Maximize Revenue Generation, Minimize Potable Water Flushing, Optimize Distribution Water Quality for Areas Impacted by Reclaimed Water Service

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Potable water utilities are facing increased challenges to water quality in the distribution system. These challenges come in several forms. The upcoming Stage 2 Disinfection Byproduct Rule will result in more stringent monitoring and trihalomethane and haloacetic acid levels. Maintaining minimum disinfectant residuals, preventing bacteriological positive occurrences, preventing nitrification, and meeting increased customer quality expectations are additional challenges.

The enemy of distribution system water quality is time. Water quality degrades with time. Chlorine residuals decay and disinfection byproducts (DBPs) form as water age increases.

With the advent of separate reclaimed water distribution systems, utilities are facing a setback in efforts to minimize water age: Separate, dual reclaimed water systems eliminate irrigation demands on a potable water system, which inherently increases water age in the system.

Also, most potable distribution systems are sized for fire flows, meaning that there are significantly oversized pipes for non-irrigation potable demands—a situation that can cause significantly high water ages in parts of the distribution system. Utilities are having to increase flushing efforts in areas where dual distribution systems have been implemented.

To comply with DBP regulations, many potable water utilities are planning to switch or already have switched to chloramine disinfectant to maintain a residual in the distribution systems. High water ages in chloramine systems have created chronic water quality issues such as taste, odor, and nitrification that have required elevated distribution flushing

quantities and efforts (Reed, 2006 and Riera, 2006, AWWA, 2006).

The increased flushing quantities that sometimes must occur in drought/water restriction periods can result in significant lost revenue and public relations issues.

Methodology

The concept behind this approach is to use select existing potable water customers to help improve potable water distribution quality. For the purposes of this article, the concept will be referred to as the Water Quality Optimization (WQO) concept. The methodology for the WQO concept is as follows:

1. Establish unit potable water and irrigation unit demands for existing customers.
2. Develop/update the hydraulic model to enable distribution water quality modeling.
3. Review water quality data and perform time analyses (chlorine residual decay, DBP formation, nitrification rate, etc.) to establish target distribution system water ages.
4. Use the water quality distribution model to locate and quantify neighborhood flushing quantities necessary to maintain target water ages inside distribution neighborhoods.
5. Select existing customers that would be converted (by the utility) to potable water irrigation equal calculated flushing quantities.
6. Establish a new class of customer: "water quality" or "conservation" meters.
7. Commission utility personnel to install new water quality meters for selected customers and disconnect from reclaimed meters, if applicable, following utility cross connection control policies.

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Theoretical Results

The following subsections represent a theoretical estimate of results using the WQO concept:

Water Use & Billing Assumptions

To estimate potential benefits using the WQO concept, baseline water use assumptions must first be established. The following represent estimates based on numerous potable water demand evaluations in the state of Florida. Unit demand estimates for potable, non-irrigation, potable irrigation, reclaimed water irrigation categories are presented in Table 1.

Water is billed in various sometimes complex block rate structures. Typically, higher useage is charged with higher rates to encourage conservation. For simplification, billing rates for potable and reclaimed water assumed for this analysis are provided in Table 2.

Set Water Age Target

To identify whether or not increased water ages associated with conversion to reclaimed water irrigation is a water quality issue, a utility must perform some simple analyses. These analyses include determining and plotting disinfectant residual decay, DBP formation, and nitrification over time. In addition to disinfectant residual and DBP compliance issues, high water

Table 1. Unit Water Demand Assumptions for Customers with In-ground Irrigation Systems

Demand Category	No Reclaimed gpd/ERC	With Reclaimed gpd/ERC
Potable Non-Irrigation	200	200
Potable Irrigation	300	0
Reclaimed Irrigation	0	350
Total	500	550

• gpd=gallon per day • ERC= Equivalent Residential Connection

Table 2. Assumed Typical Water Billing Rates

Demand Category	Potable Water $/1000 gal	Reclaimed Water $/1000 gal
Potable Non-Irrigation	2.00	--
Potable Irrigation	3.00	--
Reclaimed Irrigation	--	1.00

• gal=gallon

age has been implicated as a major factor in the occurrence of nitrification (AWWA, 2006).

