

Automated Residual Control Maintains Tank Chloramine Residual Levels and Eliminates Nitrite Issues in 3 Million Gallon Tank

Loudoun water in Northern Virginia has a history of embracing change and seizing opportunities to create a more robust and sustainable water system. Situated in the fast-growing suburbs of Washington D.C., Loudoun Water provides chloraminated drinking water to over 65,000 households through a network comprised of more than 1,200 miles of pipes and seven water storage tanks. A key element of Loudoun Water's mission to sustainably manage water resources has been its efforts to improve the operational efficiency of its drinking water system. For a chloraminated water system, that means getting control of nitrification.

Loudoun Water used to be a simple secondary system, blending free-chlorine drinking water from the City of Fairfax with chloraminated water from neighboring Fairfax County. Due to the growth in its service area, Loudoun County continued to expand its capabilities by building additional transmission mains and storage capacity that culminated with the construction of the Dulles South Tanks, a pair of 3-MG fluted composite tanks serving the southern portion of its system (Figure 1).



Figure 1. 3-MG Dulles South Tanks. Loudoun Water can only operate one tank due to water quality concerns.

When the Dulles South Tanks went online in 2012, managers of the Loudoun Water system anticipated that the additional storage would introduce some new challenges in managing drinking water quality. Water Quality Manager Cathy Cogswell developed a nitrification sampling plan to cover areas that, historically, had shown indications of low residual and nitrification. Once implemented, however, the sampling plan revealed that nitrification in the southern part of the system was worse than previous surveys had revealed. As a result, operators took one of the two Dulles South Tanks offline in October 2014 to reduce water age and nitrification.

Loudoun Water practiced a number of prudent operational strategies to reduce the risk and prevalence of nitrification. Along with Fairfax County, which supplies a large portion of water to the Loudoun system, Loudoun Water performs a free chlorine conversion of its system every Spring. For roughly 10 weeks, both systems switch from chloramines to free chlorine, supplying the distribution system with a higher level of oxidizing disinfectant to reduce the presence of nitrifying bacteria. After converting back to chloramines, Loudoun Water crews then aggressively flushed portions of the system at the first sign of lowered residual levels. "In past years we had a crew of two operators dedicated solely to flushing this part of our system all summer long," explained O&M Division Engineer Rick Johnson.

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During tank construction, Loudoun Water also installed a PAX Mixer (PWM400) in the Dulles South Tank to eliminate stratification and stabilize water quality. “We see improvement in mixed tanks versus unmixed tanks,” Jacobson confirmed. “Stratification in the mixed tanks is eliminated and residual levels are typically higher and more stable.”

In January 2014, Loudoun Water purchased the Goose Creek Water Treatment Plant from the City of Fairfax. The facility was quickly converted to chloramines to provide more control over the water system. Loudoun Water still experienced low residual levels in the region around the Dulles South Tanks, however, and more flushing was necessary.

The summer of 2014 brought a higher level of nitrification than Loudoun Water staff had seen before. With awareness of the problem areas in the system, Loudoun Water preemptively flushed, quickly mobilized crews and raised the disinfectant residual leaving the water treatment plants. “It involved a significant amount of staff hours and cost,” recalls Cogswell. At several sites, flushing would temporarily restore disinfectant residual levels, but they would deteriorate thereafter (Figure 2).

