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Fine-tune Chloramine Disinfectant Residual Levels in Distribution Networks

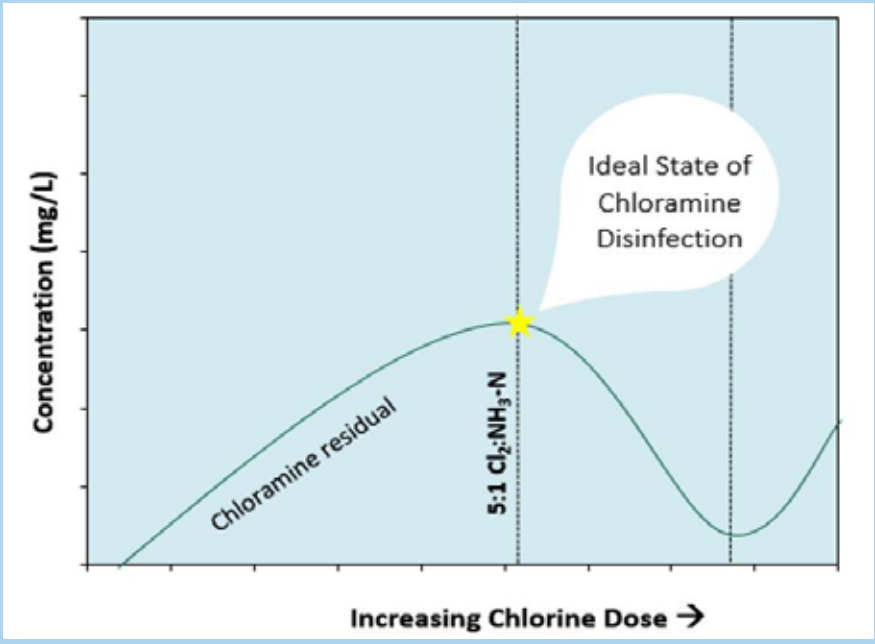
Water utilities can mitigate disinfectant-residual degradation by using automated chloramine management systems in water storage assets.

BY ANDY SEIDEL, MATT MILLER, AND PAUL JORGENSEN

CHLORAMINATION AS a disinfectant strategy in potable water systems provides many benefits, including a lower potential for disinfection byproduct formation, such as trihalomethanes (THMs), and improved disinfectant persistence in distribution systems. However, a significant challenge for water treatment plant operators relates to the shifting chemical equilibrium among ammonia, chlorine, and chloramines in water distribution systems. Premature decay of chloramine compounds can release free ammonia into distribution systems and lead to nitrification, taste-and-odor issues, and other complications as ammonia is consumed as a nutrient by various species of bacteria, ultimately causing unwanted nitrification. On the other hand, over-chlorination results in undesirable chloramine species such as dichloramines and trichloramines that engender taste-and-odor issues as well as provide additional potential for disinfection byproduct production.

