much longer than GAC. • More suitable for treating groundwater with higher PFAS concentration. • It can handle higher surface loadings at lower empty bed contact time (EBCT), therefore requires smaller footprint than GAC. • More suitable for wellhead treatment when space is limited or height restrictions apply.	• Less flexible to operate than GAC due to poor chlorine resistance of the IX media and the negative impact of backwash on the IX mass transfer zone. This is particularly true if the well is subjected to intermittent operation.
RO/NF	• Removes most PFAS at high efficiency, including shorter chain PFAS.	• Does not truly remove PFAS, but just concentrates them in a brine stream that still has to be handled. • For inland utilities, appropriate brine disposal options are unavailable, making the RO/NF option not applicable.

Installing a retrofittable media treatment system may slightly increase the capital costs; however, it will provide more flexibility in the future to switch between media types. With this approach, users can obtain competitive pricing on either GAC or IX media for treatment systems and take advantage of new types of engineered media for PFAS adsorption that may be developed in the future.

PFAS Treatability Database and Decision Support Modeling

Capital costs for GAC and IX for PFAS treatment are often straightforward and can be determined without requiring testing. However, bench testing and modeling are recommended to establish the basis for O&M and life-cycle costs related to GAC and IX.

Rapid Small Scale Column Testing (RSSCT) is a great tool for estimating the frequency of media replacement and for selecting the best media. Carollo has conducted over 40 sets of RSSCT for PFAS with research institutes, such as the Arizona

State University, or at Carollo's own Water ARC® lab. More than 15 source waters and water blends have been tested using a wide range of carbon media.

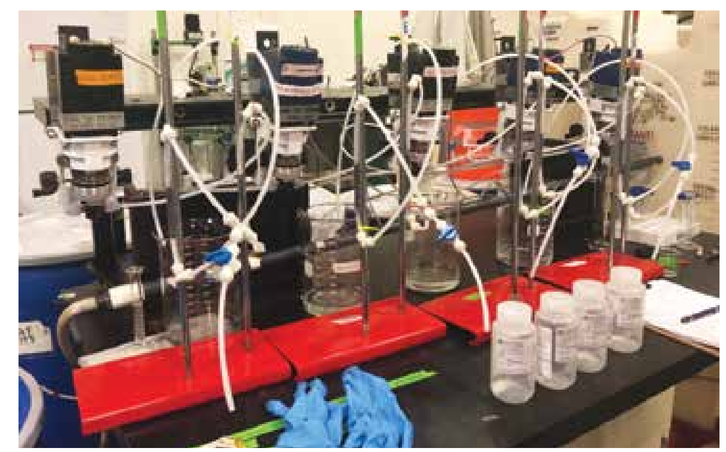
In pilot-scale and full-scale testing, it takes months to achieve a breakthrough curve. RSSCT, on the other hand, is a small-scale model of a pilot-scale/full-scale system and aims to simulate the breakthrough much more quickly, in days or weeks. The results from the RSSCT method can be used to simulate performance at the pilot scale/full scale.

Because PFAS are present at trace concentrations, constant diffusivity equations are used in lieu of the proportional diffusivity equations to scale down the hydrodynamic characteristics and mass transfer phenomena from a full-scale system to the bench-scale system.

Advanced decision support modeling tools offer significant value in converting bench-scale testing results into relevant information for full-scale design and operation.

A few of those benefits include:

- Modeling the performance of various media and resins.
- Modeling full-scale breakthrough from bench-scale testing.
- Evaluating different design configurations (e.g., parallel staged versus lead and lag).
- Supporting accurate cost estimates and efficient designs.
- Selecting an alternative by evaluating and optimizing the treatment configuration to meet a target treated water quality goal.



RSSCT testing of GAC, conducted at Arizona State University lab, greatly improved our team's productivity with shortened project schedule.

Modified RSSCT methods for IX resins have been tested as well and are being compared to pilot- and full-scale data. Figure 1 shows an example of the benefits of simulating full-scale PFAS performance for different adsorbents under different treatment configurations. It also shows that the results from full-scale testing validate the modeled performance.

