Practical Treatment Processes & Techniques for Controlling & Lowering DBPs

Sterling L. Carroll and Robert D. McVay

The Florida Rural Water Association (FRWA) has taken the practical approach to provide cost-effective, viable, established treatment processes and techniques for controlling and lowering disinfection byproducts (DBPs) in Florida's smaller water systems. The goal is to enable these smaller systems to meet the requirements of Stage 1 Disinfection Byproduct Rules and also to provide techniques that will be useful with the Stage 2 Initial Distribution System Evaluation (IDSE) implementation not far behind.

This approach takes into account the driving force of protecting public health, coupled with regulatory compliance. Working with the Florida Department of Environmental Protection (FDEP), we have assisted over 75 water systems throughout Florida with compliance issues.

Over the last decade, larger water systems have had to comply with DBPs and meet the Maximum Contaminant Levels (MCLs) set by the U.S. Environmental Protection Agency (EPA) and the FDEP. Solutions are well known in the industry and include state-of-the-art treatment schemes, such as reverse osmosis, membrane softening, nanofiltration, GAC filtration, ozonation, and other technologies. In most cases, these solutions have been appropriate, affordable, and reasonable.

As disinfection byproduct MCL enforcement extended to smaller water systems in 2004, most have successfully met the regulatory requirements, but a significant group of systems are struggling with compliance. The intriguing part of the story is that the same ready DBP answers for larger systems (reverse osmosis, membrane treatment, or nanofiltration) are too costly and don't make sense for smaller systems.

The layman may wonder why this may be, since it runs counter to our experience in today's culture. Many of the dramatic miniaturization advances we have seen in the last century have not been equally translated to water systems. Any miniaturization movement has been stymied by multiplying regulations, industry paradigms, and economies of scale.

Follow the money

Reasonable solutions used for larger systems do not always work as the application is scaled down. Innovative solutions are being played out by these systems that are of interest for all Florida systems and drinking water professionals.

Smaller water systems may be of little interest to the engineering design consultant, since there may be few financial rewards for working with these systems; nevertheless, unique approaches are in play.

A large cost component of membrane systems is the disposal of brine that requires expensive deep wells or percolation ponds. These options make sense for larger systems, but the cost puts them out of reach for smaller systems. Without major grants, small systems can not even think about membrane treatment processes.

"The time of 80-percent and 90-percent grants is over", said Michael Langston, the U.S. Department of Agriculture's Rural Development Florida Community Programs director. "Those days are past, except for a small group of disadvantaged systems."

One good example of the cost involved is a Putnam County system (355 population) with a new 130,000-gpd membrane softening system using percolation ponds for brine disposal. The total constructed cost of $2 million includes the one new surficial well, membrane skid, appropriate chemical systems, a simple concrete block building, degasifier, transfer pumps, bolted steel storage tank, and high-service pumps. The unit cost for the system is over $15 per gallon and $1,400 per connection. This is a responsibly designed plant with few frills, but it would not have been constructed without the support and participation of grants and loans from USDA Rural Development and the Florida State Revolving Fund. Should the design application have required deep well disposal, the project cost would have increased over $6 million.

Continued on page 14

Sterling L. Carroll, P.E. is the state engineer for the Florida Rural Water Association. Robert D. McVay, P.E., handles comprehensive technical assistance for the association.

TABLE 1: Community Water Systems in Florida *

CWS Population Size	Water Systems	Percentage of Water Systems	Percentage of Population Served
over 10,000	233	12.3%	90.7%
under 10,000	1,654	87.7%	9.3%
TOTALS	1,887	100%	100%

Continued from page 13

Demographics

Florida has about 1,900 community water systems (CWS) serving a population of 17.2 million people. Most of that population (15.6 million) receives water from 233 systems—a small fraction of the total (or 12.3 percent), as illustrated in Table 1 and Figure 1.

The majority of water systems serve small populations, as shown in Figure 1. Most CWS in Florida (87.7 percent) serve populations under 10,000 and do not account for residential wells permitted by the Department of Health. These smaller systems frequently can not afford extended consulting assistance for compliance issues. This defines the dilemma: Engineering solutions are not within the grasp of most systems.

Although the FRWA has a membership that includes large utility systems, it was originally formed for the benefit of smaller water and wastewater systems. Our goal is to help water systems provide Floridians with an ample supply of affordable high-quality water, while protecting natural systems. Working with FDEP, we focus our technical assistance by providing training services, regulatory representation; promoting project funding; engineering support; on-site assistance with two-dozen circuit riders, troubleshooting, emergency response BMPs, generator purchasing, O&M manuals, wellhead protection, rates, impact fees, etc.

