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Let's Solve Water

Xylem expertise helps South Carolina utility combat harmful algal blooms

ADVANCED OXIDATION TREATMENT SYSTEM ELIMINATES TASTE AND ODOR ISSUES IN DRINKING WATER

When conventional treatment methods did not resolve ongoing taste and odor issues in their finished potable water, officials of the Anderson Regional Joint Water System (ARJWS) knew they had to think beyond their immediate challenges and find sustainable, long-term solutions to deliver the high-quality water their 200,000 customers in Upstate South Carolina expected.

ARJWS is a wholesale drinking water provider capable of pumping up to 48 million gallons per day to 14 water utilities in Anderson and Pickens counties, and has been recognized multiple times for having the best tasting water in the state. After its source water Lake Hartwell started experiencing harmful algal blooms (HABs) in 2013, the water utility began receiving hundreds of complaints each week of musty-smelling and bad-tasting water.

Although the finished water met U.S. EPA quality standards, for utilities like ARJWS that rely on surface water, taste and odor complaints in drinking water are a serious and increasingly frequent concern, as well as a sizable public relations issue. In this case, frequent algaecide treatments to the source water reservoir that is also used for public recreation raised environmental concerns.

"The perception problem with the public is what led us to look at a more robust solution," acknowledged Scott Willett, ARJWS executive director. "We challenged our engineers to deliver a holistic solution that could address issues in addition to taste and odor compounds, such as environmental threats and future regulatory initiatives.

"If we were going to invest in upgrades to our water treatment plant we wanted to know what we needed to worry about for the next 15 to 20 years over the life of our equipment," Willett said.

Engineering consultant Goodwyn, Mills and Cawood (GMC) had been working with ARJWS on prior solutions to the T&O issues and was enlisted in 2016 to explore advanced treatment technologies. GMC teamed up with water technology provider Xylem Inc.

End User: Anderson Regional Joint Water System

Client: Brasfield & Gorrie

Consultant: Goodwyn, Mills and Cawood

Order Date: Sept 26, 2016

Completion: April 2018

Xylem's Role: Treatability testing and analysis of different advanced oxidation processes (AOP). Full scale Ozone AOP design submittals and equipment execution

Xylem Scope: Provided full-scale system (2 x PDOevo900 Ozone AOP System)

through representative Premier Water to begin the multiphase process of determining the most viable treatment option in terms of objectives, lifecycle costs and total cost of ownership.

Xylem's expertise in water treatment solutions, the diligence of the Xylem Wedeco team and its ability to meet the aggressive schedule set by ARJWS officials made it an excellent partner for the project.

"One of the first conversations we had with all the contractors and potential vendors is that we had to be online before May 2018," Willett said. "Xylem understood we couldn't go through another summer of substandard water quality in our community."

Traced to algae bloom

The blue-green algae, or cyanobacteria, that spread across Lake Hartwell in the summer of 2013 produced nontoxic compounds geosmin and 2-Methylisoborneol (MIB), the sources of the "dirty" tasting water. ARJWS officials tried various recommended best practices, such as copper- or peroxide-based algaecides for in-lake treatment. Adding powder activated carbon (PAC) and chlorine dioxide within the treatment plant to adsorb and oxidize the objectionable compounds did not deliver the desired results, due to the high concentrations being generated by the HABs. Lake Hartwell experienced an even larger bloom in 2014, continuing the troubles for ARJWS.

"We thought it was a transitional issue and brought GMC online quickly so we could address the problem," Willett said. "When the problem came back with brute force, there was no more stop gap."

"Concentrations entering the plant in the summer of 2014 were in the 300 to 700 ng/L range – meaning their removal below human detection through conventional treatment methods was nearly impossible," said Tony Reid, GMC project engineer, noting that most people can sense the smell or taste at concentrations of 4 to 9 ng/L.

Seeking a solution

Recognizing that in-lake treatment methods would not resolve the ongoing T&O issues, the ARJWS board changed course to explore a treatment system upgrade. The goals of the upgrade were to eliminate seasonal taste and odor events, remove color associated with naturally occurring iron and manganese, and establish resilience against algae-linked compounds and other contaminants of emerging concern (CECs).

Based on the nature of the contaminants, Xylem designed and executed a treatability study featuring ozone and two other advanced oxidation processes (AOPs) – ozone/hydrogen peroxide, as well as ozone/UV light.

"All technologies were effective at removing MIB from an influent concentration of 400 ng/L to 4 ng/L, which is below the human threshold," according to Reid. "Greater concentrations were tested and in some events 99.7 percent removal of MIB was achieved with higher oxidant doses."

Results of the study indicated ozone alone would be sufficient for most operating conditions and provide the lowest lifecycle cost based on a 20-year evaluation. However, detailed analysis of augmenting ozone with hydrogen peroxide showed that the lifecycle cost would increase slightly, but capital expenditure would be reduced with the use of a smaller ozone contactor basin.

Additionally, Ozone AOP was determined to be the most viable overall option because it provided operational flexibility and an additional AOP barrier when needed. The Ozone AOP solution would address current and future requirements based on taste and odor, color and CEC impacts for the best performance versus lifecycle cost over the expected project life.

