Managing the Challenges of Ground Water Rule Compliance in South Florida

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This article presents four case studies to demonstrate challenges faced by utilities in South Florida on their path to compliance with the requirements of the final Ground Water Rule (GWR) and Florida Administrative Code (FAC) 62-550.828. Case studies include the city of Fort Lauderdale's Peele-Dixie Water Treatment Plant, the city of Hallandale Beach Water Treatment Plant, the city of Plantation East and Central Water Treatment Plants, and the city of Naples Water Treatment Plant.

These water treatment plants were placed into service 50 to 70 years ago as lime softening treatment facilities. In recent years, they have expanded to accommodate increasing water demands and newer treatment technologies, which complicated compliance with the GWR.

Each case study presents a different situation and highlights individual approaches to managing the challenges of the GWR, either through compliance with four-log virus treatment or triggered source water monitoring requirements. For each utility, the most viable compliance option was selected based on careful consideration of potential water quality impacts, operation and maintenance needs, and capital costs associated with various alternative scenarios proposed to achieve compliance.

The GWR became effective on December 1, 2009. It was established by the U.S. Environmental Protection Agency (EPA) to minimize the incidence of disease attributed to fecal contamination in public water systems that use groundwater sources. Fecal contamination can reach groundwater sources, including drinking water wells, from failed septic systems, leaking sewer lines, through the soil and large cracks in the ground, or through improperly installed or failed well casings.

In the state of Florida, all public water systems are subject to the GWR, except those that treat all of their supplies in accordance with surface water treatment regulations. The GWR is administered and enforced in the state by the Florida Department of Environmental Protection (FDEP), which intends to incorporate the rule into FAC Chapter 62-550.828. At the time these studies were conducted, Rule 62-550.828 FAC had not been published, but it was prudent to consider the potential impacts of its more stringent provisions when developing a compliance strategy to the GWR.

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Two major tracks to GWR compliance were dictated, the most rigorous of which requires utilities to conduct four-log virus treatment and compliance monitoring. Alternatively, the triggered source water monitoring track was mandated for all treatment facilities that chose to not implement four-log virus treatment. Source water assessment monitoring was also required for groundwater systems that followed the triggered source water monitoring track.

Four-log Virus Treatment Compliance

Four-log virus treatment can be achieved by removal (filtration), inactivation (disinfection), or a combination of the two operations; however, viable compliance options for four-log virus treatment must consider some degree of inactivation through disinfection, since the FDEP grants only two-log removal credit for media filtration and it is not practical to demonstrate more than two-log removal for reverse osmosis and nanofiltration (NF) membrane processes. Achieving this level of treatment may or may not be easily accomplished, depending on the unique conditions of the water treatment system, as will be later explored.

Log inactivation for disinfection is measured by CT, where:

- CT calculated = concentration x time (mg/L-min)
- C is the disinfectant concentration in mg/L at the end of the contact time
- T_{10} is the contact time "T" in minutes for disinfection
- T_{10} = HDT x BF
- HDT = Hydraulic Detention Time
- BF = Baffle Factor

CT values are a function of baffle factors, pH, types of disinfectant used (e.g., free chlorine or chloramine), disinfectant residual concentration, and water temperature. The FDEP has established required minimum CT values to achieve four-log virus treatment in the document titled *Guidelines for Four-Log Virus Treatment for Ground Water* (Guidelines).

If a utility selects four-log virus treatment as the preferred GWR compliance track, the FDEP must approve the method. Under the proposed FAC 62-550.828, the FDEP will require that four-log virus treatment be provided between the point where water is last exposed to the open atmosphere and its delivery to the first customer.

This provision, known as the "Bird Rule", is currently a part of FAC Rule 62.555, which the Department intends to retain when the GWR is incorporated into the FAC. Assessment finished water monitoring will be mandated for systems that are providing four-log virus treatment of groundwater that is exposed to the atmosphere during treatment. A positive assessment finished water sample will trigger a Tier 1 public notice and corrective action.

Source Water Monitoring Compliance

Groundwater systems that are unable to achieve four-log virus treatment are expected to comply with triggered and assessment source water monitoring requirements. Source water monitoring is "triggered" whenever a utility obtains a total coliform positive (TC+) from a routine distribution system sample under the Total Coliform Rule of FAC Rule 62.550.

The utility is then expected to collect at least one groundwater source sample per TC+ from each of the production wells in use at the time the TC+ sample was collected. Samples must be collected and analyzed for fecal indicators within 24 hours of obtaining the TC+ notification.

For GWR compliance, the requirements for routine assessment source water monitoring are adopted from FAC Rules 62-550.518 and 62-555.315. If any triggered or assessment source water sample is positive for a fecal indicator (FI+), the utility must issue a Tier 1 public notice, collect additional samples, and initiate corrective action.