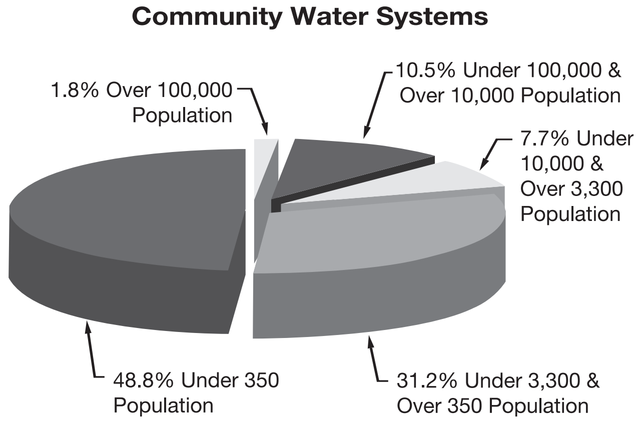


FIGURE 1

Below is a comparison of Florida's water systems and distribution by size for Community, Non-Community, and Non-Transient Non-Community.

Time for Action

Stage 1 Disinfection Byproduct Rules were implemented for smaller systems in January 2004. Sampling begun in 2004 was partially interrupted by the four major hurricanes (Charley, Frances, Jeanne, and Ivan), and water systems also had to contend with Hurricane Wilma in 2005. But sampling must go on. The systems struggling with DBP compliance are under the gun with the FDEP to show action and to show it now.

Aggressive Preventive Maintenance Program

The FRWA has been working with water systems statewide to meet the MCLs under FDEP direction. We have recommended that water systems start an aggressive preventive maintenance (PM) program before considering treatment such as GAC filters, anion exchange, or chloramines. The objective is to significantly lower chlorine feed rates and move the chlorination point to reduce contact time.

Aggressive PM improves overall water quality in the plant and distribution system. Many systems could make higher-quality water if they were operated cleaner (tanks cleaned and water piping flushed). Results of an aggressive PM program have demonstrated a minimum 30-percent reduction in TTHMs and HAA5s.

We have seen several systems reduce DBPs by 60 to 70 percent. One of our first systems to try an aggressive PM program saw an immediate reduction from 235 ppb TTHMs to 65 ppb with preventive maintenance alone! More examples are provided hereafter.

Aggressive PM and chlorine reduction is a DBP mitigation technique to reduce the amount of DBPs formed in the water system. It also manages the remaining DBP formation potential and total organic carbon (TOC) interaction with chlorine.

Florida's warmer temperatures contribute to biofilm regrowth in drinking water distribution systems and water storage facilities. Chlorine residuals are kept higher to manage regrowth, but that increases DBP formation. Chlorine levels can be kept artificially high for operator convenience and as a result of limited time spent at water plants.

PM Program Steps & Examples

Here are the four FRWA Preventive Maintenance Program Steps:

1. Establish an aggressive cleaning flushing program and increase tank turnover rate.
2. Install automatic flushing valves.
3. Move the chlorination point to minimize contact time.
4. Reduce total disinfection dosages.

Step 1: Establish an Aggressive Cleaning & Flushing Program

Begin at the water plant and move out to the extremities of the distribution system. Clean, flush, disinfect, and inspect all water tanks and treatment facilities to remove biofilm and deposits.

Flush the entire water distribution system using conventional flushing techniques or unidirectional flushing (preferred). Unidirectional flushing is different from conventional flushing and uses targeted, high-velocity water flow moving from source to hydrant in an outbound direction to scour the distribution system. It greatly increases the effectiveness of flushing and can significantly improve water quality in systems where water-quality problems are caused by the distribution system itself.

This involves closing distribution system valves so that water flows in one direction or one segment of pipe at a time, causing the velocity to reach two to six feet per second, necessary to scour deposits and debris from the mains. The technique involves a systematic plan, flushing maps, some training, water quality monitoring, and flow calculations.

Increase Tank Turnover Rate

The rate should be increased to every 72 hours; 30 percent to 50 percent of the tank vol-

Populations	Community	Non-Community	Non-Transient Non-Community	Totals
Over 10,000	233	0	1	**234**
under 10,000	1,654	3,295	975	
TOTALS	**1,887**	**3,295**	**976**	**6,158**

TABLE 2: Florida's Water Systems Sorted by Type and Size *

ume should be turned over each day. Sediments are the ideal place for biofilm development, since all conditions needed for bacterial growth are provided. Bacteria can colonize in these biofilms and produce compounds that require high chlorine demands. Biofilms can cause other problems, including turbidity, taste, and odor problems, which can be amplified in the distribution system.