Data collected through water quality sampling and bench and pilot testing were integrated into our PFAS treatability database. The breakthrough curve was modeled in Carollo's Blue Plan-it® Decision Support System using exponential, logarithmic, or polynomial equations based on either feed concentrations or the solid phase mass load. Unlike most RSSCT models, which only simulate the operational performance of a single column, our dynamic simulation model allows users to simulate and optimize a variety of complicated configurations, such as staged multiple trains in parallel, multiple vessels in series, etc. Algorithms accounting for biological activities on the media were integrated as well. This model is not just for research purposes—it can support a wide range of design and operation decisions:

- Determining the number of contactors required in parallel or in series to meet a given target product water quality goal.
- Guiding operators to determine how often and when media needs replacement, considering the turnaround time for lab analysis and the lead time for processing media replacement orders.
- Evaluating and optimizing alternative configurations (e.g., batch operation, lead-lag operation, or staged-parallel operation) by simulating full-scale operation.
- Optimizing performance to lower capital, O&M, and life-cycle costs.

Conclusion

With a collaborative effort between utilities, engineers, and academia, we can solve the challenges of treating PFAS in contaminated water and protect public drinking water supplies. Current experience, proven technologies, and continuing innovation and collaboration can greatly benefit utilities by optimizing performance, providing operational flexibility, and lowering capital, O&M, and life-cycle costs.

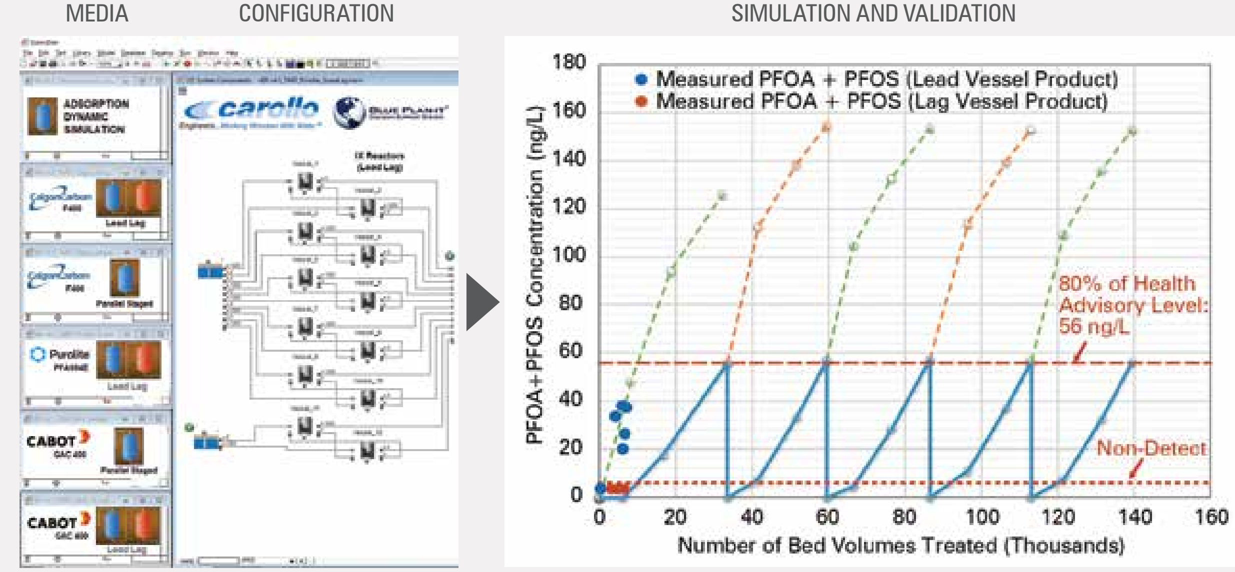
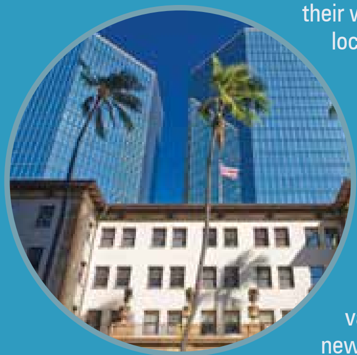


Figure 1. Simulated full-scale PFAS removal and analytical results for different adsorbents, under different treatment configurations, considering various product water quality goals.