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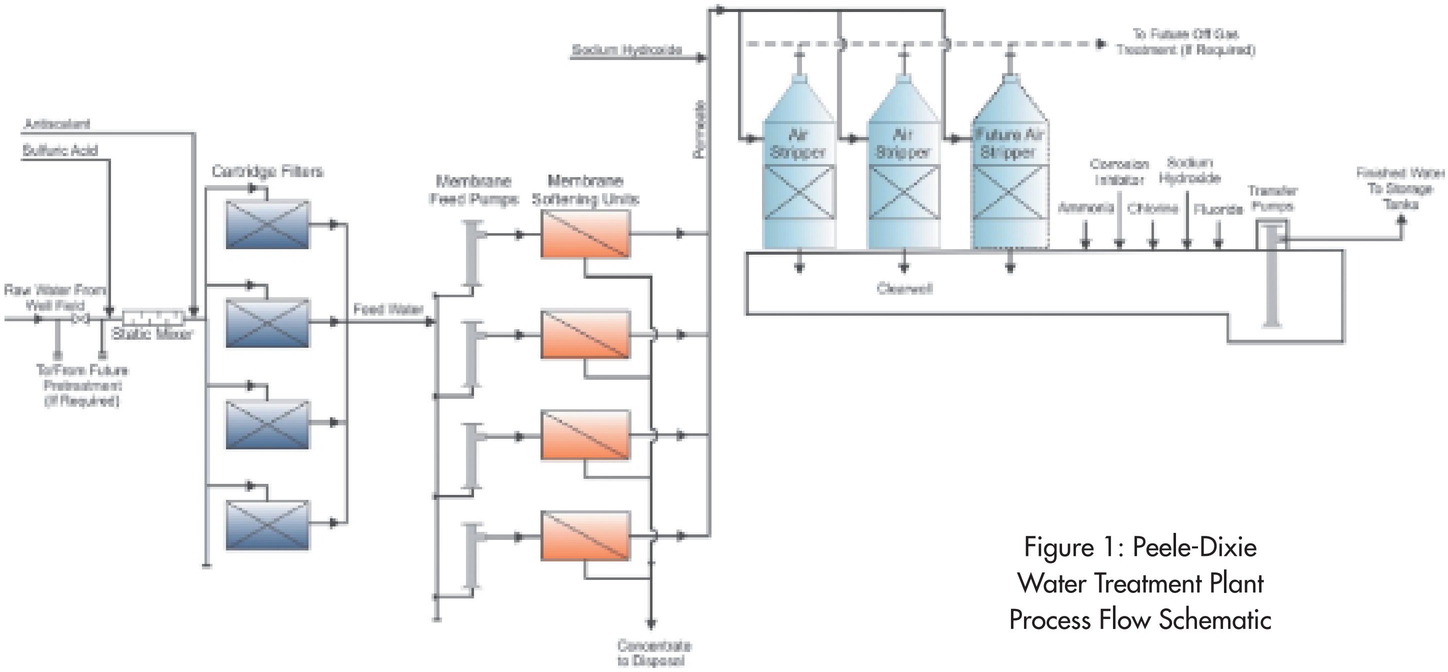

Figure 1: Peele-Dixie Water Treatment Plant Process Flow Schematic

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Case Studies in South Florida

Achieving GWR compliance in South Florida presented unique challenges to utilities. The extent and impact of these challenges varied considerably, based on the existing type of treatment process technology, the mode of plant operation, the residual disinfectant employed, and the size and layout of existing production and treatment facilities. The case studies presented highlight distinctive solutions to the challenges of the GWR.

Key issues faced by the Fort Lauderdale, Hallandale Beach, Plantation, and Naples plants include:

- Selecting between the use of chlorine versus chloramine disinfectant to achieve required disinfection credit for four-log virus treatment.
- Achieving disinfectant credit while coping with the naturally occurring background ammonia in the product water.
- Identifying feasible locations for injecting chemical disinfectant into the treatment process to achieve the necessary contact time to achieve four-log virus treatment disinfection credit, while simultaneously minimizing any potential negative water quality impacts.
- Controlling the financial costs associated with implementing modifications to the treatment process in order to achieve the required contact time for four-log virus treatment disinfection credit.
- Modifying existing and/or integrating new control systems and programming to achieve the necessary compliance monitoring required for four-log virus treatment.
- Achieving disinfection credit for four-log virus treatment by using only the portion of the treatment process that is not exposed to the atmosphere.
- Avoiding potential negative publicity associated with Tier 1 public notifications as a result of non-compliance with the requirements of triggered source water monitoring, assessment source water monitoring, and assessment finished water monitoring.
- Conducting membrane integrity monitoring and testing required for four-log virus removal credit using NF treatment technology.
- Conducting required source water and finished water monitoring and sampling in a timely, cost-effective manner.

City of Fort Lauderdale Peele Dixie Water Treatment Plant

The city of Fort Lauderdale owns and operates the Peele-Dixie Water Treatment Plant and the Fiveash Water Treatment Plant. The city uses groundwater from the Biscayne Aquifer for both plants. The wellfields supplying each plant are separate, but the plants serve a common distribution system.

The Peele-Dixie Plant is a NF membrane facility with a maximum rated capacity of 12.0 million gallons per day (MGD) and receives raw water from the Dixie Wellfield. The wellfield has a total of eight raw water wells providing a firm capacity of 15.0 MGD. Figure 1 depicts the process flow schematic for the Peele-Dixie Plant.

The NF facility produces a permeate with a total organic carbon (TOC) concentration of less than 2 mg/L. This low TOC content significantly reduces the probability for excessive disinfection byproduct (DBP) formation caused by a free chlorine residual contact time.

With no reason to be particularly concerned with DBP formation, the city considered the four-log virus treatment compliance track as its primary option to achieve GWR compliance. This track would also allow Fort Lauderdale to avoid any potential negative impacts of Tier 1 public notice.

It was assumed that two-log credit would be allocated for the NF technology and that the additional two-log credit would be obtained through chlorine disinfection. The city had determined previously that virus inacti-

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Table 1: Peele-Dixie Plant Virus Inactivation Credit through Free Chlorine Disinfectant

T_{10} (min.)	Free Chlorine Residual (mg/L)	CT - Required for 2-Log (mg/L-min)	CT – Calculated (mg/L-min)	Actual Virus Inactivation Credit Available (Logs)
2.06	2.8	2.3	5.8	5.0

Note: The CT required is based upon a minimum water temperature of 19.0 degrees Celsius and a pH of 9.2.