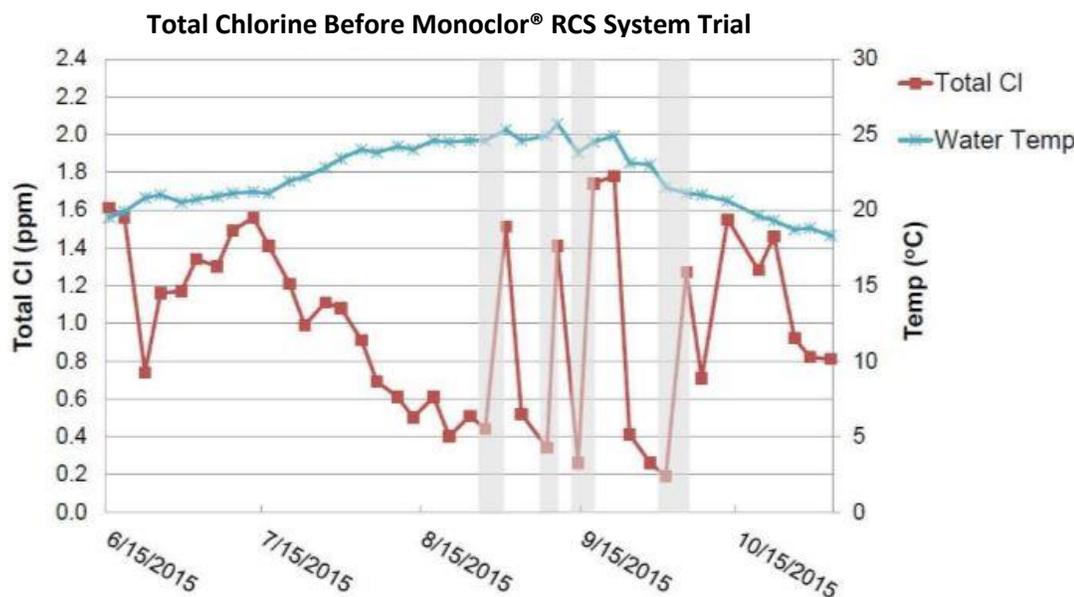


Figure 2. Total Cl and water temperature at the Aldie compliance site before the Monoclor® RCS system was installed. Periods of flushing (grey) would only temporarily restore residual levels (red).

Operators began to suspect that the Dulles South Tank itself might be part of the problem. “We would deep-cycle the tank and refill it with water with 3 mg/l of residual,” Cogswell recounted, “but you would turn around and there would be next to no residual in the water leaving the tank.”

Suspecting that nitrification was occurring in the tank itself, despite the presence of the mixer, Loudoun Water staff investigated their options. At the 2015 AWWA Annual meeting, Loudoun Water learned about the latest technology offered by PSI Water Technologies, Inc. (PSI) for actively controlling residual disinfectant levels in tanks, called the Monoclor® RCS residual control system. PSI engineers described how the system utilized the powerful PAX Mixer, along with water quality sensors, a control system, and chlorine and ammonia chemical feed skids to continuously monitor and regulate disinfectant levels. Best of all, the system was optimized to reduce the amount of free ammonia in the water – the key ingredient that kicks off nitrification.

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Eager to implement this new strategy before the next season of nitrification, Loudoun Water proposed a Monoclor® RCS residual control system pilot study to its regulatory agency, the Culpeper Regional Office at the Virginia Department of Health (VDH). Given the problems Loudoun Water and surrounding agencies had combatting nitrification, the VDH was very interested in piloting the Monoclor® RCS system. After receiving VDH approval, Loudoun Water requested an expedited factory installation of a Monoclor® RCS system at the Dulles South Tank. The installation was completed while Loudoun Water was finishing its period of free chlorine conversion making the switch back to monochloramines much simpler than in previous years.

Using the Monoclor® RCS automated system, Loudoun Water was able to make the switch in the tank at the same time the treatment systems switched over to chloramines (Figure 3). Jacobson noted, “What normally would take several days to convert the tank to monochloramines took seven hours.”

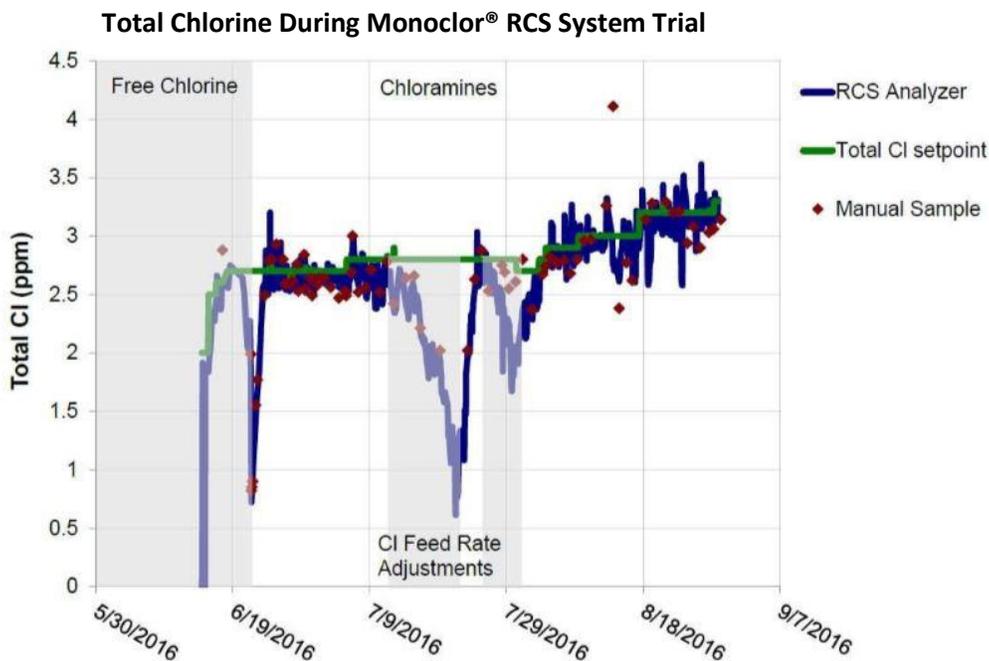


Figure 3. The Monoclor® RCS trial at the Dulles South Tank began with the Loudoun system in free chlorine. The Monoclor® RCS automatically converted the tank to monochloramines in June. In July, as temperatures heated up, the maximum feed rate for the Cl pumps had to be increased twice to accommodate higher-than-anticipated Cl demand in the tank.

