Construction Manager At-Risk Implementation for a Water Treatment Plant Granular Activated Carbon Filtration Project

Edward Alan Ambler, E. Devan Henderson, and Matt Peterson

Edward Alan Ambler, P.E., LEED AP, is water resources manager with the City of Casselberry; E. Devan Henderson, P.E., is a project manager with Reiss Engineering Inc. in Winter Springs; and Matt Peterson is a project manager with Wharton-Smith Inc. in Sanford.

The City of Casselberry evaluated many alternatives to comply with the Stage 2 Disinfectants and Disinfection Byproducts (D/DBP) Rule compliance regulatory changes and selected implementation of granular activated carbon (GAC) filtration at its South Water Treatment Plant (WTP). The City performed preliminary planning on many different precursor removal and treatment methods, including ozonation, ultraviolet radiation, GAC filtration, and changing disinfection methods to chloramination. Following preliminary selection of GAC, pilot testing was performed to evaluate precursor removal effectiveness.

Reiss Engineering Inc. designed the GAC improvements and continued its services throughout construction as part of the implementation team. Wharton-Smith Inc. was selected as a construction manager at-risk (CMAR) contractor to perform the required GAC treatment process improvements at the WTP. The CMAR process provided a reduced construction schedule and allowed the City and engineer to maintain a nonadversarial relationship with the contractor, essentially allowing all parties to act as a construction team. The team worked together to reduce time on shop drawing submittals, request for information (RFI) reviews, and field changes, and actively pursued value engineering options throughout construction of the required improvements. The team also added to the scope of the initial project to greatly improve it, while reducing the construction schedule and keeping the project within budget.