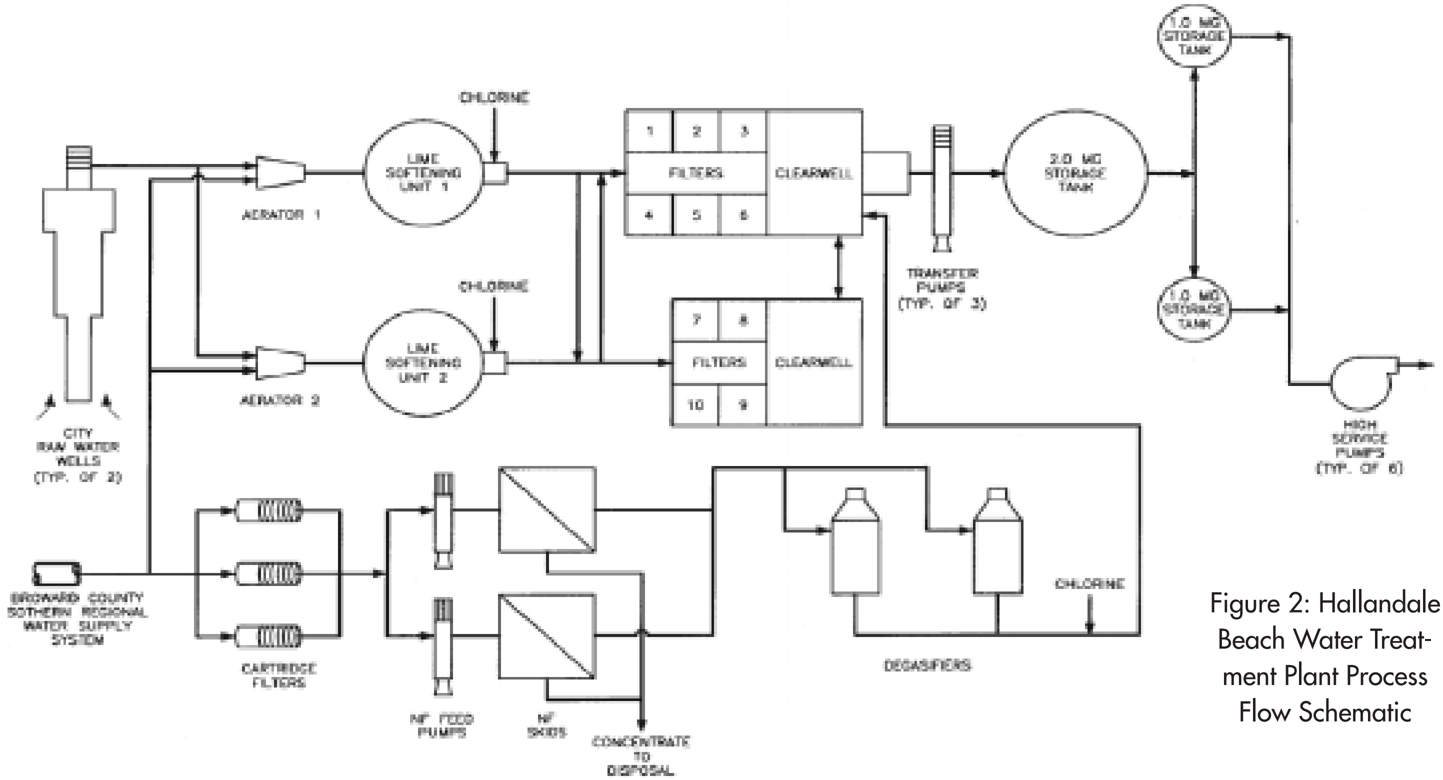

Figure 2: Hallandale Beach Water Treatment Plant Process Flow Schematic

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vation through chloramine was not a viable option for the Peele-Dixie Plant.

The first challenge was to demonstrate that a baffle factor of greater than 0.3 could be achieved in the clearwell. The city wanted to obtain as much credit for free chlorine as possible through the existing clearwells and felt that published baffle factors in the guidelines were too conservative.

A baffle factor of 0.33 was determined by a separately conducted tracer study. A desktop evaluation was then performed to calculate the achievable CT value. Table 1 summarizes the virus inactivation credit through free chlorine disinfection.

The city decided to apply for seven-log virus treatment certification: five-log disinfection through free chlorine and two-log removal through NF. Achieving certification at the Peele-Dixie Plant required modifications to the existing disinfection process. The modifications involved relocating the existing ammonia injection points approximately 40 feet downstream of the discharge header of the transfer pumps in order to facilitate breakpoint chlorination of all naturally occurring background ammonia in the product water and to establish the free chlorine concentration required for the target virus inactivation credit.

These modifications were categorized as major improvements for which the city needed to apply for a *Specific Permit to Construct PWS Components* to perform the work. The Broward County Health Department allowed Fort Lauderdale to submit the virus certification package and the construction permit application simultaneously for approval in September 2010, but certification would not be granted until all required modifications were completed.

Approval for virus treatment certification also required that the city install new sampling equipment, including chlorine residual analyzers and chart recorders at both plants, and demonstrate that the requirements for standby equipment, automatic switchovers, flow proportional control, alarms, integrity testing, and continuous monitoring were met. An upgraded alarm system, changes to the HMI and SCADA system, as well as changes to the monthly operating reports also were implemented.

Fort Lauderdale's request for virus certification was being reviewed by the Broward County Health Department at the time this article was written.

City of Hallandale Beach Water Treatment Plant

The Hallandale Beach Water Treatment Plant utilizes lime softening (LS) treatment and NF treatment technologies to provide a maximum combined capacity of 16 MGD. The city presently treats approximately 3.5 MGD through the NF facility and 3.5 MGD through the LS facility.

The NF facility treats Biscayne water from the Broward County Southern Regional Water Supply. The LS facility treats Biscayne water from the city's own wells located near the Hallandale Beach Plant. Figure 2 depicts the process flow schematic for the plant.

The feasibility of achieving four-log virus treatment at the Hallandale Beach Plant was assessed. It was assumed that two-log credit would be allocated for both rapid media filters and for NF membrane technology and that an additional two-log virus treatment through chemical disinfection would be needed.

With regard to virus treatment through chemical disinfection, DBP formation was a major concern, so chloramine was considered the most favorable disinfectant choice to achieve the necessary inactivation credit while simultaneously minimizing DBP formation in the treated water. In contrast, free chlorine potentially could react with the high TOC content present in the lime softened raw water to form total trihalomethanes and total haloacetic acids.