Figure 1. Disinfectant Breakpoint Curve

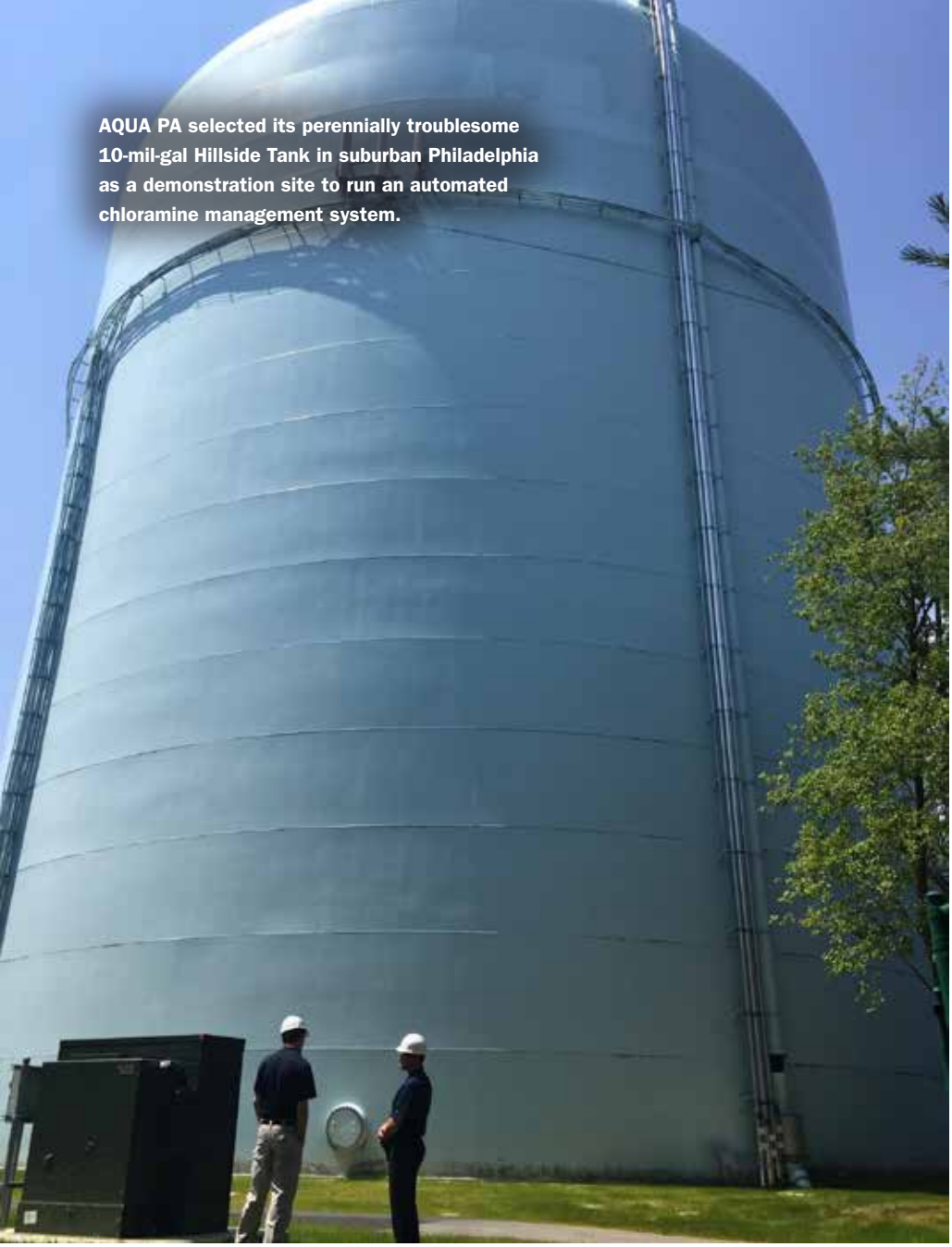
An ARCS manages the shifting chemical equilibrium along a reservoir's disinfectant breakpoint curve.



Operational activities such as tank dumping, frequent tank cycling, chlorine "burns" in distribution systems, and inefficient chlorine "boosting" in tanks and reservoirs increase utility expenses because of unpredictable manpower scheduling, overtime, and additional lab work as operators struggle to meet water quality levels, particularly in warmer months. Most chloramine decay occurs post–treatment plant as water ages in pipes, reservoirs, and tanks. Therefore, arresting chloramine degradation in distribution system storage assets is the most efficient way to maintain water quality and manage operating costs.

An automated residual control system (ARCS) deftly manages the shifting chemical equilibrium along a reservoir's disinfectant breakpoint curve (Figure 1) to ensure all free ammonia is reacted

PHOTOGRAPH: AQUA AMERICA



AQUA PA selected its perennially troublesome 10-mil-gal Hillside Tank in suburban Philadelphia as a demonstration site to run an automated chloramine management system.

with chlorine to provide an optimal level of monochloramine without overdosing chlorine, which can create undesirable chloramine species. By combining aggressive tank mixing with smart chemical reagent addition and real-time process control, an automated chloramine management system ensures chlorine or monochloramine residual set-points are maintained without the need for constant operator attention. An ARCS consists of four basic elements: (1) 24-7 full-time tank mixers with enough mixing energy to keep the water storage tank's chemistry homogeneous during the tank's fill and drain cycles, (2) an analyzer package that can determine the tank's disinfectant residual position on the breakpoint curve in real time, (3) a controller that can instruct chemical feed pumps to dose ammonia and or chlorine at the right time, and (4) a process feedback loop that repeats the process as the tank's dynamic environment changes.

EARLY ADOPTERS

Dozens of US water utilities have turned to such automated systems to solve their disinfectant residual issues. Featured here are two utilities (a water retailer and a wholesaler) that successfully tackled their distribution water quality issues by installing an ARCS from UGSI Solutions.