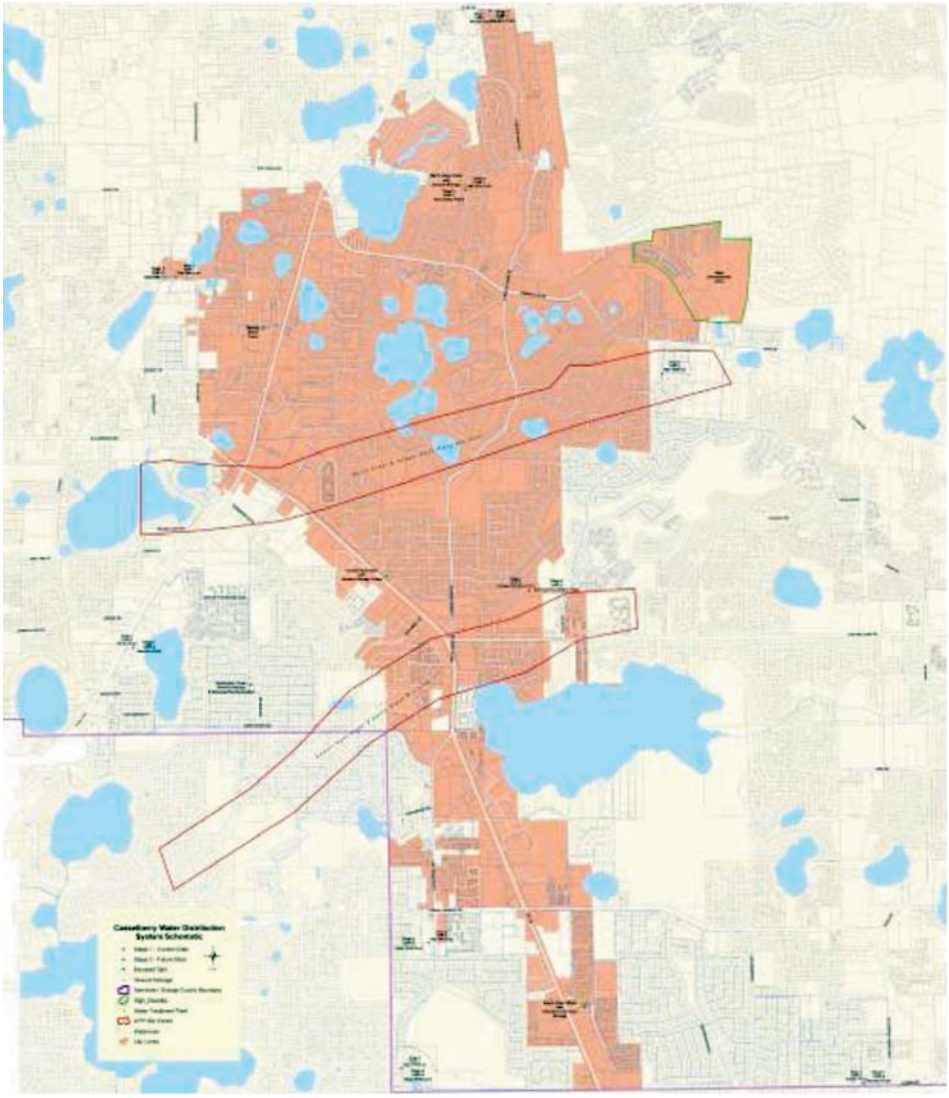

Figure 1. Casselberry Initial Distribution System Evaluation Sampling Plan

Steps to Compliance

The City is in the process of upgrading its finished water treatment process at the WTP in order to comply with EPA's Stage 2 D/DBP Rule. The EPA adopted the Stage 2 D/DBP Rule in 2006 and started working with potable water providers for completion of the Initial Distribution System Evaluation (IDSE) to evaluate the drinking water sampling plans implemented by those providers (Figure 1.) A major change between the Stage 1 D/DBP Rule and the Stage 2 D/DBP Rule is the implementation of the Locational Running Annual Average (LRAA) method of reporting samples. Previously, utility providers averaged the DBP concentrations from samples taken throughout the entire distribution system. The LRAA method tracks DBP results of specific sampling sites and requires reporting on every specific site. The City anticipated that it would be

Figure 2. Forced Draft Aerators

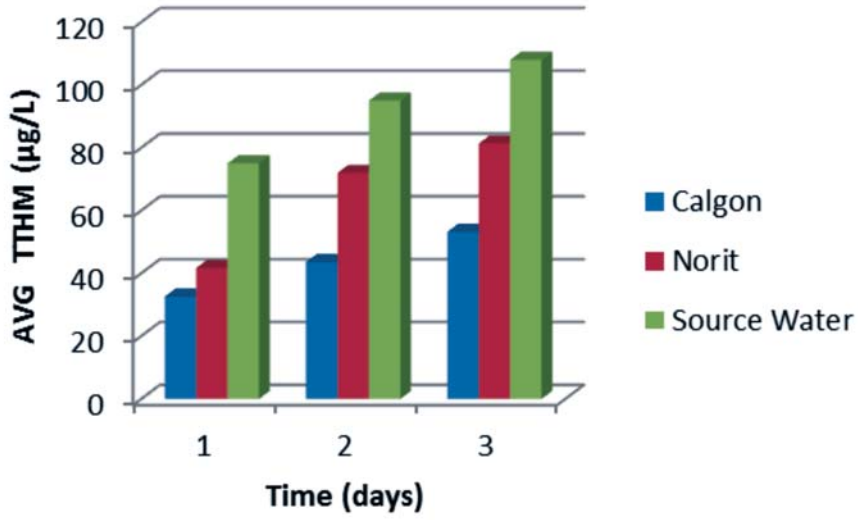

Figure 3. Trihalomethane Formation in Granular Activated Carbon-Treated Water

in noncompliance with the Stage 2 D/DBP Rule based on implementation of the LRAA method for the WTP. The City started preliminary planning for treatment alternatives and selected utilization of GAC filtration to remove the DBP precursors within the source water to ensure compliance with the Stage 2 D/DBP Rule.

Unfortunately, the City was unable to construct the required capital improvement project prior to implementation of the Stage 2 D/DBP Rule and encountered its first Maximum Contaminant Level (MCL) exceedance in late fall of 2013.The City proceeded with the design of the required improvements, and design and permitting were completed in the winter of 2013.