To implement the use of free chlorine successfully for disinfection credit, Hallandale Beach would have to conduct a detailed evaluation to determine the extent and severity of the potential for DBP formation. Alternatively, the city could consider a TOC removal technology such as granular activated carbon or the MIEX Process, both of which have potential cost implications.

Utilizing chloramine disinfectant to achieve virus treatment credit at the Hallandale Beach Plant presented a serious challenge. The plant is unique in that currently, background ammonia exists in sufficient quantity in the source water to be used to form residual chloramine for disinfection. This practice restricted the use of the established CT values for chloramine, since the EPA requires that chlorine must be added prior to ammonia to achieve breakpoint chlorination of all natu-

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Table 2: Hallandale Beach Plant Virus Inactivation Credit through Chloramine Disinfection

	LS Plant, Full Disinfection Segment	LS Plant, Segment Closed to Atmosphere	Nanofiltration Plant
T_{10}, minutes	38.81	35.79	25.63
Chloramine Residual, mg/L	4.0	4.0	4.0
CT - Calculated, mg/L-min	155.26	143.17	102.53
CT - Required for 2-Log Inactivation at 18.5 degrees C for a pH of 8, mg/L-min[1]	353.5	353.5	353.5
Actual Virus Inactivation Credit Available, Logs	0.88	0.81	0.58

[1] CT values based on linear interpolation of tables provided in the Guidelines.

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rally occurring ammonia.

A desktop evaluation of the existing condition was performed to determine the viability of both the LS and NF membrane treatment processes. Table 2 summarizes the results of the evaluation to achieve two-log virus inactivation through chloramine disinfection.

Calculated CT values for both treatment processes were less than the minimum required CT values to achieve two-log virus treatment through disinfection by chloramine. In order to achieve the required CT values using chloramine, it was determined that the city would need approximately 4 million gallons of well-baffled storage capacity through the addition of piping and tankage.

Significant capital expenditure and space limitations because of the layout of existing facilities presented a significant challenge to implementing any proposed infrastructure. Also, significant changes to the existing disinfection process would be imperative to allow the use of established CT values for chloramine. The city would need to install a new ammonia dosing system to form a stable chloramine residual and increase chlorine usage to reach breakpoint chlorination of background ammonia.

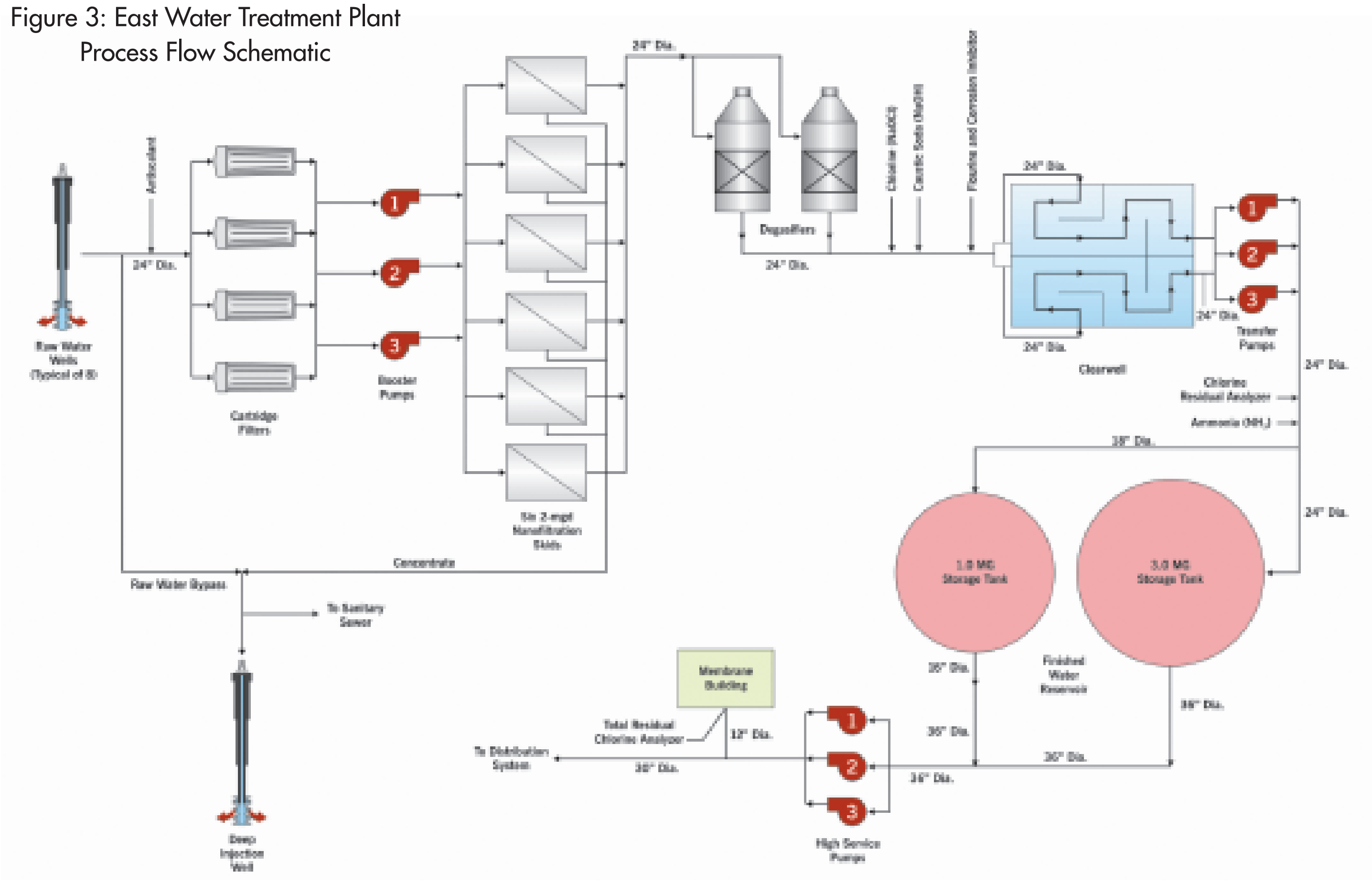
These changes would present financial burdens, increased operation and maintenance efforts, and an increased potential for DBP formation. Since sections of the LS treatment process are exposed to the atmosphere, finished water monitoring would also be required unless the city relocated the existing chemical injection points for the lime softening process or provided covers on all areas exposed to the atmosphere.