CAROLLO EXPANDS TO **THE ALOHA STATE**



Carollo has recently expanded operations to the state of Hawaiʻi with the opening of a Honolulu office, bringing their water-focused services to one of the most resource-scarce regions of the country. The new office is located at the Pacific Guardian Center in downtown Honolulu.

Managed by Honolulu-native Dr. Cari Ishida, the Hawaiian office is providing a wide range of water and wastewater services, including long-range master planning, treatment technology evaluations and design reviews, and construction management. Cari earned her BS in Environmental Engineering from the University of Southern California and her MS and PhD in Environmental Engineering from Northwestern University. She has worked in Carollo's offices located in Walnut Creek, California, and Chicago, Illinois. After gaining over 12 years of mainland experience, Cari moved back to Honolulu to help service local clients and to be closer to family.

Often sighted in the Honolulu area is Senior Client Services Manager, Gary Deis, who provides valued leadership and technical expertise. The year 2019 has been an exciting year of growth with new projects secured in Hawaiʻi. Look for more details on Carollo's recent Hawaiʻi projects and growing Honolulu office in the coming issues of *Currents!*

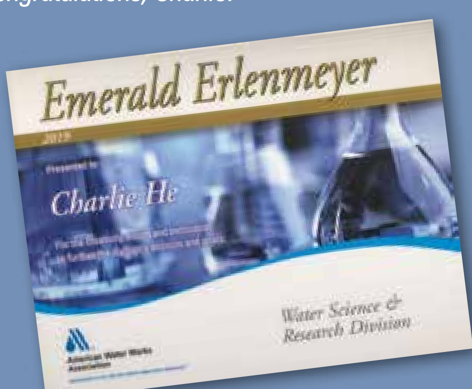
Charlie He

2019 Recipient of the Water Science & Research Division Emerald Erlenmeyer Award

Charlie He, Chief Technologist with Carollo (Phoenix Office), was the 2019 recipient of the Water Science & Research Division Emerald Erlenmeyer Award. This award is given to recognize exemplary contributions, initiative, and dedication to the mission of the AWWA Water Science & Research Division.

Charlie received the award during the Opening General Session of the 2019 Water Quality & Technology Conference (WQTC) held in Dallas, Texas, November 3-7, 2019.

Congratulations, Charlie!



INTELLIGENT WATER CHALLENGE

The **Leaders Innovation Forum for Technology** (LIFT) program, a joint effort of The Water Research Foundation (WRF) and the Water Environment Federation (WEF), held the second annual Intelligent Water Systems Challenge Final Competition at the 2019 WEF Technical Exhibition and Conference (WEFTEC) in Chicago. Competitors were to demonstrate the value of intelligent water systems to utilities and thereby foster the adoption of smart water technologies. The challenge gives students, professionals, and technology aficionados the opportunity to showcase their talents and innovation, with a focus on leveraging data using the best available tools to help utilities better understand the dynamics of complex systems and make better decisions.

Winning team participants: City of Boulder, Colorado School of Mines, Baylor University, and Carollo Engineers.

The topic of the competition was "Practical Considerations of Operating and Advancing Ammonia-Based Aeration Control." The winning team investigated the performance of dissolved oxygen (DO) and ammonia-based aeration control (ABAC) side-by-side using predictive modeling control methods and historical data from the City of Boulder's Water Resource Recovery Facility. The analysis showed that ABAC was more functional and had superior process stability compared to traditional DO. To enhance ABAC operation further, the team developed predictive model code using diurnal and linear model components that achieved over 90% accuracy in predicting ammonia concentrations at the ABAC control location in the aeration basins about 50 minutes into the future. The City is currently testing the model's predictive control code at the full-scale level.