Aqua Pennsylvania, Abington, Pa. Aqua Pennsylvania (Aqua PA), an Aqua America subsidiary, serves more than 1.4 million people in 32 counties across Pennsylvania. Aqua PA has significant experience using chloramine chemistry as a means to mitigate THM formation in its many distribution systems. As with most water utilities, this traditionally meant constant monitoring and unplanned operator callouts to adjust influential water storage tank disinfectant residual levels, particularly in the summer.

After Pennsylvania published its Disinfection Requirements Rule (DRR) in April 2018, utilities were required in most cases to maintain a minimum chlorine residual of 0.20 mg/L at the point of use (in a home, for example). Leading up to the DRR's promulgation, Aqua PA had been considering deploying a residual control system that could automatically maintain chloramine residuals and positively influence downstream network water quality. In 2015, the utility selected its perennially troublesome 10-mil-gal Hillside Tank in suburban Philadelphia as a site to run a demonstration ARCS. The system was prepackaged in a trailer and included a 24-7 tank mixing system, a 40-pound-per-day on-site sodium hypochlorite generator as a chlorine source, an online water quality analyzer, and chemical dosing skids for ammonia and chlorine.

The ARCS was designed to fully mix the tank with sufficient energy to account for its volume and fill-drain cycles, determine real-time residual levels, and dose the appropriate ratio of ammonia and chlorine (constituents of monochloramine) for the position of the tank's residual on the chloramine breakpoint curve. The system was engaged in September 2015 and ran for a 60-day trial period.

As shown in Figure 2, the Hillside Tank began the pilot with seasonally low residuals as expected. The tank was initially taken to breakpoint to ensure an existing volume of compromised water didn't influence the test run's baseline. Within three to four days, the disinfectant

Ultimately, Aqua PA designed and installed an ARCS with 100 pound-per-day chlorine capacity at the Hillside Tank.

residual levels stabilized at the selected 1.5 ppm. At that point, it became apparent that for the 10-mil-gal tank, 40 pound-per-day available chlorine equivalents were insufficient to boost the residual to more than about 2 ppm.

The trial was a success, and ultimately Aqua PA designed and installed an ARCS with 100 pound-per-day chlorine capacity at the Hillside Tank, as shown in the photograph on page TK. The system managed a consistent residual throughout the previously problematic summer months in 2017 and 2018. In addition to successfully managing the Hillside Tank's residual, the full-scale system significantly influenced the cluster of surrounding tanks (about 9 mil gal of volume) used with Hillside to manage the system's downstream distribution network. Furthermore, the ARCS delivered significant economic savings in avoided unplanned overtime and consumables for manual tank boosting during the summer and early fall months.

City of Thousand Oaks Public Works Department, Thousand Oaks, Calif. Located northwest of Los Angeles in Southern California, in eastern Ventura County, the city of Thousand Oaks Public Works Department has approximately 190 employees who are responsible for managing the city's public infrastructure, which includes streets, sidewalks, landscaping, storm drains, water distribution/wastewater collections and treatment, and traffic signals. The Water Operations group serves 51,000 customers through 17,000 service connections, managing 230 miles of water distribution pipeline and 16 water storage tanks.

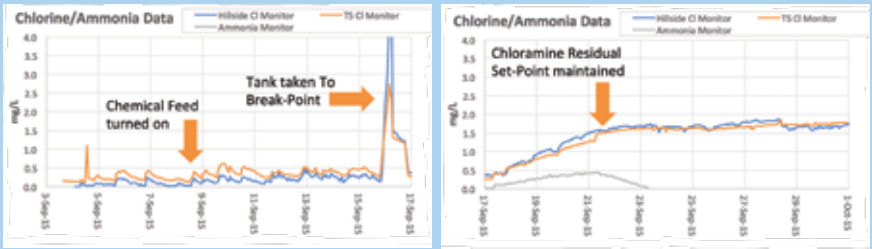
Thousand Oaks relies on chloraminated water from its wholesaler, Calleguas Municipal Water District/Metropolitan Water District, but challenges have arisen from the region's severe drought conditions and resulting water conservation efforts. With sustainability as a core value, Thousand Oaks has invested in new technologies to meet the water quality demands caused by increasingly warm weather. Initially, the city invested in water tank and reservoir mixing to stabilize chloramine disinfectant decay. Mixers provided a degree of system stability, but it became clear that chemical addition consistent with breakpoint chemistry at influential tanks would be required to actually boost monochloramine levels rather than prevent decay.