Once the nitrification season began, Loudoun Water staff closely monitored the system. Loudoun Water operators tested which ratio of components maximized residual Cl and reduced free ammonia. “Our field data showed that our chlorine-to-ammonia ratio could vary between 4.7 and 5.7 to 1,” recalls Jacobson. “This indicated to us that we had more free ammonia in our source water than we had suspected.”

Within the first few weeks of operation, the operators at Loudoun Water realized that they had made a breakthrough. “We were seeing better residual levels in the tank than we had ever seen for this time of year, and we were seeing higher residual levels throughout this portion of the system,” reported Water Plant Superintendent Tom Barrack. Managers at Loudoun Water noticed something else different, as well: They received no customer complaints for water quality from anywhere in the system served by the Dulles South Tank.

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The startup of operation was not without its hiccups. There were issues with the chemical feed pumps, chlorine demand, and off-gassing of the 12% hypochlorite solution. Fortunately, because the Monoclor® RCS has multiple levels of alarms and onboard diagnostics, and the ability to directly send alarms via text message to operators' phones, operators were aware of any changes in the performance of the system. "The alarm systems were most helpful for getting pump status and understanding when the diaphragm pumps may have become air-bound, and appropriately shut down the system," noted Jacobson. "Also, the way the system and alarms can be configured was very useful. It can be tailored to each utility's needs. This was also important to our regulatory agency – they liked seeing that level of control and safety."

As the trial progressed, operators from Loudoun Water routinely checked on the Monoclor® RCS and took manual samples of water leaving the Dulles South Tank to measure total chlorine, free ammonia and nitrite. Surprisingly, the data showed that free ammonia levels in the water entering the Dulles South Tank were highly variable, with swings as large as 0.3 mg/l in one day. But, with the Monoclor® RCS residual control system, operators could automatically adjust the chlorine-to-ammonia ratio in response and lower the free ammonia leaving the tank. As a result, nitrite levels remained low, indicating that nitrification was under control. "It's like a little treatment plant," observed Barrack, "We're controlling the water." Over time, as the operators became more comfortable with the automated residual control system and the positive impact it had on the system, the residual chlorine target was raised from 2.8 to 3.3 ppm.

At the end of each summer, Loudoun Water usually experiences its worst water quality, requiring continuous and spot flushing in multiple locations. This summer, however, was different (Figure 4). "In 2016, not only did we essentially eliminate flushing, but construction inspectors [putting sections of pipeline back into service] reported that they could flush and restore a residual much quicker than before, saving additional time and money," observed Jacobson.

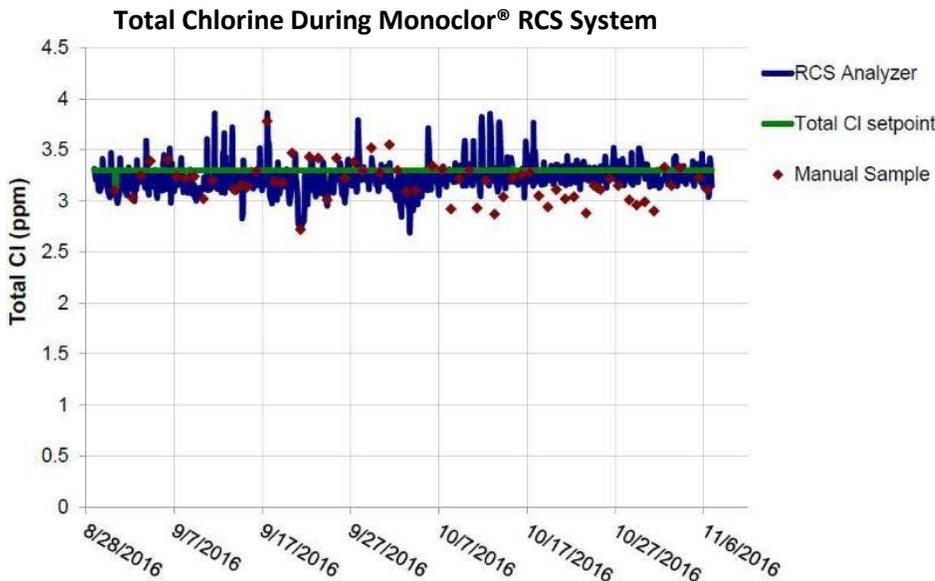


Figure 4. After optimizing the Cl:ammonia feed ratios and stabilizing operations, the Monoclor® RCS maintained a consistent, high monochloramine residual in the Dulles South Tank throughout the most challenging water quality season at Loudoun County.