Although not a preferred option initially, disinfection through free chlorine was also evaluated. It was assumed that sufficient chlorine would be added to achieve breakpoint chlorination and maintain a free chlorine residual throughout the treatment process up to the transfer pump station. Ammonia would be added at the transfer pump station to form residual chloramine for the distribution system.

For two-log virus treatment by disinfection through free chlorine, the calculated CT was greater than the minimum required CT value for both the LS and NF treatment processes, but disinfection by free chlorine would require a significant increase in the use of sodium hypochlorite, as well as the installation of a new ammonia dosing system to provide a stable chloramine residual out in the distribution system.

The use of chemical disinfectant to achieve

Figure 3: East Water Treatment Plant Process Flow Schematic



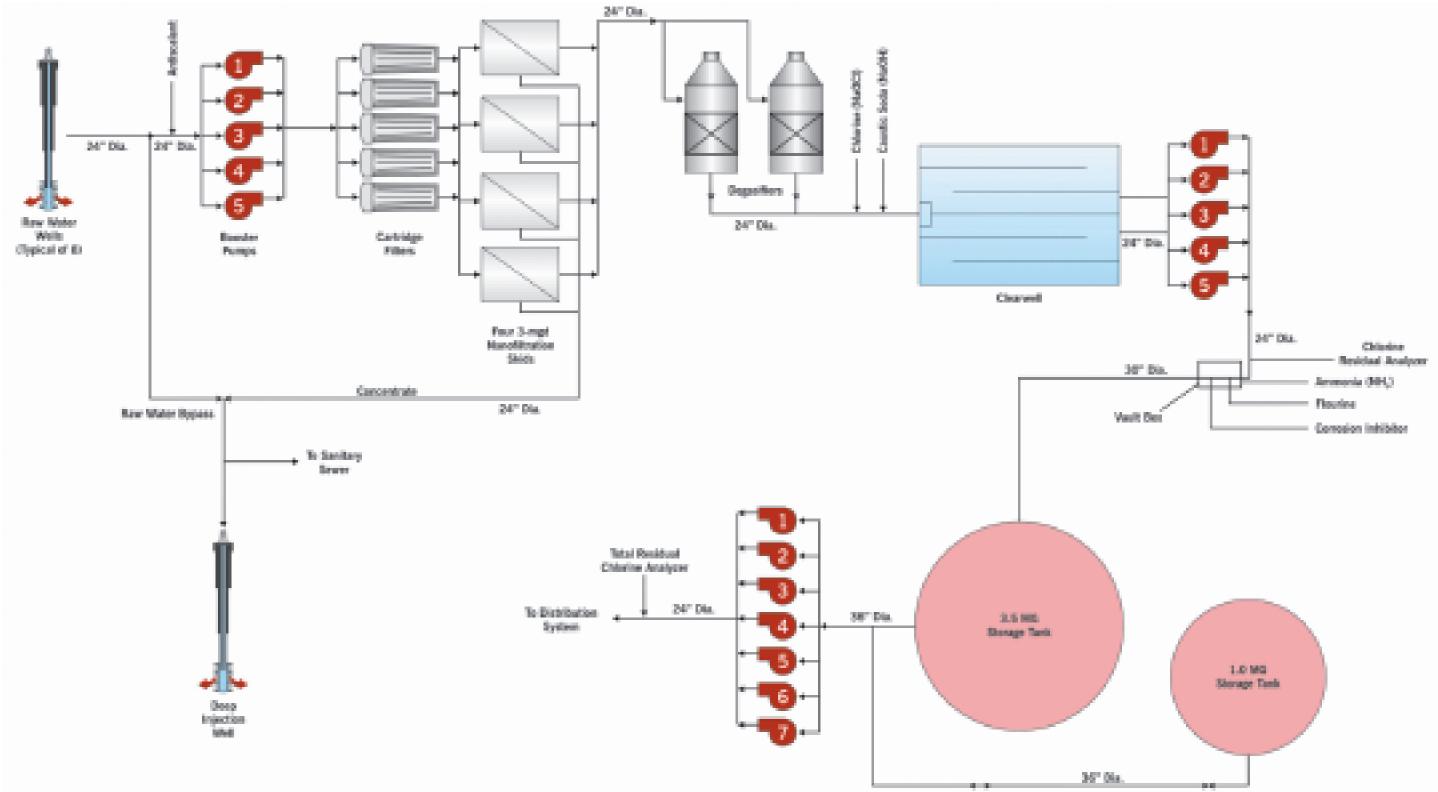


Figure 4: Central Water Treatment Plant Process Flow Schematic

virus inactivation credit was not a viable option for the Hallandale Beach Plant. After careful consideration of the significant capital expenditure necessary to meet CT requirements using chloramine or to convert the plant to free chlorine disinfection, as well as the potential for increased DBP formation with free chlorine, the city elected to comply with triggered and assessment source water microbial monitoring, in lieu of four-log virus treatment compliance.

The source water monitoring track was best suited for Hallandale Beach because the city only has to contend with the sampling of the two production wells presently used, in the event that source water monitoring is triggered. The city will also be required to inform Broward County Water and Wastewater Services of the TC+ notification, which will then be required to sample production wells within the area and notify the public accordingly, if necessary.

