FLORIDA RURAL WATER ASSOCIATION

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FRWA Whitepaper

Water Age and Water Quality Deterioration

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Water, unlike wine, does not improve with age.

Florida Rural Water Association is finding that systems having water quality compliance issues frequently also have high water age. These systems flush as a reaction to complaints, when residuals are low, or when the operator remembers to do it, and has not installed automatic flushing valves. Additionally FRWA is finding some small to medium sized water systems designed for continuous operation that are being operated as batch plants. Problems resulting from high water age can include: Disinfection By-Products MCL issues, bacteriological hits in the distribution system, high chlorine feed rates, corrosion, lead / copper leaching, increasing odors and taste, blackwater formation as hydrogen sulfate converts back to elemental sulfur, or nitrification if chloramines are used.

Water Age is a Major Factor in Water Quality. From the moment that water is treated and leaves the plant degradation of water quality occurs within storage tanks and the distribution system. So the quicker the finished water reaches the customer the better.

Increased water age contributes to poor water quality. The mechanisms of water degradation are chemical, physical, and aesthetic; and include: (1) interplay of the water to the pipe wall and tank surfaces; (2) reactions within the water itself (including disinfectant decay and disinfectant reaction with organic materials); and (3) bio-chemical interactions with biofilm, microbial growths, deposited materials and sediment. Adding a fourth and possible fifth mechanism unique to Florida are the ambient water temperatures that accelerate water quality degradation, and the fact that we often start out with poorer raw water is high in tannins, organics, iron, hardness, and so forth.

Disinfectant Decay. Over time, disinfectants break down allowing nitrification and biological growth of microbes to occur. Nitrifying bacteria can cause a biofilm to form on the walls of distribution system piping. This usually occurs when a system that uses chloramines for disinfection is operated improperly. For these systems, it is important that nitrification does not push nitrate and nitrite concentrations above the maximum contaminate level (MCL). Regrowth of pathogens in the water system can occur when there is not enough disinfectant to prohibit their growth. Systems need to be careful not to develop a coliform problem in the distribution system or violate the Total Coliform Rule (TCR).

Reaction to Naturally Occurring Materials (NOMs). Florida has more than its share of waters high in organics – some have used the phrase “swamp water.” Since Florida’s groundwater sources are rich with tannins and other NOMs chlorination causes a host of problems and tend to create Disinfection By-Products (DBPs). Additionally increased water age and temperatures accelerates the formation of Disinfection By-Products – Florida is the ideal place to make DBPs.

Factors Contributing to Increased Water Age. As you can imagine from the discussion above there can be several factors contributing to increased water age. These include:

- Demand Planning (over-design) of water lines for future demands, pressure, fire flows
- Storage Tanks with extra reserves for future demand
- Distribution System Geometry - areas of long pipe runs with few customers, dead-end lines instead of looping
- Batch Plant Operations

The table below demonstrates why small to medium sized systems have a greater problem with water age. The EPA has recognized the importance of water age on water quality in the distribution system and has produced a paper, "Effects of Water Age on Distribution System Water Quality" (available at http://www.epa.gov/safewater/disinfection/tcr/regulation_revisions.html).

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

** Source "Effects of Water Age on Distribution System Water Quality", EPA (2002)*

FRWA recommends that water age should be kept to 3 days or less if at all possible.

Demand Planning for water facilities based on future growth may seem prudent in the long run, but can cause problems in the short term. These large pipes provide plenty of capacity for fire flow and to accommodate future demand but contribute to high water age in the interim. These designers followed the correct recommendations in the AWWA Manuals for sizing water mains however the economic downturn has reduced demands, high vacancy rates, and the loss of major industrial water users. Some systems are seeing vacancy rates of 10% due to the sub-prime mortgage crisis.

Storage Tanks and Fire Flow. Small to medium sized systems have a greater problem with tank turnover than large systems since the fire protection volume is large in comparison to average demands. FRWA found one system flushing (wasting) half of its daily water production to keep the water in its elevated storage tank fresh. Storage tanks are the ideal place for water to cook in the hot Florida sun!