Troubleshooting Problem #1A:

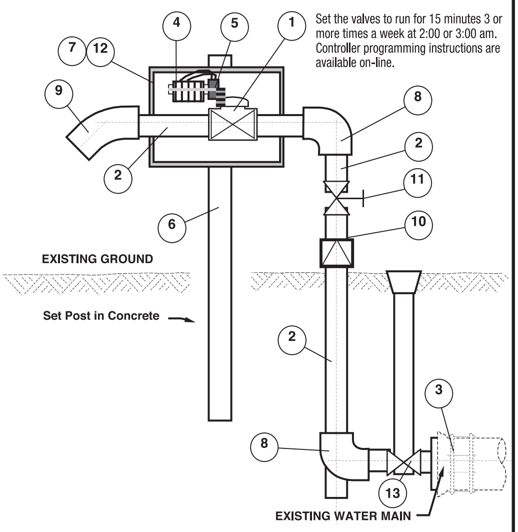
A water system experiences a significant DBP excursion in its distribution system following long period of **extended hot weather**.

- Water Samples/Observations: Free and combined chlorine residual and heterotrophic plate count (HPC).
- Probable Cause: A biogrowth in the distribution system concentrating organic materials that are reacting with free chlorine.
- Operator Checks: (1) Check chorine residual, (2) determine if the free chlorine portion is greater than 80 percent of total chlorine, and (3) perform an HPC.
- Possible Remedies: (1) Increased flushing frequencies and (2) super-chlorination to burn the biogrowth out, followed by a change to chloramines as disinfectant.

Troubleshooting Problem #1B:

A water system experiences a significant DBP excursion **near water storage tanks**.

- Water Samples/Observations: Free and combined chlorine residual, HPC, water age calculations, water tank temperatures, water tank levels, tank fill and turnover calculations.
- Probable Causes: (1) Sediment accumulations in the water storage tank are concentrating organic material and reacting with free chlorine producing DBPs, (2) stratification and turnover of stagnant water in tank has occurred, and (3) changes in tank levels have occurred because of hydraulic demands.
- Operator Checks: (1) Maintenance records for last sediment removal, (2) tank temperatures for water stratification, and (3) performance of tank fill and turnover calculations.
- Possible Remedies: (1) Ensure that the tank is filling and emptying properly and that no stratification is occurring, and (2) ensure that tank levels are changing daily, with at least 2/3 of the tank water changing over.



Set the valves to run for 15 minutes 3 or more times a week at 2:00 or 3:00 am. Controller programming instructions are available on-line.

AUTOMATIC FLUSHING VALVE DETAIL

FIGURE 2

Step 2: Install Automatic Flushing Valves on all dead-end lines 6-inches and larger.

Water systems may purchase utility-grade devices that are commercially available or construct their own automatic flushing valves for under $300 (the design is available by request at no charge from the FRWA at **Sterling.Carroll@frwa.net**).

The operational goal is to lower residence age. The valves can be set to run three or more times a week at night for 15-30 minutes. Although it is not always practical, try to keep water age to two or three days in the water system.

Continued on page 16

TABLE 3: Summary of Water Age Evaluation *

Population Served	Miles of Water Main	Range of Water Age
> 750,000	> 1,000	1 - 7 days
< 100,000	< 400	> 16 days
< 25,000	< 100	12 - 24 days

Continued from page 15

Water, unlike wine, does not improve with age. See Table 3 for a description of water age related to system population.

Troubleshooting Problem #2A:

A water system experiences a significant DBP excursion in the distribution system **at select points**.

- Water Samples: Free and combined chlorine residual.
- Probable Cause: Excessive water age, allowing reaction between free chlorine and TOC.
- Operator Checks: Check the water age in the distribution system or have an engineer run the calculations.
- Possible Remedies: (1) Initiate a corrective flushing program and (2) install automatic flush valves.

Troubleshooting Problem #2B:

A water system experiences a significant DBP excursion occurring **in isolated areas of low flow or in areas with dead-end pipelines**.

- Water Samples/Observations: Free and combined chlorine residual, HPC, system pressure analysis, and water age calculations.
- Probable Causes: (1) Biogrowth in the distribution system concentrating organic materials that are reacting with free chlorine-producing DBPs, (2) pipelines experiencing tuberculation, and (3) system valves closed, increasing water age in some isolated pipelines.
- Operator Checks: (1) A chorine residual check, (2) determining if the free chlorine portion is greater than 80 percent of total chlorine, (3) performing HPC, and (4) performing a system pressure test.
- Possible Remedies: (1) Increase the flushing frequencies, (2) use super-chlorination to burn the biogrowth out, followed by a change to chloramines as disinfectant, (3) ensure that all system valves are open, and (4) possibly pig the lines to restore hydraulic efficiency.