City of Plantation East Water Treatment Plant & Central Water Treatment Plant

The city of Plantation's East Water Treatment Plant and Central Water Treatment Plant are NF treatment facilities, each with a maximum rated capacity of 12 MGD. They receive raw water from the Biscayne Aquifer through 24-inch transmission mains from the East Wellfield and Central Park Wellfield, respectively.

The East Wellfield has a total of eight raw water wells providing a firm capacity of 15.7 MGD. The Central Park Wellfield has a total of eight raw water wells providing a firm capacity of 14.1 MGD. Figures 3 and 4 depict the process flow schematic for the East Water Treatment Plant and the Central Water Treatment Plant, respectively.

Similar to the Peele-Dixie Plant, the NF facilities at the East Plant and Central Plant produce a permeate with a low TOC concentration and thus presented no major concern for DBP formation. The city of Plantation decided to pursue the four-log virus treatment compliance track as its primary option to achieve GWR compliance.

It was assumed that two-log credit would be allocated for the NF technology and that the additional two-log credit would be obtained through chemical disinfection. The viability of the two facilities for the additional two-log virus credit was assessed.

The disinfection practice at both plants at the time of the evaluation involved adding chlorine and ammonia at adjacent locations on the 24-inch discharge header of the degasifier system to form residual chloramine. This practice did not comply with the EPA's implicit requirement that chlorine be added prior to ammonia to achieve breakpoint chlorination of all naturally occurring ammonia in the product water, so to complete chloramine evaluation, it was assumed that the established EPA CT values for chloramine can also be applied to the existing condition.

The entire disinfection segment selected for evaluation at both plants was closed to the atmosphere; it began at the chlorine and ammonia application points at the discharge header of the 24-inch degasifier system and terminated at the membrane building. Table 3 on page 26 summarizes the virus inactivation credit through chloramine disinfection.

At both the East and Central Plants, the calculated CT value was less than the minimum required CT value to achieve two-log virus treatment. Site space restrictions and considerable capital expenditures limited the successful implementation of the chloramine option, which required additional storage capacity in the form of tankage and piping or increased chemical usage to obtain the necessary CT value.

Since DBP formation was of minimal concern, it was proposed that the city consider a switch completely from chloramine to free chlorine as a residual disinfectant; consequently, the viability of free chlorine disinfectant was assessed.

For this option, the chlorine application point would be maintained at the discharge header of the 24-inch degasifier system and would provide a free chlorine contact time through the entire disinfection segment (same as for chloramine). Ammonia application would be terminated at both treatment plants. Table 4 on page 26 summarizes the virus inactivation credit through chlorine disinfection.

At both the East and Central Plants, the calculated CT value was greater than the minimum required CT value to achieve two-log virus treatment. Although the necessary disinfection credit

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Table 3: East Plant and Central Plant Virus Inactivation Credit through Chloramine Disinfection

Treatment Plant	T_{10} (min.)	Chloramine Residual (mg/L)	CT – Required for 2-Log (mg/L-min)	CT - Calculated (mg/L-min)	Actual Virus Inactivation Credit Available (Logs)
EWTP	10.21	2.8	364	28.59	0.16
CWTP	24.80	2.8	364	69.44	0.38

Note: The CT required is based upon a minimum water temperature of 18 degrees Celsius and a pH of 8.0.

Table 4: East Plant and Central Plant Virus Inactivation Credit through Free Chlorine Disinfection

Treatment Plant	T_{10} (min.)	Chloramine Residual (mg/L)	CT - Required for 2-Log (mg/L-min)	CT - Calculated (mg/L-min)	Actual Virus Inactivation Credit Available (Logs)
EWTP	10.22	2.8	1.7	28.63	33.68
CWTP	24.80	2.8	1.7	69.44	81.70

Note: The CT required is based upon a minimum water temperature of 18 degrees Celsius and a pH of 8.0.

Table 5: East Plant Virus Inactivation Credit through Free Chlorine and Chloramine

Disinfectant	T_{10} (min.)	Residual Concentration (mg/L)	CT - Required for 2-Log (mg/L-min)	CT - Calculated (mg/L-min)	Actual Virus Inactivation and/or Removal Credit Available (Logs)
Chlorine	4.29	2.8	1.7	12.02	14.14
Chloramine	5.97	2.8	364	16.73	0.09

Note: The CT required is based upon a minimum water temperature of 18 degrees Celsius and a pH of 8.0.

Table 6: Central Plant Virus Inactivation Credit through Free Chlorine and Chloramine

Disinfectant	T_{10} (min.)	Residual Concentration (mg/L)	CT - Required for 2-Log (mg/L-min)	CT - Calculated (mg/L-min)	Actual Virus Inactivation and/or Removal Credit Available (Logs)
Chlorine	6.65	2.8	1.7	18.63	21.92
Chloramine	18.15	2.8	364	50.81	0.10

Note: The CT required is based upon a minimum water temperature of 18 degree Celsius and a pH of 8.0.

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was achievable, this option was not considered for further implementation because of concern about the ability to maintain an adequate residual in remote parts of the distribution system and compatibility with neighboring systems with which Plantation has interconnects.

Finally, the city considered a combination of free chlorine and chloramine to achieve virus inactivation credit. For this option, the chlorine application point would remain in its existing location at the 24-inch discharge header of the degasifier system. The ammonia injection point would be relocated downstream to the discharge header of the transfer pumps.

Free chlorine residual would be maintained to the ammonia application location (disinfection segment for free chlorine) at which point a chloramine residual for the distribution system would be formed. Tables 5 and 6 summarize the virus inactivation credit through a combination of free chlorine and chloramine disinfection.

At both plants, the calculated CT value to achieve two-log virus credit through chlorine disinfection exceeded the minimum required CT value. Since the city potentially could achieve more than the required log inactivation through chlorine disinfection, additional inactivation credit through chloramine was not required.

