Source: Kasco Marine

RESEARCH SPOTLIGHT

Sustainable Algal Control Technologies

Small Investments in Diffused Aeration and Ultrasound Systems Make Big Improvements in Water Quality

By Rich Abbott, Watershed Quality Coordinator, Skaneateles Lake Watershed Protection Program and Justin Rickard, Technical Publications Manager, The Water Research Foundation

At a Syracuse, New York-area reservoir the use of two technologies—diffused aeration systems and ultrasonic algal control—reduced the need to mitigate algae through use of costly chemical algaecides. The payback period of these two technologies was less than two years.

Water utilities have particular interest in mitigating algae within their water bodies to ensure a high-quality water supply for their customers. Traditional algal mitigation techniques include the use of a chemical algaecide or fungicide like copper sulfate pentahydrate (copper sulfate).

To curb algal growth at the City of Syracuse, NY Woodland Reservoir, the city applied copper sulfate each year dating back to the mid-1970s, yet modern, more sustainable algal mitigation methods became necessary.

Decades of Algaecide Applications at Woodland Reservoir

Completed in 1894, Woodland Reservoir is a 126-million-gallon man-made reservoir with approximately 14 acres of water surface area providing clean drinking water for Syracuse, NY, residents. Through 19 miles of conduit, the reservoir receives water from Skaneateles Lake, located in New York's

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Finger Lakes region. Concrete lines the reservoir bed and the side walls are faced with rubble masonry laid in cement.

To control algal growth at Woodland Reservoir, copper sulfate was applied regularly to the reservoir from May through October starting in 1975 and lasting for 44 years. Treatment typically started after algae levels crossed certain thresholds or water quality in the reservoir visually deteriorated.

The method of algaecide application depends on the type of growth—planktonic (organisms drifting or floating in water) or periphytic (organisms attached to underwater surfaces). To mitigate planktonic algae, city employees towed bags of copper sulfate along the entire reservoir surface by boat. For periphytic algae mitigation, employees dragged 50-pound burlap bags of medium crystal copper sulfate around the perimeter of the reservoir.

Aerial photo of Woodland Reservoir and the surrounding area. Source: Google Earth

As Copper Sulfate Applications Increased, So Did Resistant Algal Species

From 1975–2018, at least one copper sulfate treatment was recorded each year for a total of 266 treatments. Treatments averaged six per year and ranged from 125 pounds in 1978 to 14,650 pounds in 2005. However, from 2004–2015 copper sulfate treatments increased to a total of 112, averaging 8,708 pounds applied a little over 10 times per year during the 11-year span. Starting in 2004, algal cell counts were increasing over time, even with additional amounts of algaecide added.

During this time, of the 17 targeted treatments for the cyanobacteria species *Chroococcus Type I* post-treatment cell counts exceeded pretreatment counts 35 percent of the time within two to four days of treatment. To make matters worse, in 2004 *Chroococcus Type II* cell counts increased from 3,000 cells per milliliter (cells/mL) to greater than 28,000 cells/mL within a six-day period despite several copper sulfate treatments.

Between 2004 and 2015 copper sulfate treatments in the Woodland Reservoir increased dramatically—and so did algal cell counts, even with additional amounts of algaecide.

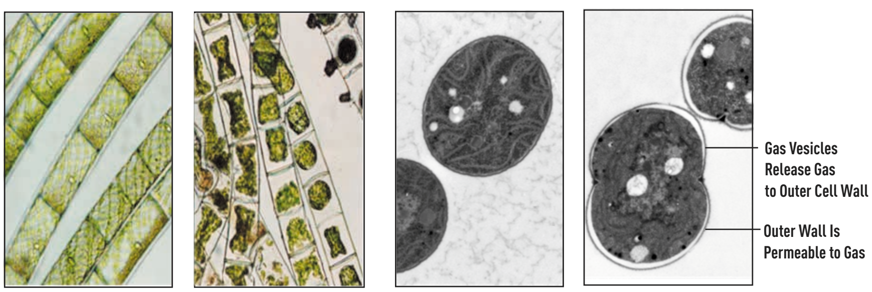
The reservoir was taken off-line for more copper sulfate applications. However, water quality did not improve. The reservoir was drawn down and not put back into service until colder water temperatures resulted in a significantly reduced cell count.