The City worked closely with the Florida Department of Environmental Protection (FDEP) to detail the process the City would follow to correct the MCL exceedances. The FDEP evaluated the information provided by the City and determined it was taking proactive measures to correct the MCL exceedance. The FDEP issued the City a compliance assistance offer instead of a consent order to make the necessary improvements. A compliance assistance offer is a letter presenting an action plan required to correct the regulatory violations. A consent order is a court-approved case dictating the terms of an agreement between a city and FDEP that could be enforced.

City and System Background

Casselberry is a medium-sized community in urban Orlando that provides potable water to approximately 55,000 customers. The City owns and operates three water treatment plants that treat and distribute potable water to its customers. The WTP currently supplies drinking water to meet an average annual demand (ADD) of 1.7 mil gal per day (mgd) and a maximum day demand (MDD) of 2.5 mgd. The existing WTP includes three groundwater wells, forced draft aeration, storage, and high-service pumps. The City currently disinfects the groundwater using sodium hypochlorite and adds orthopolyphosphate as a corrosion control inhibitor (Ambler et al, 2013).

The groundwater from the wells at the WTP contains higher levels of hydrogen sulfide and organic content than the groundwater used as source water at the other two Casselberry WTPs. The forced draft aerators (Figure 2) at the WTP are used to reduce the levels of hydrogen sulfide in the finished water.

Historically, the City observed higher levels of trihalomethane (THM) and haloacetic acids (HAA) levels in the southern portion of the City's distribution system. Multiple sampling events from the GAC pilot study at the WTP indicate the average source water total organic carbon (TOC) is 1.7 mg/L, pH is 7.7, and the ultraviolet measure (UV-254) is 0.04 cm^{-1} (Ambler et al, 2013). It was anticipated that at these TOC levels, the City would be in violation of the Stage 2 D/DBP requirements, based on experience with other utilities in the vicinity. The City evaluated several options at the planning level to minimize the DBP formation, including the following:

- Inspection and remediation of the potable water wells
- Use of chloramines, ozone, or ultraviolet irradiation for disinfection instead of free chlorine
- Unidirectional flushing to remove any debris or other material within the distribution system that would reduce the effectiveness of disinfection
- Autoflushers aimed at purging old water from the distribution system
- GAC filtration to remove the organics from the source water (Ambler et al, 2014)

Many of the lower-cost options, such as operational changes, well remediation, and unidirectional flushing were completed, but little change in DBP formation was observed. The City anticipated this result and proceeded with conducting a pilot study for GAC at the WTP.

Granular Activated Carbon Pilot Study and Design

During initial phases of the project, no facilities were operating at full scale with GAC treatment in the central Florida area to assess the efficiency of GAC to remove TOC from the groundwater; therefore, a pilot study was conducted at the WTP to define GAC design parameters. Over the course of three months, aerated well water was fed into two types (Calgon and Norit) of GAC-filled columns to monitor TOC and UV-254 (a surrogate of TOC) breakthroughs and determine the carbon regeneration rates. Treated water was tested for chlorination DBPs and various water quality parameters. The DBP formation potential was evaluated by dosing chlorine to the GAC effluent water, and to blends of GAC effluent with source water, to obtain representative DBP formation, rather than performing a theoretical extrapolation between source wa-

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ters and blended streams. The chlorine dose applied was sufficient to provide chlorine residual from 0.4 to 1.8 mg/L after three days of contact time. Dose and contact time were selected to represent system operations and distribution system conditions.

In general, results from the pilot study indicated that water treated with Calgon GAC media had lower THM and HAA (Figure 3). The THM concentrations for the Calgon media were about 55 µg/L after three days and about 60 µg/L for HAA. For the Norit GAC media, the THM concentration after three days was approximately 65 µg/L and about 70 µg/L for HAA.

Based on the pilot study results, the following design criteria were developed for the design phase of the GAC system:

- Four 12-ft-diameter GAC vessels
- 40,000 lbs of carbon per GAC vessel
- Minimum empty bed contact time (EBCT) of 17 minutes at MDD

During the design phase of the project, multiple adjustments were made based on project team discussions to improve the operations at the WTP; these included GAC vessel incorporation into the process flow, bypass options, and an additional GAC vessel. The incorporation of the GAC vessels was selected following the aerators to prevent sulfide in the water from absorbing to the carbon and decreasing its TOC removal effectiveness. The existing clearwell was utilized and the pump station was upgraded to accommodate the change in head conditions required to pump the water from the clearwell through the GAC vessels into the ground storage tanks. This option was cheaper in cost compared to construction of a second pump station and allowed for less maintenance of equipment. The option was also simpler in terms of instrumentation and controls.