Troubleshooting Problem #2C:

A water system experiences a significant DBP excursion **after maintenance, repair, or start-up of distribution pipelines**.

- Water Samples/Observations: Free and combined chlorine residual, flushing frequency, and locations.
- Probable Causes: (1) Flow patterns have been disrupted and/or sediment transported, and (2) excess chlorine has entered the water system following repair or start-up.
- Operator Checks: (1) Check the maintenance records for the last water main repairs or new main start-up, and (2) ensure that system valves are in the open position.
- Possible Remedy: Re-institute flushing in the affected areas.

Step 3: Move the Chlorination Point to Minimize Contact Time

This is an excellent DBP management strategy, but the risks for balancing microbial pathogens and DBPs can be a challenge.

- Change the chlorination point to minimize contact time by moving it downstream and closer to customers.
- Reduce prechlorination or periodically use shock treatment units to manage biological regrowth.
- Lower the pre-tray aeration feed rate to 15 to 25 percent of the current dosing rate. The chlorine dose should not provide a residual at the pre-tray aeration feed point.

Step 4: Reduce the Total Disinfection Dosages Used

This step should also include maintaining the minimum free chlorine residual. For systems with large or remote service areas, we recommend installation of sodium hypochlorite booster systems to allow reduction of chlorine dosing at the water plant, reduction of the overall system-wide chlorine feed rate, and a resulting reduction of DBPs.

Troubleshooting Problem #4A:

A water system experiences a significant DBP excursion **following changes in chlorination practices**,

- Water Samples/Observations: Free and combined chlorine residual, HPC, temperature, pH, turbidity, and TOC.
- Probable Causes: (1) Changes in dosing at a plant location that produce higher levels of DBPs, and (2) a chlorine dose that is too high for conditions.
- Operator Checks: (1) Check bromide levels in the source water, and (2) perform water-quality checks for temperature, pH, turbidity, reducing inorganic agents, and TOC increases.
- Possible Remedies: (1) Plot the chlorine demand curve and reset the dosage to achieve the desired residual, and (2) adjust the chlorine dose based on pH.

Troubleshooting Problem #4B:

Pre-chlorination has been initiated **to control tastes or odors**.

- Water Samples: Free chlorine, dosage, and residuals.
- Probable Cause: Pre-chlorination is causing premature DBP reactions prior to the removal of TOC.
- Operator Check: Determine the DBP formation potential.
- Possible Remedy: Move the point of chlorine application.

Troubleshooting Problem #4C:

A water system experiences **changes in chlorine residual** in plant processes with no chlorine dose increases.

- Water Samples/Observations: Free and combined chlorine residual, pH, TOC, turbidity, flow rate, and detention times in basins.
- Probable Causes: (1) Source-water quality has changed, (2) plant flow has significantly changed, decreasing detention, and (3) pH has changed, resulting in more reactive disinfectant.
- Operator Checks: (1) Determine the source-water quality, (2) check for equipment failures, chlorine feed calibration, and improper chlorine feed rates, and (3) determine if chlorine feed rates are not being flow-paced.
- Possible Remedies: (1) Decrease the chlorine feed to establish necessary in-plant residuals, (2) repair and/or recalibrate equipment, and (3) calibrate chlorine monitoring equipment, including handheld test equipment.

Simultaneous Compliance Challenges

Florida's drinking water professionals face the dilemma of increased total coliforms as the balance is struck between aggressive preventive maintenance and reduction of chlorine feed to mitigate DBP formation. The complex set of regulatory challenges is placing water systems in a regulatory box known as simultaneous compliance.

Tweaking treatment to comply with new rules can easily impact compliance with existing rules or cause a violation in another area. Operators and engineers must be more aware of the delicate balance of water chemistries and interactions on the water plant and distribution system.

The EPA evaluated the health risks to set maximum containment levels (MCLs) for disinfection byproducts. MCLs roughly represents a risk of between one in a million and one in 10,000 excess cases of cancer as a result of consuming two liters of water per day for about 70 years—a LOW RISK, in spite of the fact that most of these DBPs are chemicals with unpronounceable and confusing names to the general public and journalists. The EPA should take the lead and courageously establish realistic hierarchies, beginning with acute MCL violations in relationship to chronic DBP risks.

Life expectancy was shorter for our grandparents because of communicable diseases like typhoid and cholera. Epidemics were common. Disinfection was a major factor in reducing these epidemics. Chlorine protects health; it is an essential part of drinking water treatment today and so are DBPs.