Over a 20-year period, GMC estimated the cost for ozone + peroxide would be $11.9 million, with a guaranteed maximum price (GMP) of $12 million. Final GMP was $11.3 million for the new treatment system with an annual operations and maintenance cost of $378,000. (Figure 1)

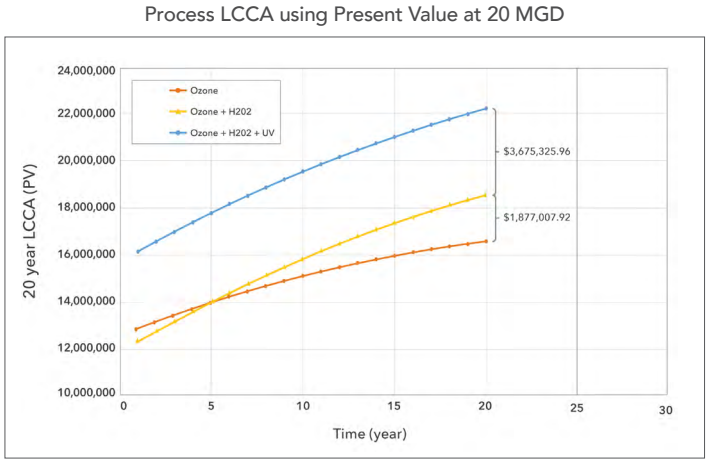

Figure 1.

AOP is emerging as a new best practice in water treatment in recent years, with a handful of utilities around the world employing this proven technology. Before deciding to implement the state-of-the-art treatment system, ARJWS officials visited Xylem project sites in Florida and Texas, ultimately green-lighting the project and selecting Xylem as their partner.

"Xylem has a significant amount of experience with ozone and AOP in unique applications around the world," Reid said. "The treatment solutions were pretty narrow in this situation, but the process was more complicated due to site constraints, project timing and affordability."

Additional priorities that factored into the selection process included:

- **Safeguarding against contaminants of emerging concern (CECs):** ARJWS wanted to ensure the new treatment system could address future environmental threats and regulatory initiatives based on the EPA's list of CECs. AOP and ozone-enhanced filtration systems like the one proposed for ARJWS have proven effective in CEC removal.
- **Location of the treatment system:** ARJWS officials wanted to install the system upfront of the clarifier, expecting the pre-ozonation process would improve the clarification and filtration performance and reduce the need of a pre-chlorination for the filters.
- **Maintaining licensure:** With the new plant being classified as a pretreatment facility, plant operators would not be required by the state of South Carolina to obtain additional training and certification, which would have adversely impacted the project timeline.
- **Avoiding additional operational expenditures:** "We did not want to repump our source water within the primary plant treatment process," Willett said. "We thought that would be a very expensive proposition in addition to all of the other costs."
- **Maintaining staffing levels:** Xylem's fully automated system and TotalCare Services package meant ARJWS could avoid the challenge of finding additional qualified operators to run the new system.

In addition to providing the full-scale system, Xylem also ensured optimization of the overall plant upgrade design concurrently with the equipment manufacturing process.

"A lot of what we were looking at in selecting a vendor was experience and comfort level," Willett said. "We were impressed with both the Xylem marketing and technical teams. It's one thing to sell a product, but to really understand it and how it works with everything in the facility is another."

Construction of the required structural components began in February 2017. The project was completed ahead of schedule and under budget by general contractor Brasfield & Gorrie. All parties credit the Construction Management at Risk (CMAR) project delivery approach as successful in meeting the aggressive schedule and providing value through a collaborative relationship among the designer, builder and equipment supplier.

Ozone AOP explained

Ozone is generated by means of a silent electrical discharge in an oxygen containing gas. As soon as ozone is introduced into water, any hazardous pollutants present are effectively degraded through oxidation without creating harmful chlorinated byproducts or significant residues. By decomposing into oxygen as it reacts, ozone provides a cost-effective and environmentally responsible alternative to oxidation with chlorine, absorption (activated carbon) or separation processes (reverse osmosis).

AOP is the combination of two or more processes to generate hydroxyl (OH-) radicals. Compared to other oxidants, OH- radicals have considerably higher oxidation potential, and once formed in water they immediately attack virtually all existing oxidizable substances. The high degradation performance and the quick reaction kinetics of AOP provide the formula for success when it comes to eliminating numerous persistent contaminants.

The processes used in AOP – ozone (O3), hydrogen peroxide (H2O2), ultraviolet (UV) radiation and chlorine – are powerful treatment technologies by themselves. The key to selecting the best AOP solution is to find the right combination of these processes to most efficiently generate OH- radicals that reduce the seemingly nondegradable contaminants, rendering them harmless.