Decay and formation in distribution systems are influenced by bulk water reactions and pipe wall effects. Bulk water effects can be determined via simple bottle tests, while pipe wall effects can be determined empirically by sampling in the distribution system using modeled water ages. Also, different source waters can have dramatically different characteristics, so all finished water inputs should be analyzed.

A sample of resulting plots for chlorine residual decay and DBP formation is illustrated in Figures 1 and 2 respectively. Based on the results of the plots, distribution water age targets can be established. Note that the age of the finished water storage tanks must also be included and is not always accounted for in water quality models. In this example, the DBP formation was the controlling issue, and a target distribution water age of 75 hours was established as shown in Figure 2.

Water Quality Improvement

To demonstrate potential water quality improvement with the WQO concept, a typical in-ground irrigation subdivision was devised. The subdivision as shown in Figure 3 is served primarily by 8-inch diameter pipes. Using a water quality model and typical de-

Figure 1. Disinfectant Decay vs. Time
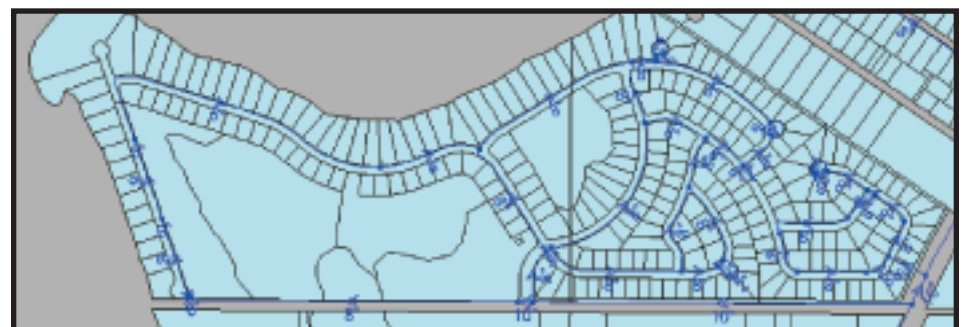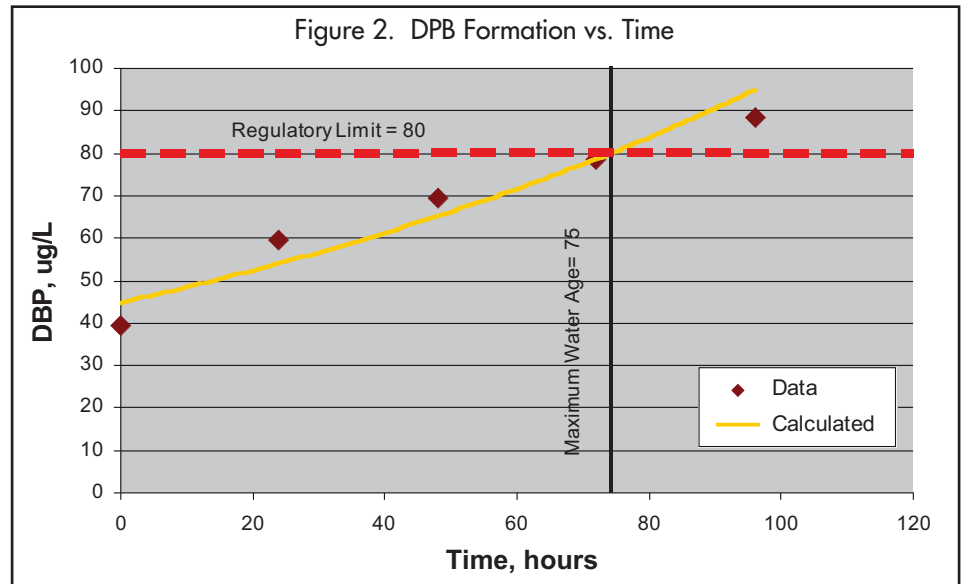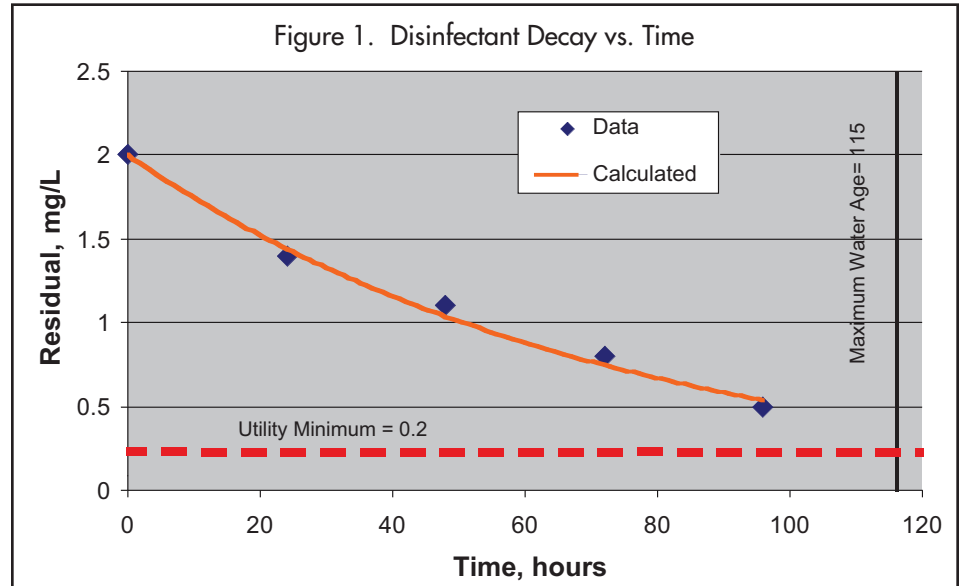