It was recommended that Plantation provide the entire log virus treatment through disinfection. In so doing, the city would avoid the capital and operation and maintenance costs for modifying the existing NF instrumentation system to achieve additional removal credit. The FDEP requires that continuous salt passage monitoring be provided for each treatment train and that salt passage not exceed 25 percent for NF treatment.

In January 2010, Plantation made a formal request to the Broward County Health Department for 14-log and 21-log virus treatment certification at the East Plant and the Central Plant, respectively. The city presented documents to demonstrate compliance with both the GWR and FAC 62-555 Bird Rule disinfection requirements at both facilities.

Achieving certification for virus treatment required modifications to the disinfection process, as well as implementation of sampling and compliance monitoring requirements. These modifications were categorized as major improvements for which the city needed a *Specific Permit to Construct PWS Components* to perform the work.

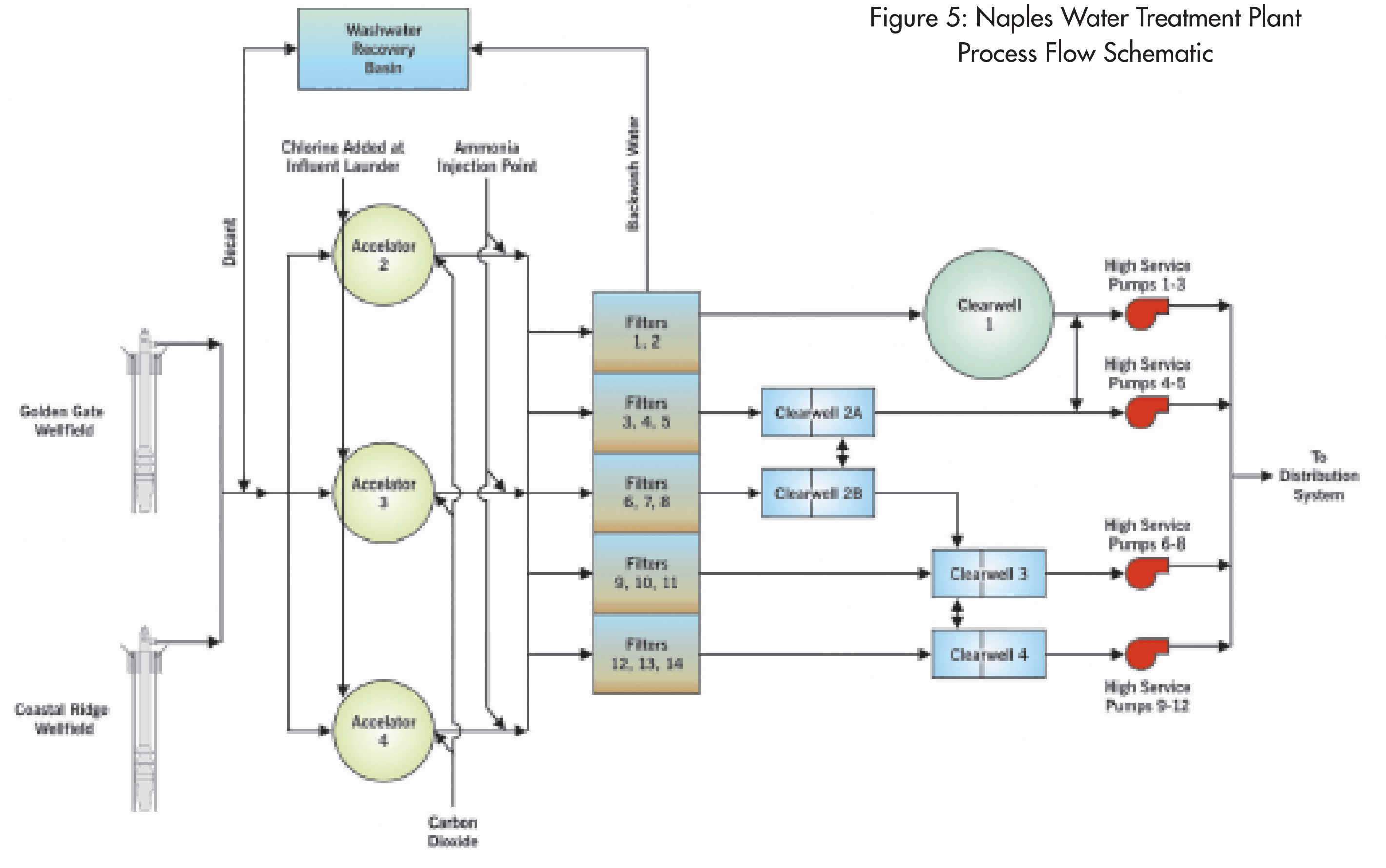
These modifications involved relocating the existing ammonia injection points at both plants. At the East Plant, the entire ammonia disinfection system, including the ammonia storage tank and injection point, needed to be relocated. At the Central Plant, because of the close proximity of the new injection point to the ammonia system, it was necessary to relocate only the ammonia injection point.

The selection of feasible injection points required an in-depth evaluation of the treatment process and layout of existing facilities. It was necessary to select locations which were easily accessible and which also minimized short circuiting in the system, while providing the needed contact time. The construction costs, including permitting fees, to complete the required modifications at the two plants amounted to approximately $23,000. Plantation was able to minimize the potential cost impacts by performing the construction work using city workers.

The city also installed new sampling equipment, including chlorine residual analyzers and chart recorders at both plants, and demonstrated that the requirements for standby equipment, automatic switchovers, flow proportional control, and alarms were met. An upgraded alarm system, changes to the HMI and SCADA system, and changes to the monthly operating reports were also implemented.

In March 2010 the city successfully ob-

Figure 5: Naples Water Treatment Plant Process Flow Schematic



tained written approval for four-log virus certification at both the East and Central Plants.

City of Naples Water Treatment Plant

The city of Naples Water Treatment Plant utilizes LS treatment technology to provide a design maximum rated capacity of 31.65 MGD. The treatment process consists of three Accelator units, each capable of feeding flow to any of the 14 rapid media gravity filters.