Comparing water quality data from 2015 versus 2016 told the story. Two locations, roughly two miles west of the Dulles South Tanks have been monitored weekly as part of Loudoun Water’s Nitrification Management Plan since 2013 (Figure 5). Total Cl and nitrite levels in both locations were dramatically better in 2016 (Figure 6), indicating that active chloramine control was capable of eliminating nitrification not only in the Dulles South Tank, but also in the surrounding area.



Figure 5. Location of two compliance points influenced by Dulles South Tank (in red). Aldie Springs Dr. (1.83 miles W) and Glen Meadow Pl. (2.2 miles WNW) are both influenced by water coming from the Dulles South Tank.

Total Cl and Nitrite at Sample Locations

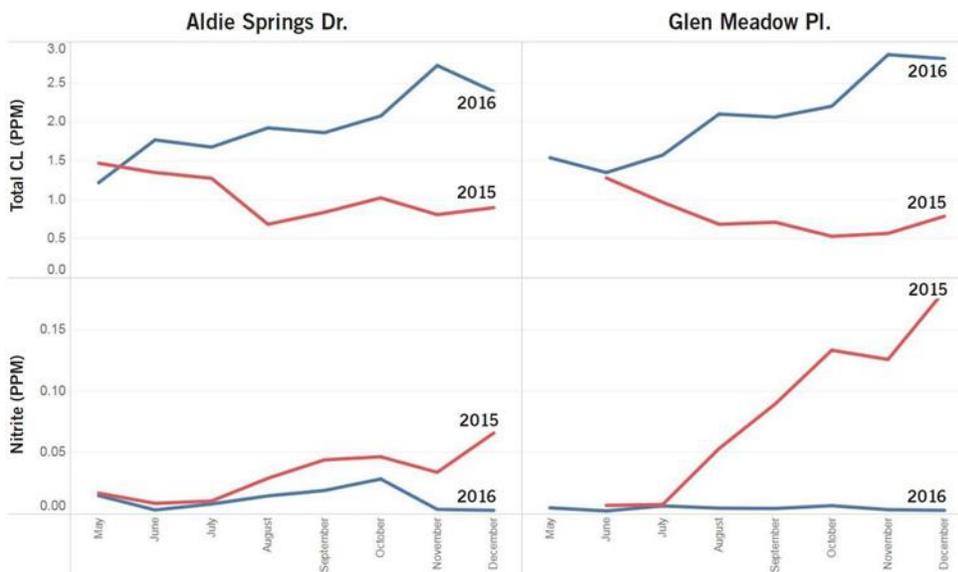


Figure 6. Total Cl and nitrite at sample locations at Aldie Springs Dr. and Glen Meadow Pl. in 2015 versus 2016. Operation of the Monoclor® RCS in 2016 resulted in major improvements in total Cl levels in both locations while nitrite levels remained under control. This indicates the system’s capability to stabilize water quality across a significant fraction of the Loudoun Water System.

With the arrival of Fall, and cooler weather in Northern Virginia, operators closed out their nitrification season with no problems.

“For me, it’s all about having individual control, instead of chasing your tail,” observed Cogswell. “I used to spend so much time digging into water quality data and guessing where my worst problems would be. With the Monoclor® RCS, I can focus on the big picture of how the entire system is running.”

“We used to struggle with water age in this part of our system,” noted Barrack, “but the Monoclor® RCS has made our water age problems essentially go bye-bye.”

Loudoun Water is planning to install additional PAX Mixers and Monoclor® RCS systems at other tanks in its system. With the added control from multiple Monoclor® RCS systems throughout the distribution system, managers will consider whether they can lower the residual level leaving the Goose Creek Treatment Plant. Best of all, having demonstrated that water quality can be controlled - even during the most challenging periods of the year- managers at Loudoun Water are contemplating something that was previously unthinkable: Putting the second Dulles South Tank back into service.

“It’s like a little treatment plant. We’re controlling the water.”

-Tom Barrack, Water Plant Superintendent, Loudoun Water