Program Results

Many water systems have had success complying, and we are actively assisting systems statewide with recommendations, treatment design, and permit applications. In some places the message has met with mixed results. Unfortunately, a few systems have not really worked the program. Some have assured the FDEP that they have started "flushing," paying lip service to the preventive maintenance recommendations, or in a few cases, using it as a delaying tactic. Compliance enforcement should induce the stragglers into action.

One system called to complain about flushing program results. Their TTHMs were at 95 ppb before flushing and 145 after! After talking, the whole story became clear. Apparently the system would be flushed only immediately before taking samples—really flush—the whole 24-hours before sampling. No other changes, no line/tank cleaning, no automatic flushing valves, same chlorine dose, and the chlorination point was not moved.

I was able to explain that too much of a good thing sometimes has bad results. Flushing only before sampling stirs up the sediment in the tank and lines and only makes water quality worse. "If two aspirins

Continued on page 18

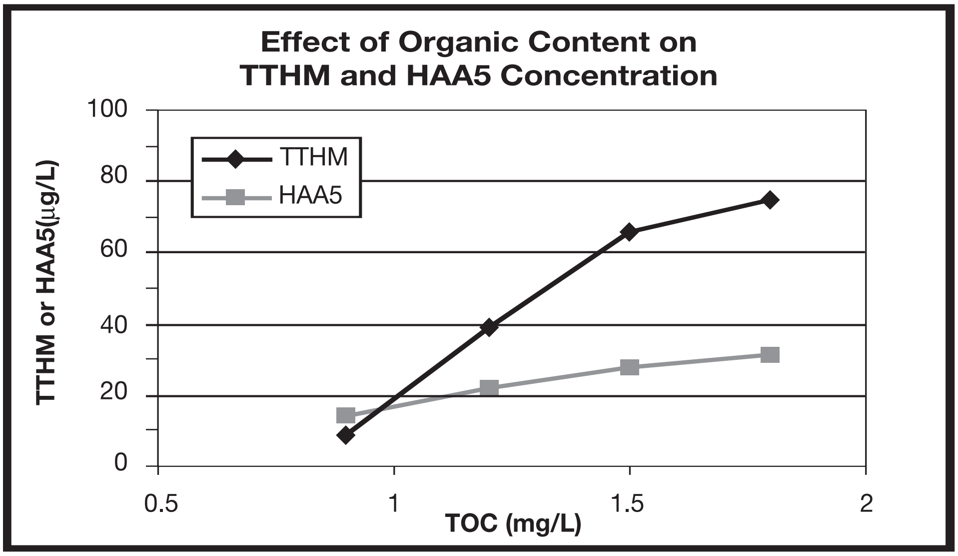


FIGURE 3: Effect NOM Concentration on TTHM & HAA5 Concentration
(Source: EPA 815-D-03-004 "Stage 2 Disinfectants And Disinfection Byproducts Rule Significant Excursion Guidance Manual" July 2003, page 2-3)

Continued from page 17

make me feel better, then how about the whole bottle?" Only part of the message was received and implemented.

For systems with TTHMs above 240 ppb, no amount of preventive maintenance will get them under the MCL. It is prudent to design treatment to lower DBP based on raw-water TOC levels, but if the preventive maintenance and reduced chlorine regime is ignored (which can constitute over half of the DBP level), the design engineer will over-design the treatment and the system will bear unnecessary construction and operation costs.

About 40 to 60 percent of systems we have assisted have been able to comply with DBP MCLs using the preventive maintenance and reduced chlorine regime (see the following PM examples). Currently we are working with about 20 percent of systems preparing treatment designs (GAC filters, POU devices, anion exchange or chloramination). About 10 percent have been given recommendations and assistance, but have not taken it. The remainder are working with engineering consultants.

PM Example #1:

The Hendry County system (414 population) followed an aggressive preventive maintenance and chlorine reduction program with excellent results.

- First Quarter results: TTHMs = 200 ppb, HAA5s = 88 ppb
- Last Quarter results: TTHMs = 62 ppb, HAA5s = 6 ppb
- 69-percent reduction in TTHMs & 93-percent reduction in HAA5s

PM Example #2:

The Glades County system (63 population) followed an aggressive preventive maintenance and chlorine reduction program with excellent results.

- First Quarter results: TTHMs = 157 ppb, HAA5s = 131 ppb
- Last Quarter results: TTHMs = 63 ppb, HAA5s = 46 ppb
- 60-percent reduction in TTHMs & 65-percent reduction in HAA5s

PM Example #3:

The Highlands County system (250 population) began the aggressive preventive maintenance and chlorine reduction program, but results are up and down, not consistent. They have not stuck with the program consistently, and we will be recommending that they consider treatment.