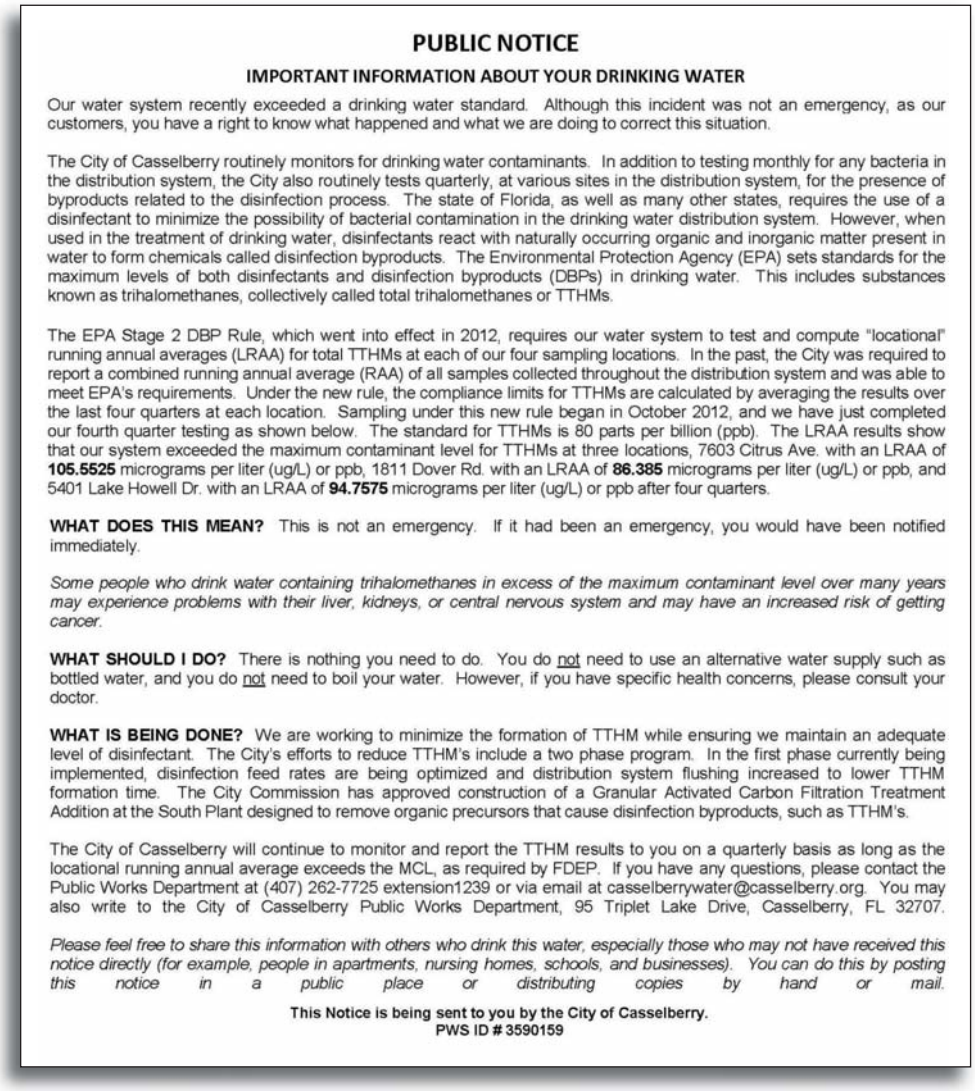
Although the pilot testing indicated that treatment of full flow is necessary to achieve the desired reduction in DBPs, a bypass option was included to aid operations with cost optimization in the event that the full-scale operations performed better than initial pilot testing. An additional GAC vessel was added to allow for increased flexibility and reliability. Five GAC vessels and the bypass allowed for the operations staff to run all WTP wells simultaneously, as well as decrease the number of deliveries required. Although not a requirement, decreased deliveries is an additional benefit for this facility since the WTP is located in a residential area.