In 2015, Thousand Oaks installed an ARCS for demonstration purposes at two of its 16 tanks: Pederson (3 mil gal) and Willow (5 mil gal). The two systems successfully eliminated the seasonal pattern of water quality degradation and eliminated nitrification risk. By 2017, Thousand Oaks had permanently installed the two systems and completed a more holistic system review.

After collecting more than 2,900 points of historical sample data from

Figure 2. Hillside Tank Disinfectant Residual Levels

The Hillside Tank began the pilot with seasonally low disinfectant residual levels as expected (left), but in a few days levels stabilized after ARCS use (right).



There's increasing recognition that water quality improvement is a holistic endeavor that considers the treatment plant and the distribution network.

2010 to 2016, the utility was able to analyze seasonal nitrite and chlorine levels per location and map the hot spots geographically. Not surprisingly, as water temperature increased across the system, disinfectant residual decreased and nitrite formation increased as ammonia-oxidizing bacteria became more active (Figure 3), with the most problematic months between August and December. The Pederson and Willow tanks were the dramatic exception and steadily maintained the 2.2-ppm residual set-points, with a resulting lack of nitrite formation and no nitrification episodes.

Although only two of 16 tanks were addressed with active measures, the city's overall system disinfectant residual average increased by about 30 percent. Backed by data and the demonstrated positive influence of each ARCS on downstream pressure zones, Thousand Oaks can systematically address less severe issues in other zones by rationally equipping other tanks. Also, by plotting the aggregated sample data for all tanks, the city can forecast a system average residual that can eliminate any nitrification risk (Figure 4). With its success, the city has been able to maintain control of its system's water quality while continuing to receive water from its wholesale supplier in a time of unprecedented drought.

ONGOING ADVANCES

Over the past few decades, most North American water spending has been concentrated in treatment plant construction and upgrades. There's increasing recognition that water quality improvement is a holistic endeavor that considers the treatment plant and the distribution network. Today, regulators, utilities, and programs such as AWWA's Partnership for Safe Water are working together to add measurement and treatment tools such as ARCSs to better manage distribution network water quality and realize the goal of enterprisewide water quality improvement.

Figure 3. Thousand Oaks' Pederson and Willow Tanks

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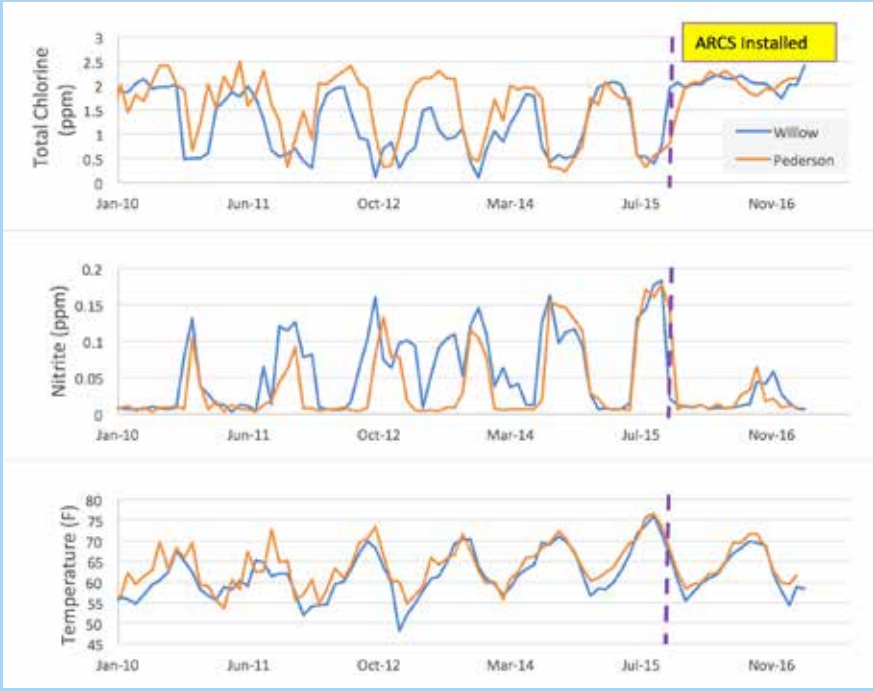

Figure 4. Chlorine vs. Nitrite

By plotting the aggregated sample data for all tanks, Thousand Oaks can forecast a system average residual that can eliminate any nitrification risk.