- First Quarter results: TTHMs = 205 ppb, HAA5s = 147 ppb
- Last Quarter results: TTHMs = 164 ppb, HAA5s = 97 ppb
- 20-percent reduction in TTHMs & 34-percent reduction in HAA5s

DBP Precursor Removal

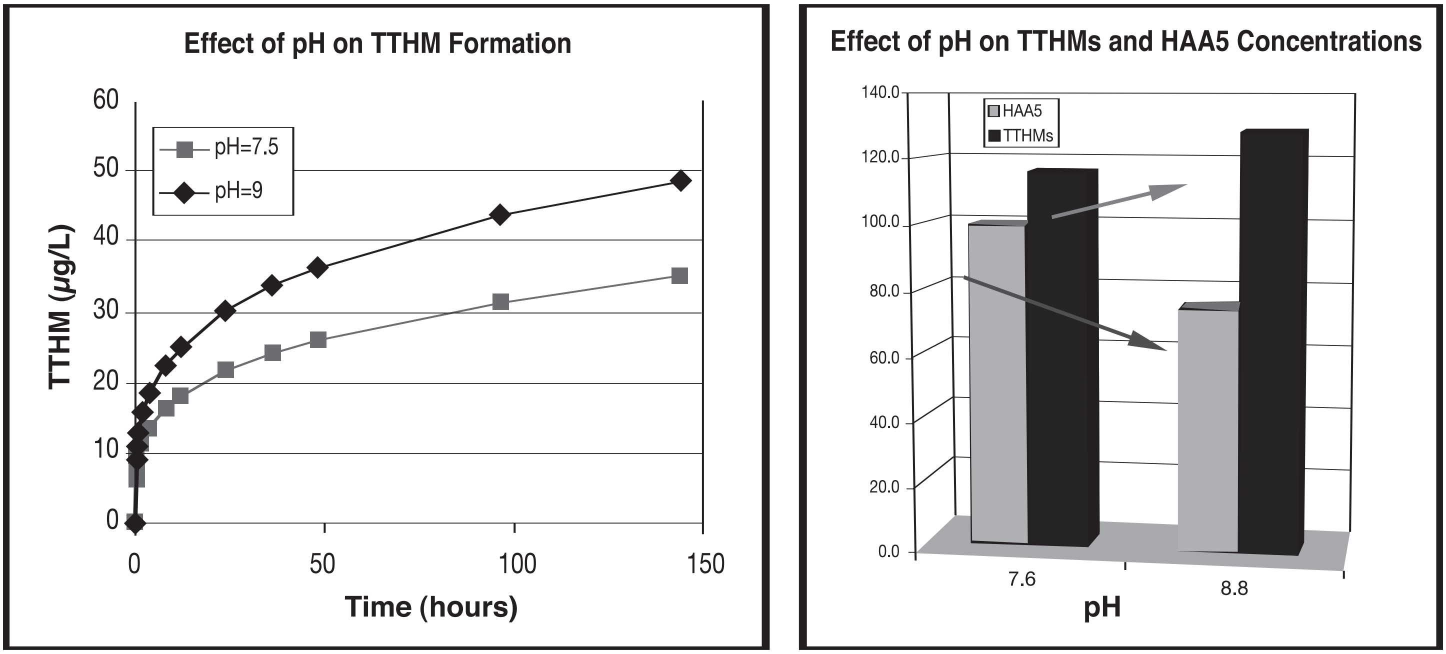


FIGURE 4: Effect of pH on TTHM and HAA5 Formation
Source: EPA 815-D-03-004 "Stage 2 Disinfectants And Disinfection Byproducts Rule Significant Excursion Guidance Manual" July 2003

TABLE 4: DBP Formation Potential

DBP Yield %	Formation Potential	Simulated Distribution System Test
TOX *	100%	N / A
TTHMs	23%	7%
HAA5s	33%	11%
Other DBPs	44%	N / A

The three common removal categories for DBP precursor removal are as follows. Predicted DBP reductions vary from 50 percent to 90 percent, according to design and application.

1. Source Water Management
2. Solids Removal Treatment Processes
   - Pre-Sedimentation
   - Coagulation
   - Filtration & Membrane Filtration
   - Sedimentation or
3. Adsorption & Absorption Processes
   - Activated Carbon Use or Addition
   - Resin Absorbents (Ion/Anion Exchange & Magnetic Ion-Exchange Resin)

Several studies illustrate the reaction of chlorine with organic material. In the graph in Figure 3, we see that TTHM formation rises significantly with higher organic carbon concentration levels in the presence of free chlorine. The chlorine dose is 4.3 mg/L. Note that the formation rate of HAA5s is slower than for TTHMs, and HAA5s level off much quicker.