Regulatory Summary and Severity of Risk Associated with Maximum Contaminant Level Exceedances

In fall of 2013, while the design phase of the WTP improvements was ongoing, the City received its first quarterly sampling MCL exceedance associated with the implementation of the Stage 2 D/DBP Rule. Several sampling sites within the City's distribution system exceeded the MCL limits for THMs. These sampling sites were previously averaged in with the remaining sampling sites, which had lower THM concentrations and reduced the overall THM average concentration for the entire distribution system. The sampling sites were now in violation because of implementing the LRAA change in the Stage 2 D/DBP Rule. The sampling sites were geographically focused within the influence zone of the WTP within the distribution system. The City reported the MCL exceedance to FDEP and both worked closely to determine the appropriate notification procedure.

The City was required to send a one-page mailer (Figure 4) to all customers within its existing distribution system and place an advertisement in the local newspaper concerning the MCL exceedance. The notification contained one full page of complex language as specified by the U.S. Environmental Protection Agency (EPA) and FDEP and a contact number for the City for any questions. This notification was delivered to the City's customer base in January 2014 and the City received well over 100 inquiries concerning the first notification. At the time, the City anticipated having to mail the notification every quarter until its GAC project was completed at the WTP, which was in December 2014. This timeline encouraged City staff to research additional information concerning MCL exceedances to include frequently-asked questions on its website and direct conversations with customers who had concerns over the public notification.

Specific language within the public notification that appeared to bring the most concern



PUBLIC NOTICE

IMPORTANT INFORMATION ABOUT YOUR DRINKING WATER

Our water system recently exceeded a drinking water standard. Although this incident was not an emergency, as our customers, you have a right to know what happened and what we are doing to correct this situation.

The City of Casselberry routinely monitors for drinking water contaminants. In addition to testing monthly for any bacteria in the distribution system, the City also routinely tests quarterly, at various sites in the distribution system, for the presence of byproducts related to the disinfection process. The state of Florida, as well as many other states, requires the use of a disinfectant to minimize the possibility of bacterial contamination in the drinking water distribution system. However, when used in the treatment of drinking water, disinfectants react with naturally occurring organic and inorganic matter present in water to form chemicals called disinfection byproducts. The Environmental Protection Agency (EPA) sets standards for the maximum levels of both disinfectants and disinfection byproducts (DBPs) in drinking water. This includes substances known as trihalomethanes, collectively called total trihalomethanes or TTHMs.

The EPA Stage 2 DBP Rule, which went into effect in 2012, requires our water system to test and compute "locational" running annual averages (LRAA) for total TTHMs at each of our four sampling locations. In the past, the City was required to report a combined running annual average (RAA) of all samples collected throughout the distribution system and was able to meet EPA's requirements. Under the new rule, the compliance limits for TTHMs are calculated by averaging the results over the last four quarters at each location. Sampling under this new rule began in October 2012, and we have just completed our fourth quarter testing as shown below. The standard for TTHMs is 80 parts per billion (ppb). The LRAA results show that our system exceeded the maximum contaminant level for TTHMs at three locations, 7603 Citrus Ave. with an LRAA of **105.5525** micrograms per liter (ug/L) or ppb, 1811 Dover Rd. with an LRAA of **86.385** micrograms per liter (ug/L) or ppb, and 5401 Lake Howell Dr. with an LRAA of **94.7575** micrograms per liter (ug/L) or ppb after four quarters.

WHAT DOES THIS MEAN? This is not an emergency. If it had been an emergency, you would have been notified immediately.

Some people who drink water containing trihalomethanes in excess of the maximum contaminant level over many years may experience problems with their liver, kidneys, or central nervous system and may have an increased risk of getting cancer.

WHAT SHOULD I DO? There is nothing you need to do. You do not need to use an alternative water supply such as bottled water, and you do not need to boil your water. However, if you have specific health concerns, please consult your doctor.