Sustainable Approach One: Ultrasonic Algal Control

Rich Abbott, Watershed Quality Coordinator for the Skaneateles Lake Watershed Protection Program, monitors the water at Woodland Reservoir. As a commercial pesticide applicator, he is responsible for recording and reporting algaecide applications in the reservoir.

"Algal cell counts were increasing and so were the quantities of copper sulfate, at a considerable financial cost to the city," said Abbott. "We needed to consider a more sustainable solution to mitigate the growing algal cell counts at the reservoir and eliminate the costly and labor-intensive applications of copper sulfate."

In 2007, a new strategy was deployed using ultrasonic algal control at the Woodland Reservoir to mitigate the increase of *Chroococcus Type II* along with copper sulfate treatments. The ultrasonic method uses soundwaves at the same frequency of algal cell structures to reach critical structural resonance, a condition causing internal cell wall damage or ruptured gas vesicles.



Spyrogyra: Before/After Ultrasonic Treatment

Microcystis Aeruginosa: Before/After Ultrasonic Treatment

Before and after ultrasonic treatment of different algal species. Source: Adapted from SonicSolutions Algae Control, LLC

Internal cell wall damage can halt nutrient transfer and lead to a compromise of the cell's defense mechanism, allowing bacteria to invade and begin digesting the algae. Ruptured gas vesicles cause algae to sink, reducing their access to sunlight for photosynthesis.

Five ultrasonic units from SonicSolutions, LLC were installed around the reservoir perimeter. These devices work by emitting soundwaves from a transducer head positioned just under the water surface, converting electrical energy into sound energy with the sound projected into the water body. Damage to algal cells occurs when a target's natural resonance frequencies match the ultrasonic frequencies emitted by these devices. The sonic heads produced 18 frequencies.

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"Although the ultrasonic units initially appeared to be effective in controlling *Chroococcus Type II* cell counts, a new form of cyanobacteria identified as *Cyanobium* became dominant in the reservoir in the summer and fall of 2007," Abbott said. "Unfortunately, the ultrasonic units and copper sulfate treatments were not effective in controlling *Cyanobium* growth."

In 2009, the ultrasonic frequency set was increased to 79 frequencies. This was the first attempt at increasing the frequency density to increase the odds of hitting critical structural resonance frequencies of more algal species.

From 2007 through 2015, 77 copper sulfate treatments were applied, totaling 77,850 pounds. However, *Cyanobium* was consistently the dominant form throughout this period, ranging from 34.1%–76.4% of annual cell counts. The situation was becoming unmanageable again even with the combined use of ultrasonic units and copper sulfate applications.

Sustainable Approach Two: Ultrasonic Plus Diffused Aeration Algal Control

In 2016, two diffused aeration systems were installed in the reservoir. The diffusers were positioned in 25–35 feet of water. This system pumps compressed air from a shore-mounted compressor through self-weighted tubing to diffusers on the reservoir bottom.

Land-based compressor cabinet and power supply for the ultrasonic units. Source: City of Syracuse

Diffusers continuously release microbubbles—typically two millimeters in diameter—that rise at one foot per second to the surface pushing and dragging large volumes of water from the reservoir bottom to the surface, which is beneficial for water movement and mixing. Exchanging gases with