The graph on the left in Figure 4 shows the effects of pH in the production of THMs over a 150-hour period. The plot on the right shows the same situation compared to HAA5 production. It can be observed that HAA5s are less susceptible to pH increases and actually have decreased, apparently due to the biodegredation of the HAA5 over a long period of time.

DBP Treatment Example #1: Volusia County system (210 population)

Construction of the GAC filter system is complete and certified and water started to flow only just recently. The fiberglass filters have a 30-minute empty bed contact time and pre-cartridge filters. The total cost was under $20,000, which is less than $1 per gallon construction cost. We included a chloramination feed system option with the permit, just in case they wish to install it in the future.

DBP Treatment Example #2: Hendry County system (80 population)

The county has decided to install point-of-use devices with GAC filters.

DBP Treatment Example #3: Charlotte County system (472 population)

Design of the GAC filter system is complete and permit application will be submitted presently. The fiberglass filters have a 25-minute empty bed contact time and pre-cartridge filters. We included a chloramination feed system option with the permit, just in case they wish to install it in the future.

DBP Treatment Example #4: Collier County system (100 population)

The county has installed point-of-use devices with GAC filters. Written request to FDEP and POU demonstration is underway.

DBP Treatment Example #5: Collier County system (2,500 population)

Made recommendations and discussed them at length. They are working with their consultant and operator on solutions. First recommendation from their consultant included a $2.5 million fix for the system—or about $10 per gallon and $2,500 per connection.

DBP Removal Treatment Technology

This grouping of strategies focuses on removing disinfection byproducts or trihalomethanes from the water AFTER THEY FORM. This approach is based on the premise that DBPs (e.g., chloroform) are sometimes easier to remove than total organic carbon (DBP precursors).

Some volatile DBPs (e.g., chloroform) can be significantly removed through appropriately designed aeration or oxidation processes, which include packed towers, aeration trays, dissolved/bubble aeration, ozone, or GAC. Temperature and air-water transfer ratio are significant design factors, and expected removals vary greatly.

Although we have made recommendations for this type of treatment, no system has pursued the process. Projected removals are expected in the 50-to-75-percent range.

Table 4 demonstrates that not all organic compounds form regulated DBPs. The tests performed on potential DBP formation have been based on 100-percent chlorine reaction with organic compounds. As can be seen, a little over 50 percent of the DBPs produced will be either regulated THMs or HAA5s. The other 44+ percent are unknown or unregulated compounds.

The other interesting feature of this table is that organic compounds in source water contain both fulvic and humic compounds, and thus, under simulated conditions, do not react with all the organic material present. The actual reactive constituents will fall somewhere between the ranges shown,

Continued on page 20

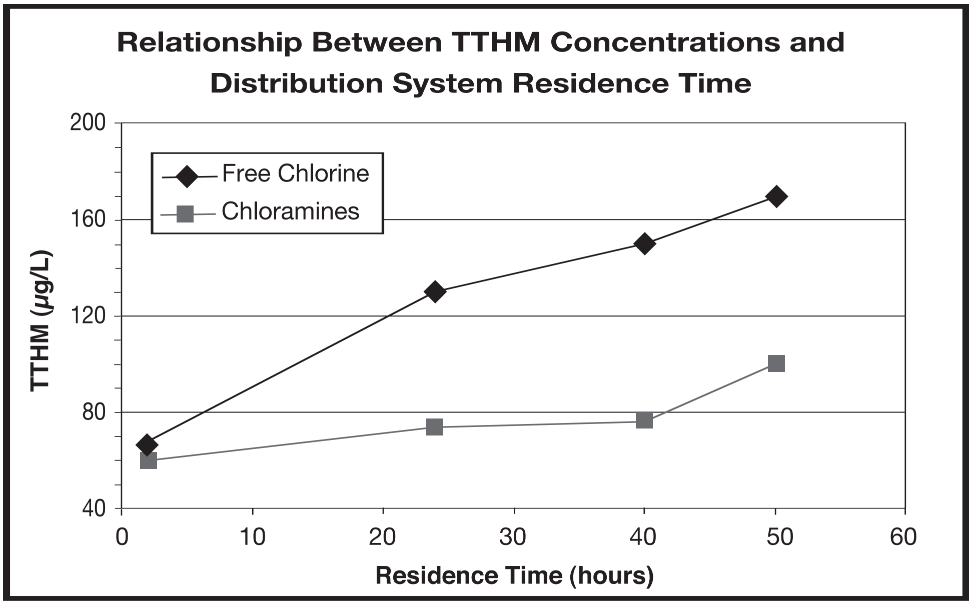


FIGURE 5: Relationship Between TTHM, Distribution Residence Time, and Chloramines