WHAT IS BEING DONE? We are working to minimize the formation of TTHM while ensuring we maintain an adequate level of disinfectant. The City's efforts to reduce TTHM's include a two phase program. In the first phase currently being implemented, disinfection feed rates are being optimized and distribution system flushing increased to lower TTHM formation time. The City Commission has approved construction of a Granular Activated Carbon Filtration Treatment Addition at the South Plant designed to remove organic precursors that cause disinfection byproducts, such as TTHM's.

The City of Casselberry will continue to monitor and report the TTHM results to you on a quarterly basis as long as the locational running annual average exceeds the MCL, as required by FDEP. If you have any questions, please contact the Public Works Department at (407) 262-7725 extension1239 or via email at casselberrywater@casselberry.org. You may also write to the City of Casselberry Public Works Department, 95 Triplet Lake Drive, Casselberry, FL 32707.

Please feel free to share this information with others who drink this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools, and businesses). You can do this by posting this notice in a public place or distributing copies by hand or mail.

This Notice is being sent to you by the City of Casselberry.
PWS ID # 3590159

Figure 4. Maximum Contaminant Level Exceedance Notification

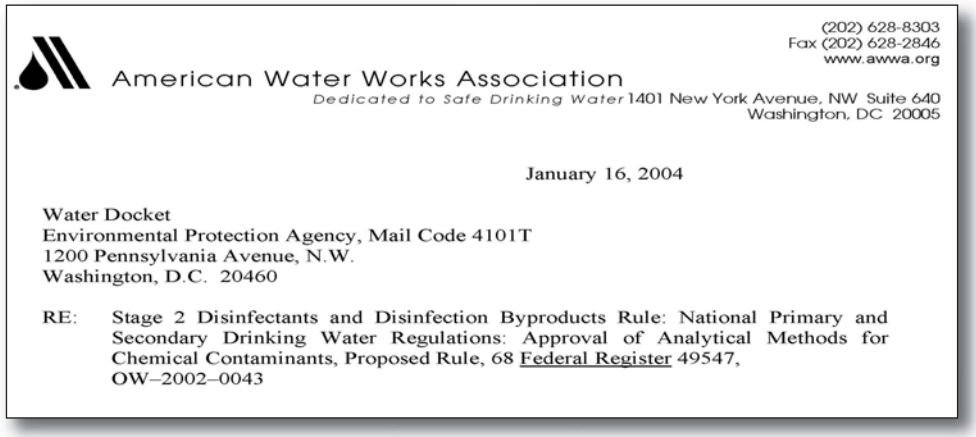
to the City's customers is "Some people who drink water containing trihalomethanes in excess of the Maximum Contaminant Level over many years may experience problems with their liver, kidneys, or central nervous system and may have an increased risk of getting cancer." This language is harsh and it is understandable how the City's customer base could have reservations concerning drinking the City's water. City staff researched the basis on which this determination was made to prepare City staff to answer the questions of its customers.

During development of the Stage 2 D/DBP Rule, EPA determined the increased risk of developing cancer based on a reference dose (RfD) and health advisory (HA) limit. The RfD is a daily exposure level that is believed to be without appreciable health risk to humans over a lifetime. This RfD correlates to a 70-kilograms (kg) adult who consumes 2 litres of water per day over a 70-year lifetime. The HA limit for THMs and HAA is based on an upper-bound excess lifetime risk of 1 in 1 million. So, if customers consume a little more than a half-gal of City water over a 70-year period, they are 1 in 1 million times more likely to get cancer (EPA, 2007).

In January 2004, the American Water Works Association (AWWA) issued a 126-page letter (Figure 5) to EPA officially responding to the proposed rule making for Stage 2 D/DBPs. The Association commended EPA for all of its work developing the Stage 2 D/DBP Rule (done in conjunction with AWWA), but offered three main defects to the proposal:

- The definition of significant excursions and the resulting actions required of utilities are inappropriate. The AWWA defines significant excursions as individual high THM or HAA compliance sample values that place a water provider close to or into noncompliance with either the Stage 2 D/DBP THM or HAA5 MCLs.
- The bias in the presentation of health-effects data is so pervasive that it calls into question EPA's obligation and commitment in the agreement in principle to issue a regulation that complies with applicable law and regulation.
- The quantification of health effects that may or may not be realized through the new MCLs is inappropriate, particularly in areas where the agency specifically concluded that quantification was not possible in "illustrative examples" (AWWA, 2004).