Figure 2. DPB Formation vs. Time

Figure 3. Example Residential Potable Water Distribution System with In-Ground Irrigation

mands, water age results were determined for three scenarios: 1) potable water irrigation, 2) reclaimed water irrigation, and 3) reclaimed water irrigation with select customers converted to potable water irrigation, per the WQO concept. The resulting water ages for the three scenarios is shown in Figures 4, 5, and 6, with color of pipe representing ranges of pipe water age.

A summary of average subdivision potable water age for the three scenarios is summarized in Table 3. Water age for the potable water irrigation averaged 37 hours. Implementing a separate reclaimed water system in the neighborhood would increase water age almost 100 percent to 71 hours. Maximum water age increased from 51 to 95 hours.

Implementing select potable water customers back to potable water irrigation (WQO concept) reduced average water age from 71 to 59 hours and reduced the maximum water age from 95 to 75 hours within the 75-hour target.

Revenue Impacts

To comply with DBP regulations throughout the system, a utility would have to flush an equal amount of potable water to achieve target water age. The utility would receive no revenue for the flushing water, and the cost of flushing crews and autoflushers would be incurred. While a reduced revenue would be received for the water, it is greater than the no-revenue flushing water.

The lost revenue for the reclaimed water can be countered with new reclaimed water customers that would also offset potable water used for irrigation elsewhere. Table 4 indicates the revenue increase with the proposed concept for the 240-home neighborhood study, and Table 5 relates the result to a 10-million-gallon-per-day (mgd) average annual demand utility.

The results indicate a significant positive revenue impact from the WQO concept: an estimated $23,000 per year positive impact for each 240 homes in the form of capturing revenue capture and lost flushing revenue. Assuming that 30 percent of a typical system has inground irrigation systems, a 10-mgd average annual flow system could realize a positive revenue impact on the order of $570,000 per year. Over a 10-year period, positive revenue impacts could exceed $5 million.

Water Conservation

An additional benefit of the WQO concept would be the potable water savings associated with the increased reclaimed water quantity available. Water savings has a value and should also be considered in the equation.

Implementation Issues

A major sticking point with the WQO concept will be the creation of a new class of water meters. Legal, engineering, regulatory

Table 3. Water Age Results

Item	No Reclaimed Water	Full Reclaimed Water	WQO Approach
Average Water Age	37 hours	71 hours	51 hours
Maximum Water Age	52 hours	95 hours	75 hours
Potable Water Used	100%	40%	50%