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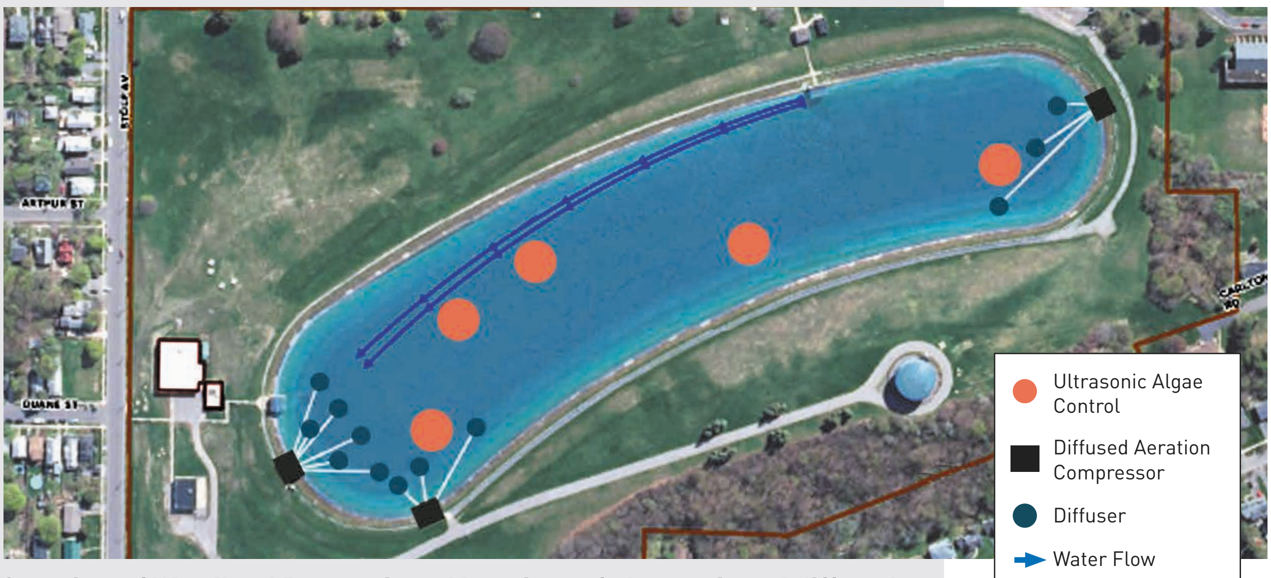
the atmosphere induces oxygen-transfer and allows carbon dioxide gas to be expelled. Continued mixing of the reservoir allows for uniform chemical and physical properties including temperature and pH.

Kenneth Rust, CEO of Enterprise Aquatics LLC and a distributor for Kasco Marine diffused aeration products, understands how aeration can disturb the preferred state of cyanobacteria in the reservoir. “Since cyanobacteria require extended photoperiods and warmer water, continuously mixing the reservoir disrupts cyanobacteria’s ability to dominate the upper water column,” Rust said. “Cyanobacteria cells traveling up and down through the water encounter a mixture of dark and light environments and cooler water conditions, both of which discourage their ability to dominate in the reservoir.”

Flow studies, water quality observations, and cell counts indicated that stagnant zones form within the reservoir due to the reservoir’s kidney shape and the locations of the inlet and outlet. Since the inlet is located along the southeast perimeter and the outlet is at the north end, influent water can short-circuit along the east side of the reservoir. To enhance



Overview of Woodland Reservoir and locations of ultrasonic and diffused aeration algae control assets. Source: Adapted from Syracuse Water Department, NY

mixing, the diffusers were placed along the northwest and south sections of the reservoir as shown in the figure above. To increase coverage, more diffusers were added or replaced starting in 2017 through 2022.

Combined Ultrasonic Units and Diffused Aeration Systems Reduce Algal Count

The impact of ultrasonic units and diffused aeration systems has contributed to a substantial reduction in the dominant forms of cyanobacteria.