The low risk (1 in 1 million) of developing cancer (EPA, 2007) from the City's potable water that exceeded the MCLs for THM and HAA, coupled with AWWA's comments on the Stage 2 D/DBP Rule development, did not appear to make answering customers complaints or comments any easier for City staff. However, the City was still in violation of the MCL limits as imposed by the Stage 2 D/DBP Rule and began extensive communication with FDEP on how to correct the MCL exceedance.



(202) 628-8303
Fax (202) 628-2846
www.awwa.org

American Water Works Association
Dedicated to Safe Drinking Water 1401 New York Avenue, NW Suite 640
Washington, DC 20005

January 16, 2004

Water Docket
Environmental Protection Agency, Mail Code 4101T
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

RE: Stage 2 Disinfectants and Disinfection Byproducts Rule: National Primary and Secondary Drinking Water Regulations: Approval of Analytical Methods for Chemical Contaminants, Proposed Rule, 68 Federal Register 49547, OW–2002–0043

Figure 5. AWWA Letter to EPA on Stage 2 D/DBP Rule Promulgation

Compliance Assistance Offer With Florida Department of Environmental Protection

The FDEP had several options available to ensure that the City would take corrective action to address the MCL exceedance and bring its potable water into compliance with regulations. Compliance assistance is one of the four tools available that EPA and FDEP use for promoting or addressing compliance with regulations. Compliance assistance primarily includes activities, tools, or technical assistance to help the regulated community meet its regulatory obligations. Another method, compliance monitoring, involves on-site visits by qualified inspectors and review of required agency submittals. Compliance incentives are a set of policies and programs that eliminate, reduce, or waive penalties for businesses, industry, and government agencies that voluntarily discover, promptly correct, and/or prevent future environmental violations. Another tool is enforcement actions, which are defined as civil enforcements that protect human health and the environment by taking legal action to bring polluters into compliance with the law. An administrative order can be issued with or without penalties that directs an individual, business, or other entity to take action to come into compliance or to clean up a site (http://www.epa.gov).

City staff requested a meeting with staff from FDEP to discuss the MCL exceedance violation and the City's plans to correct the deficiency. City staff subsequently explained in extensive detail the preliminary planning efforts, pilot study, design for GAC improvements, and preliminary efforts the City had made to construct the improvements via the CMAR method. The City had received a construction permit for the project approximately a week prior to meeting with FDEP about the MCL exceedance. The FDEP acknowledged that the City had been making significant effort to correct the MCL exceedance; however, the City was unable to construct the required improvements prior to the implementation of the new regulations

The FDEP elected to offer a compliance assistance offer instead of an alternative enforcement action, such as a consent order. The compliance assistance offer still maintained the minimum regulatory actions required, such as continued quarterly sampling and public notification in the event of MCL exceedance. Additional information, such as continued monthly updates on the status of construction of the GAC project at the WTP and voluntary inspections, were required within the compliance assistance offer. Complying with these requirements and maintaining the established project schedule without further MCL exceedance once the GAC treatment upgrades are placed into service will allow the issue to be resolved without enforcement. The FDEP understood that the City was progressing towards resolving the problem and it wanted to work with the City without involving burdensome enforcement procedures.

Construction Management At-Risk Method Benefits

As design documents were finalized, Wharton-Smith was contacted for preconstruction services for construction of the GAC treatment system at the WTP. With the City being up against the compliance deadline set forth by the compliance assistance

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offer, the CMAR delivery method was the best-suited contract delivery method for this project. Benefits in using the CMAR delivery method for the GAC treatment addition at the WTP include:

- Selection of contractor and subcontractors based on qualifications
- Preconstruction services
- Expedited schedule
- Construction manager minimizing change orders by establishment of an owner contingency within the guaranteed maximum price (GMP)
- Transparency of cost control

Selection of a Construction Manager At-Risk Contractor

The CMAR delivery method is the best contract delivery method to fast-track a project while maintaining a high quality level. This project built upon the previous success that all of the represented firms had established. Key staff members on each team were identified that performed together well on previous projects and that were assembled for this project. Several meetings were held early in the process to establish goals, objectives, and a clear path for project success.