Characteristics of Batch Plant Operations. FRWA is finding some small to medium sized water systems designed for continuous operation that are being operated as batch plants. The water treatment plant is operated several days a week as a batch plant – discrete on/off operations. These systems have excess design capacity, few customers, high vacancy, no growth, large water lines designed for fire flow, and so forth. Water treatment reactions do not have a chance to stabilize or come to equilibrium – the operator makes one plant adjustment, sets it, and leaves it running overnight. The elevated storage tank is filled and allowed to empty over several days.

The operational choice is based on economics and operator convenience – the contract operator is more interested in his/her time and effort than water quality, and the owner provides minimal oversight and doesn't fully understand the consequences until compliance issues loom.

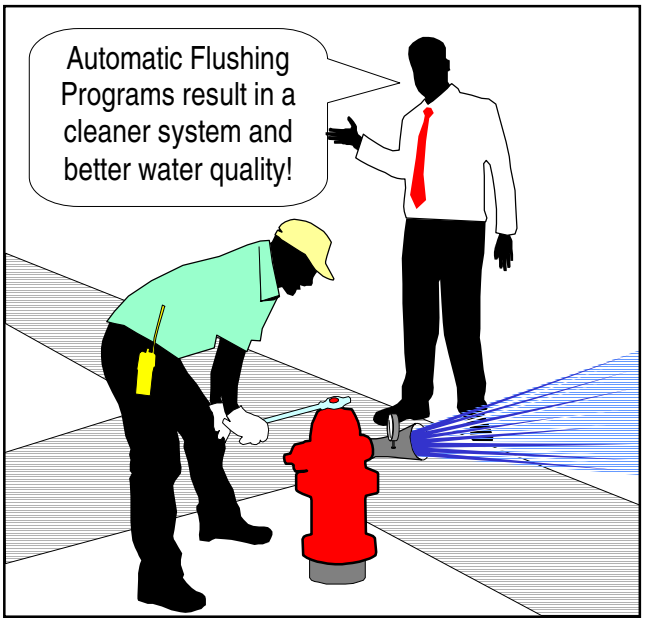
High Water Age Issues. High water age causes a number of predictable problems. Chlorinated water sits in elevated storage tank for days making disinfection by-products and degrading water quality. Unnecessary high chlorine feed rates are used to maintain a residual in the furthest point in the distribution system – resulting in:

- Disinfection By-Products / MCL issues
- Degraded water quality – corrosion, lead / copper leaching
- Blackwater formation as H_2S converts back to elemental sulfur
- Nitrification if chloramines are used

Approach to Solving Batch Plant Operations. The key to discouraging batch operations is education of the owner and then the operator. The specific message should be *"batch operation is contrary to good finished water quality."* The approach should begin with owner education about the ramifications of batch operations. Secondly, the operator should be convinced that batch operations carry overall higher costs and inferior results, although more convenient and less time consuming. FRWA circuit riders and engineers will assist the DEP District and approved county health department personnel in transmitting the message to water systems. This message will be delivered at this year's Focus On Change sessions.

Minimize Storage Duration. Increase tank turnover rate so that 50% of the tank volume is turned over each day. Also, the tank should be cleaned on a regular basis. DEP requires storage tanks be cleaned and inspected every 5 years per Rule 62-555.350(2), FAC. Sediments are the ideal place for development of biofilm 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 such as turbidity, taste and odor problems that can be amplified in the distribution system.

Develop A Regular Flushing Program. Flush the entire water distribution system using conventional flushing techniques or unidirectional flushing (preferred). Unidirectional flushing is different that 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 2 - 6 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.



Summary. Water systems having water quality compliance issues may have high water age, particularly some small to medium sized systems. Addressing water age is an excellent management practice to bring the system back into compliance. FRWA circuit riders and engineers are happy to work with DEP District and approved county health department personnel in assisting water system with these issues.