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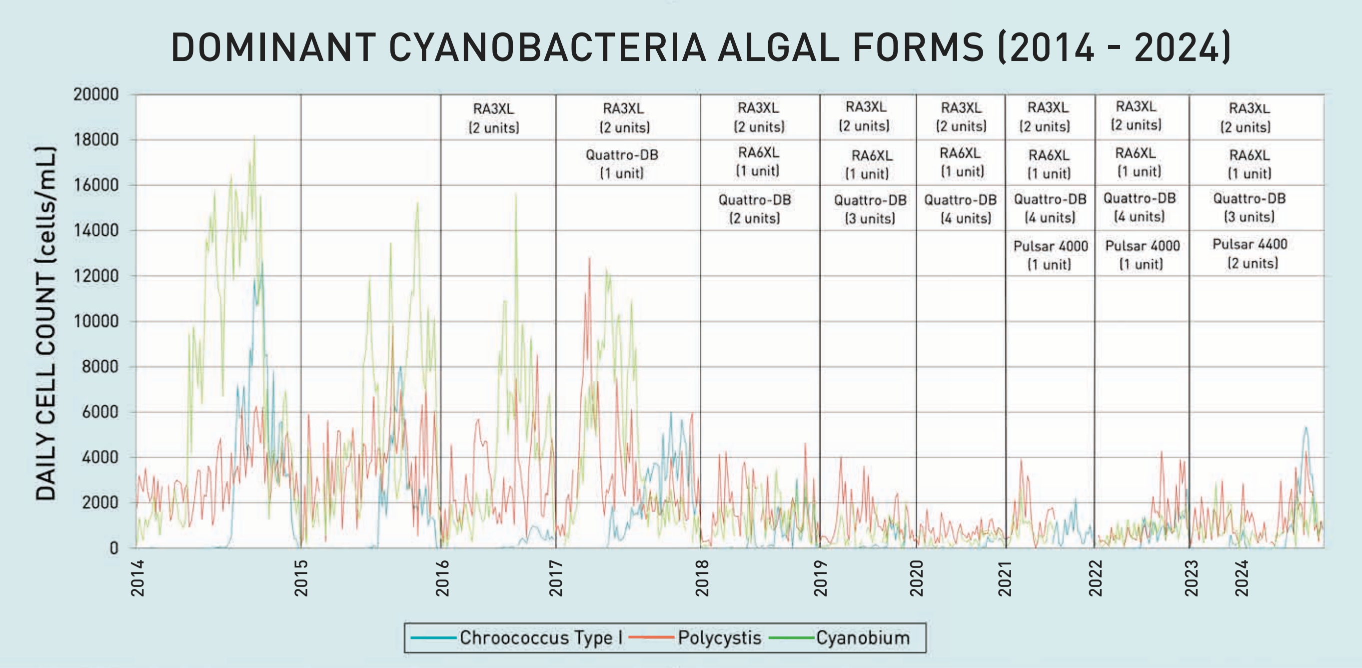
Maximum daily cell counts in 2014 and 2015 peaked at 18,223 cells/mL and 15,251 cells/mL respectively, even though the reservoir was treated with copper sulfate on ten occasions in 2014 and eight occasions in 2015. Following installation of the combined technologies, the highest daily cell counts recorded in 2019–2024 ranged between 1,710 cells/mL, and 10,907 cells/mL.

The figure below illustrates the steep decline in cell counts of *Chroococcus Type I*, *Cyanobium,* and *Polycystis*, corresponding to additional diffused aeration systems and ultrasonic units. *Chroococcus Type I*, *Cyanobium,* and *Polycystis* have decreased by 45%, 88%, and 56% respectively from 2014–2024.



Algal cell counts in Woodland Reservoir from 2014 to 2024. Source: Syracuse Water Department, NY