Filtered water flows to one of five belowground clearwells and is then pumped by dedicated high-service pumps into the distribution system. There are a total of 12 high-service pumps. The existing chlorine application points are located at the inlet of each Accelator unit. Ammonia is injected downstream, directly into the effluent launder of each Accelator unit to form residual chloramine. Figure 5 depicts the process flow schematic for the plant.

The Naples Plant was assessed for two-log virus credit through either chloramine or free chlorine disinfection. It was assumed that an additional two-log credit would be obtained for media filtration.

Because of the many flow paths existing at the facility, the evaluation process was complicated. To simplify the process, the two shortest flow paths were evaluated. If the required CT could be demonstrated to be achieved for the shortest flow paths, then the CT would be achieved through the remaining flow paths at the facility.

The viability of the current chloramine disinfection practice to obtain two-log virus credit was evaluated based on the assumption that chlorine is added prior to ammonia in sufficient quantity to allow breakpoint chlorination to occur. Two disinfection segments comprising of only the portion of the treatment process "closed to the atmosphere" were assessed.

Flow Path 1 consisted of the segment from the Accelator 2 effluent pipe to Filters 3, 4, and 5 to Clearwell 2A. Flow Path 2 consisted of the segment from the Accelator 3 effluent pipe to Filters 9, 10, and 11 to Clearwell 3. Table 7 summarizes the results of the evalua-

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Table 7: Naples Plant Virus Inactivation Credit through Chloramine Disinfection

	Flow Path 1 - Treatment Train A	Flow Path 2 - Treatment Train B
T_{10}, minutes	3.51	4.06
Chloramine Residual, mg/L	3.0	3.0
CT - Calculated, mg/L-min	10.54	12.18
CT – Minimum Required for 2-Log Inactivation at 18.5 degrees C for a pH of 8.0, mg/L-min(1)	353.5	353.5
Actual Virus Inactivation Credit Available, Logs	0.06	0.07

(1) CT values based on linear interpolation of table provided in the Guidelines.

Table 8: Naples Plant Virus Inactivation Credit through Free Chlorine Disinfection

	Flow Path 1 - Treatment Train A	Flow Path 2 - Treatment Train B
T_{10}, minutes	3.51	4.06
Free Chlorine Residual, mg/L	3.0	3.0
CT - Calculated, mg/L-min	10.54	12.18
CT – Minimum required for 2-Log Inactivation at 18.5 0C for a pH of 9.0, mg/L-min(1)	1.65	1.65
Actual Virus Inactivation Credit Available, Logs	12.78	14.76

(1) CT values based on linear interpolation of tables provided in the Guidelines.

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tion to achieve two-log virus credit through chloramine disinfection.

Two-log credit through chloramine could not be achieved for all flow paths without major modifications to the present plant configuration. The city would need to add approximately 5 million gallons of storage through the addition of piping and tankage to increase the contact time.

Despite major concerns for DBP formation, the use of free chlorine was also evaluated. It was assumed that sufficient chlorine would be added at the Accelator effluent launder to achieve breakpoint chlorination and maintain a free chlorine residual into the clearwell up to the ammonia application point. It was further assumed that the ammonia application point would be relocated downstream of the filters at the clearwells to form residual chloramine for the distribution system. Table 8 summarizes the results of the evaluation to achieve two-log virus credit through free chlorine disinfection.

Two-log credit through free chlorine could be achieved for all flow paths, but the use of free chlorine for disinfection would require a significant increase in the use of sodium hypochlorite, resulting in an increased potential for DBP formation. It is possible, based on the concentration of naturally occurring humic substances in the raw water, that DBP formation would be excessive under these proposed conditions.

To minimize the DBP formation potential under this free chlorine disinfection strategy, the city would need to provide residual chloramine for the distribution system, which would require the addition of ammonia following the filtration process. Multiple ammonia injection points would need to be relocated downstream of the filters at the clearwells to provide chloramine residual in the distribution system. Implementation would require baffling of clearwells 2A, 2B, 3, and 4 to create suitable sites for ammoniation and possibly secondary chlorination.

Achieving the necessary two-log credit using either chloramine or chlorine disinfectant would require significant capital and operational costs. Under these circumstances, the city decided that four-log virus treatment was not a viable option and opted to follow the triggered and assessment source water monitoring approach to GWR compliance.

To minimize the sampling and analysis requirements of the 54 raw water production wells located collectively within the Eastern Golden Gate and Coastal Ridge wellfields, Naples prepared a representative triggered source water monitoring plan and a representative assessment source water monitoring plan for approval by the FDEP. This process involved allocating wellfield zones and representative sampling points through an analysis of the wellfield hydraulics and piping, production well design data, production well run time, and usage data.

The primary goal was to minimize the number of well samples required when a TC+ is documented in the distribution system. The two plans were submitted to the FDEP in September 2010 and were under review at the time this article was written.

Conclusions

Overcoming the challenges of GWR compliance required broad insight and careful evaluation of the existing treatment process for each individual facility. The evaluation process included the engineering calculations, followed by the economical evaluation and the analysis of the cost-benefits to each utility.

The individual utilities weighed their risk of finding positives in the distribution system against the capital expenditures required to demonstrate four-log compliance. In some cases, utilities determined that because they had not experienced significant numbers of positives in recent years, and/or because their sampling procedures had been modified to reduce the risk of positive samples in the distribution system, the required expenditures for compliance with the GWR requirement of four-log virus treatment demonstration were not warranted.

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- City of Plantation Utilities Department: ***Victor Pedlar*** and ***Hank Breitenkam***
- City of Naples Utilities Department: ***Bob Middleton***, ***Bob Reeder***, and ***Barry Stein***

References

- Florida Department of Environmental Protection Guidelines for Four-Log Virus Treatment for Ground Water
- Environmental Protection Agency Ground Water Rule Triggered and Representative Source Water Monitoring Guidance Manual