The ARJWS AOP system consists of two Wedeco PDOevo 900 Ozone AOP Systems, each producing 1,000 pounds of ozone per day with the option for an additional generator upgrade in the future. As noted above, ozone is introduced as a pretreatment step prior to entering the existing treatment process. The ozone is fed into a contact chamber with a minimum retention time of 12 minutes. When necessary, hydrogen peroxide can be fed prior to ozone addition through two static mixers to generate hydroxyl radicals, which improves the oxidation process. Peroxide can also be used at the end of the ozone contactor to remove any ozone residuals within it.

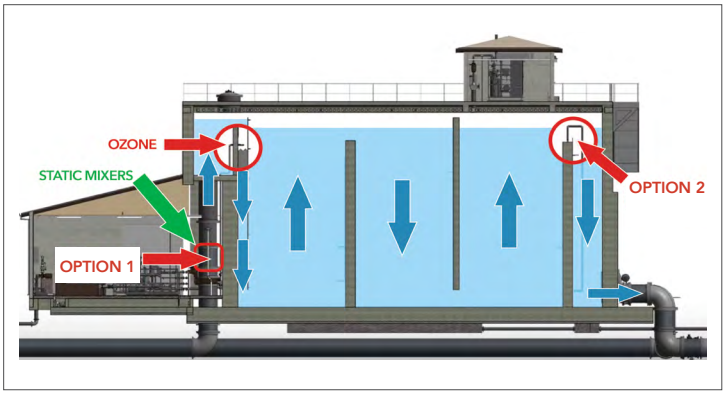

Figure 2. The system design includes two options for dosing hydrogen peroxide. In option 1, peroxide is fed prior to ozone addition to create hydroxyl radicals in AOP mode. In option 2, peroxide can be used at the end of the contactor to quench any ozone residuals.

Performance measurables

In the first six months of operation, MIB and geosmin concentrations in Lake Hartwell are down significantly from previous years, though still at levels detectable by humans. At the start of the algae bloom season, the ozone AOP system is reducing 99.9 percent of the incoming MIB/geosmin, resulting in non-detect values in the outlet. Color has consistently been clear with the increased iron and manganese removal.

The effectiveness of the preoxidation process is bringing considerable operational efficiencies to the clarification and the Xylem Leopold Filterworx™ system. Additionally, Trihalomethanes (THME) levels are reduced by more than 50 percent due to the ozone treatment and reduced chlorine use. (Figure 2)

Average Total Organic Carbon (TOC) removal rates have increased from 35 to 40 percent to 60 to 65 percent, further reducing organic compounds in the finished water, which also aids in reducing post-treatment Disinfectant Byproduct (DPB) formation.

"We are spending significantly less in combined chemicals and additional power costs than with the PAC treatments we were previously using," Willett reported. Electricity costs per million gallons were projected to increase 10 to 12 percent with the new system, however, after three months, electricity costs rose just 5 to 6 percent.

Recordable savings include:

PAC: With PAC no longer in use, the plant is saving more than $500,000 per year in consumables, plus many operating and servicing hours. The PAC system required an annual cleanout of the backflush pond at

a cost of $125,000, which is no longer necessary, as the dosed PAC would accumulate there, representing up to 50 percent of the settled solids and diminishing capacity.

Mixed oxident solution: Upfront chlorination to keep the media filter cleaner is no longer required, reducing overall chorine use by 50 percent. This results in a savings of about $40,000 to $50,000 annually and is expected to significantly increase the overall lifetime of the chlorine system.

Conclusion

AOP treatment technology is an increasingly attractive solution for utilities experiencing threats to their source water due to nutrient pollution. Lab and/or pilot testing provides valuable information on the most viable treatment options within each plant.

As other regional water agencies are experiencing similar water quality issues as ARJWS, the facility has become a showcase for AOP treatment technology, according to Willett. He notes that ARJWS also is taking a leading role in the community in regard to source water protection.

As far as his customers are concerned, Willett says drinking water quality is no longer a topic of local discussion. ARJWS has not received a single complaint about the water since the new treatment plant came online. "Going unnoticed is a good thing," Willett said.

"We're pretty proud of what we've got here," Willett said. "We are looking forward to being back in the competition for best tasting water in the state."

Salvador Dominguez is the Treatment Product Manager Americas for Xylem Inc. He is based in Charlotte, North Carolina. Steve Green is the Water Utilities Business Development Manager for Xylem Inc., based in Portland, Oregon. He is an advisor member of the Water Design Build Council, a not-for-profit organization dedicated to evolving best practices in water design-build delivery.

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1) The tissue in plants that brings water upward from the roots;
2) a leading global water technology company.

We're a global team unified in a common purpose: creating advanced technology solutions to the world's water challenges. Developing new technologies that will improve the way water is used, conserved, and re-used in the future is central to our work. Our products and services move, treat, analyze, monitor and return water to the environment, in public utility, industrial, residential and commercial building services settings. Xylem also provides a leading portfolio of smart metering, network technologies and advanced analytics solutions for water, electric and gas utilities. In more than 150 countries, we have strong, long-standing relationships with customers who know us for our powerful combination of leading product brands and applications expertise with a strong focus on developing comprehensive, sustainable solutions.

For more information on how Xylem can help you, go to www.xylem.com

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