(Source: EPA 815-D-03-004 "Stage 2 Disinfectants And Disinfection Byproducts Rule Significant Excursion Guidance Manual" page 2-17)

Continued from page 19

depending on the chlorine concentration, the contact time, pH and temperature. Long contact times in the presence of free chlorine can eventually approach the upper limits shown.

Disinfection Alternates

Alternate disinfection strategies, other than chloramine, include ozone, chlorine dioxide, potassium permanganate, and ultraviolet, among others. A variety of reasons underlie the selection of chloramine disinfection; cost and unfamiliarity are noteworthy. Also, few small systems would be able to effectively operate these alternatives consistently (ozone, chlorine dioxide, potassium permanganate, etc.). The chart in Figure 5 demonstrates the effectiveness of chloramination over time.

Chloramine systems have shown 60-to-75-percent reductions in DBPs. This is significant, but chloramination is not a panacea, since it has disadvantages such as bioslime regrowth. Operators frequently respond to these conditions by raising the chlorine-to-ammonia ratios well above the recommended 3:1 ratio for production of the desirable monochloramine disinfectant. Ratios as high as 5:1 are common in practice.

At these ratios, production of the undesirable dichloramine species will be favorable, and this condition can result in customer taste and odor complaints. Some of this imbalance is a result of a fundamental misunderstanding by drinking water professionals and operators about the chlorine-to-ammonia ratio; the ratio refers to measured **chlorine residual**, not chlorine dosage rates.

Simultaneous compliance issues for chloramines include the total coliforms rule and nitrification, which are EPA primary standards. Periodic conversion to full-strength free chlorine is necessary to kill the biofilm. Often called “burning,” the length of time for free chlorination starts at a couple of weeks or longer, following the proper notifications to customers and the FDEP.

Chloramines have a tendency to break down in the distribution system, given long residence times. When this situation occurs, the chlorine becomes more reactive and forms DBPs as illustrated in Figure 5.

When considering alternatives, we recommend that water treatment professionals first seriously focus on better water treatment and distribution system operation methods before adding ammonia to potable water in order to form chloramines. It is counterintuitive to add ammonia (a pollutant) to drinking water, and as a result, the FRWA has not been encouraging chloramination, but will help any system that chooses it.

Total installed cost for an ammonium hydroxide feed system is often less than $1,000 and includes a chemical tank of 55 gallons or less, a peristaltic chemical feed pump, tubing, an injection point, and controls.

Summary

The focus for reducing disinfection byproducts has been to recommend that systems consider treatment ONLY AFTER they have improved plant and distribution system water quality. Aggressive preventive maintenance is performed with the express objective of significantly lowering chlorine feed rates, moving the chlorination point to reduce detention time, improving water quality, and reducing DBPs. Florida’s water systems can use these practical, proven techniques to control and lower DBPs.

Water systems can count on a minimum DBP reduction of 30 percent after a program of aggressive preventive maintenance and chlorine reduction, but may experience a significant reduction of up to 60 to 70 percent. These gains should not be ignored when designing a treatment regime; to do so would translate into over-designing treatment components and causing unnecessary operational expense.

Treatment processes and techniques for removing DBP Precursors (TOCs) result in DBP reduction of 50 to 80 percent, according to design. One of the best treatment schemes for DBP reduction are membrane processes; however, it can be too costly for smaller systems. Alternates include GAC filters, anion exchange, resin absorbents, air stripping, other oxidation processes, enhanced coagulation, etc.

Chloramine is the disinfection alternate of choice for many systems because of excellent DBP reductions and low cost. Chloramination has resulted in statewide increased Total Coliform Rule violations (per Van Hoofnagle, administrator, FDEP Drinking Water Program).

Chloramines may be a moving target. In light of recent events in the national media, the EPA may be formulating additional regulations. Chloramines may pose future simultaneous compliance problems such as nitrification, biofilm regrowth, and degraded water quality.

Practical solutions are available to water systems of any size without immediate capital costs. The dialogue between drinking water professionals and water system operators should include the complete repertoire of options—realistic options.

Compliance with DBP MCLs can be accomplished with a step-wise approach and in a reasonable and systematic process. Recommendations to water systems should include all practical alternatives in the best interest of the water industry and ratepayers.