Preconstruction Services and Value Engineering

Preconstruction involvement of the construction manager (CM) adds value by injecting the builder's insight into the project prior to the establishment of the GMP. It is in the owner's interest to select a construction manager early in the design phase so that CM preconstruction services provide the best value to the project (Kaplin and Conley, 2009). In the beginning phases of the GMP establishment for the project, it was apparent that this project would be over budget for previous funds allotted by the City. A thorough review of the contract documents was done, which generated questions to avoid scope gaps, add value-minded changes, and address potential conflicts in the contract drawings. As the CMAR, Wharton-Smith was responsible for creating bid packages for subcontractors and vendors and providing bidding services to the City for the project. The questions and answers generated in preconstruction review may have minimized the value engineering (VE) offered after establishment of the GMP, but they allowed for competitive bid pricing on value-minded changes and scope gaps during the question-and-answer process, which reduced the overall cost of the project. Considerable effort was made during design of the project to minimize construction costs, so it was not surprising that there was not much opportunity for additional VE on the project. At the early stages, it was essential to award the project and start construction as soon as possible to meet the pressing schedule requirements.

Cost Control, Transparency, and Owner Contingency

In a CMAR delivery method, the CM is compensated for actual costs incurred, general conditions, and the CMAR fee. General conditions are defined as support costs during construction, such as field trailers, utility usage, materials testing, survey, security, dumpsters, and similar auxiliary costs required to complete the project (Kaplin and Conley, 2009). Invoices and backup documents for all costs are submitted with the monthly pay requisition as a transparent "open book" accounting relationship with the owner; this provides assurance that all involved parties are being good stewards of the rate payers' money. Being good stewards was defined as a primary objective early on in initial project meetings and has been clearly adhered to throughout design and construction of the project.

Included in the GMP, the City provided for a contingency which can only be used upon mutual agreement among the involved parties. The purpose of this contingency is to protect the City from unforeseen conditions, scope gaps, and/or design errors and omissions that would typically result in contract change orders. One of the many successes of the project is that the contingency has remained protected throughout construction. After construction progressed far enough along, with the contingency remaining unspent, a portion of it was refunded to the City to fund alternative projects outside of the scope of the WTP project.

Conclusion

The City of Casselberry performed extensive preliminary planning work and pilot-tested the effectiveness of GAC in conjunction with existing forced draft aeratoration at the WTP, the only treatment plant in Casselberry's system that supplied potable water that did not meet the Stage 2 D/DBP Rule. The GAC proved to be an effective treatment method for the removal of organic matter, which contributed to THM and HAA formation levels that exceeded the MCLs under the revised regulations. Significant capital improvement and operating costs are associated with design and construction of GAC improvements to treat the source water at the WTP.

The City worked closely with FDEP to illustrate all of the efforts the City completed in an attempt to meet the Stage 2 D/DBP regulations. The FDEP offered an alternative to enforcement action with a compliance assistance offer since the City had a defined correction plan. The City was required to provide continued notifications to its entire customer base for every failed LRAA each quarter, which is costly and requires significant interaction with the customers. City staff performed extensive research on the adverse health effects of MCL exceedance and was partially able to convey this message to its customer base. It would be helpful if EPA could provide additional guidance to clarify these adverse health effects, as requested by AWWA.

The CMAR project delivery method was selected as the best method to meet the aggressive schedule and ensure quality delivery of construction of the improvements. Establishing a clear goal of being good stewards for the rate payers at the beginning of the project was successful in encouraging the team to make continual strides to meet the goal. The City has maintained a successful project schedule and is anticipating completing the WTP project in December 2014.

Compliance with the Stage 2 D/DBP regulations could potentially have a further-reaching effect on utility providers than EPA may have initially predicted, specifically due to the changes with implementing LRAAs.

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