The Cost of Copper Sulfate and the ROI of Ultrasound and Diffused Aeration

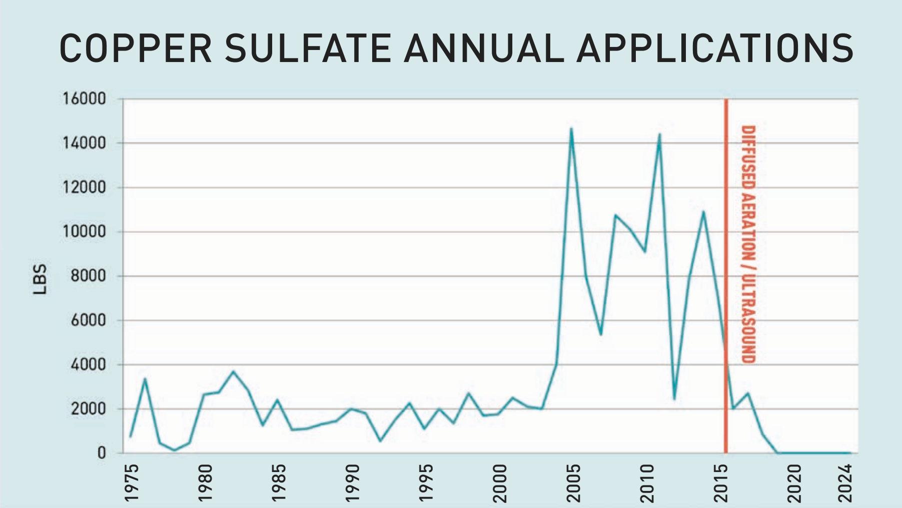
The material cost to the city from 2004–2015 for copper sulfate averaged $16,110 per year, with a total cost of $193,325. Beyond material costs, there were several other difficult-to-quantify costs and challenges with the use of copper sulfate, including:

- Staffing and miscellaneous costs to transport, bag, and apply the product.
- Applying copper sulfate in ideal conditions, i.e., full sunlight, and acquiring a dedicated crew available during the peak vacation season posed operational challenges.
- Continuous monitoring of the reservoir's water quality through visual observations, cell counts, and physical parameters (temperature and turbidity) added up to many hours, especially in the late summer and fall months.

This was a large expense for the city when both copper sulfate use and algal counts were increasing.

A Smarter and More Sustainable Investment for the City of Syracuse, NY
To reach the goal of eliminating copper sulfate treatments in the reservoir, the city invested a total of $26,056 in diffused aeration units and advanced ultrasound algae control devices from 2016–2019. The average annual algal control material cost throughout the four-year transition phase was $9,081 (diffused aeration and ultrasound units: $6,514; copper sulfate: $2,567).

Seasonal operation and maintenance of the ultrasonic algal control units involve approximately a half-day of installation in the spring, monitoring, and removal of biofilm/mineral deposits on the transducers monthly, then another half-day removing and cleaning the units in the fall.



Pounds of copper sulfate added to Woodland Reservoir from 1975–2018. From 2004–2015 the pounds of copper sulfate radically increased until the introduction of diffused aeration and ultrasonic systems (orange line). Source: Adapted from Syracuse Water Department, NY

Basic maintenance of the diffused aeration systems consists of cleaning or replacing air filters and cleaning the compressor cabinets. Following two to three seasons of operation—or if reduced air flow or preferential air flow is observed between diffusers—the compressor piston cups must be replaced. Compressor rebuild kits supplied by the manufacturer are serviced in the field.

"After all, we are pleased with implementation of ultrasonic units and aeration diffusers to help us mitigate algal growth," said Abbott. "The sustainability of these technologies is not only cost-effective, but the quality of the water supply has consistently improved with each new generation of the ultrasound model."

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Employing additional units and devices within the reservoir has also supported water quality improvements and suppressed daily cyanobacteria cell counts throughout consecutive years (2019–2024). Starting in 2019 no copper sulfate was applied.

With lower cell counts and improved water quality, algal monitoring and cell counting activities have been gradually reduced from a total of 67 days in 2014 to 29 days in 2023 and 37 days in 2024. The benefits of both ultrasonic algal control and diffused aeration technologies have proven to be a smarter and more sustainable investment.

For any questions regarding details in this article, please contact Rich Abbott, Watershed Quality Coordinator, Skaneateles Lake Watershed Protection Program at rabbott@syr.gov.

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ACKNOWLEDGMENTS

Rich Abbott would like to thank Kaylyn Dion, Environmental Engineering, Syracuse University 2020, for her valuable contributions to this article. Special thanks to technical contributors/reviewers George Hutchinson and Kenneth Rust and technical reviewers Dan Robbino and Mike Cole.