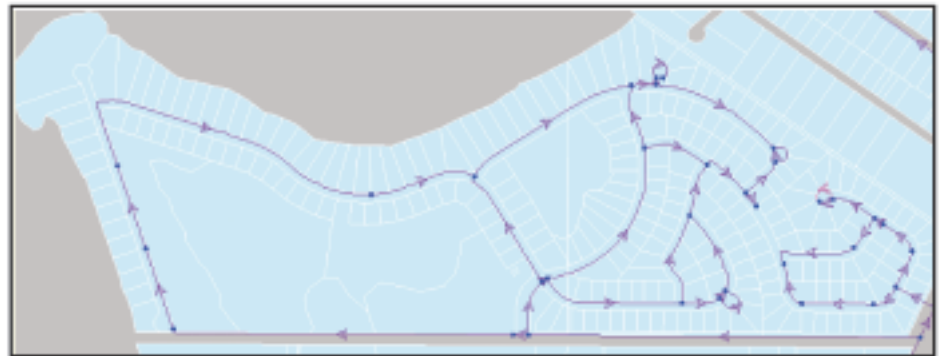WQO = Water Quality Optimize-Max Revenue
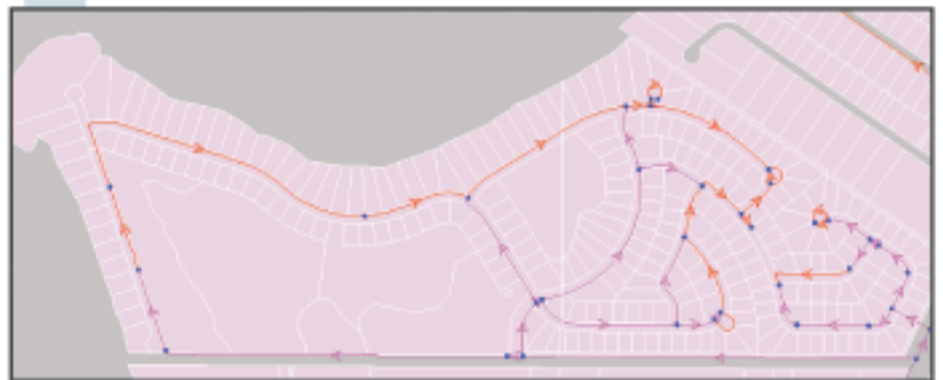

Figure 4. Average Water Age – Potable Water Irrigation

Figure 5. Average Water Age – Reclaimed Water Irrigation
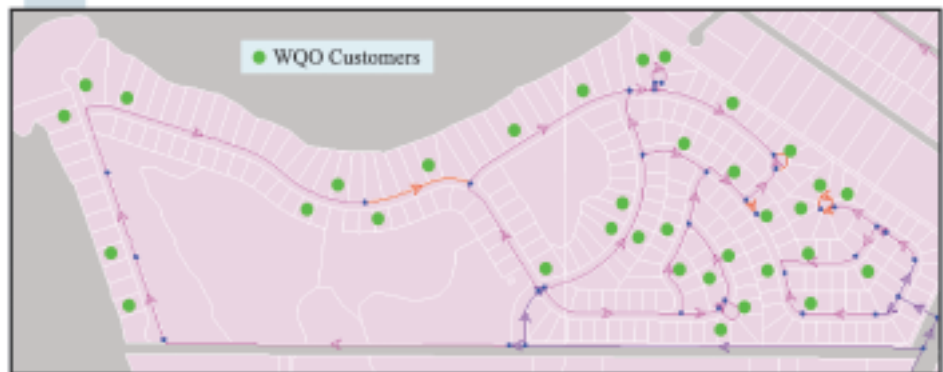

Figure 6. Average Water Age – Reclaimed Water Irrigation w/ the WQO Concept

Color Coding Legend
Pipe: Age
(Calculated) (hours)

<= 0		<= 72	
<= 24		<= 95	
<= 48		<= 500	

Table 4. Revenue Comparison – per 240-Home Neighborhood

Item	No Reclaimed Water $/year	Full Reclaimed Water $/year	WQO Approach $/year
Potable Water Lost	35,040	35,040	35,040
Potable Irrigation	78,840		7,665
Reclaimed Water	-	30,660	30,660
Lost Flushing Revenue	-	(15,330)	-
Total	113,880	50,370	73,365
Difference	-	-	22,995

WQO= Water Quality Optimize-Max Revenue
Key Assumption: Lost reclaimed water revenue is recovered via customer expansion elsewhere.

Table 5. Revenue Comparison – per 10-mgd Utility

Item	No Reclaimed Water $/year	Full Reclaimed Water $/year	WQO Approach $/year
Potable Water Lost	876,000	876,000	876,000
Potable Irrigation	1,971,000	-	191,625
Reclaimed Water	-	766,500	766,500
Lost Flushing Revenue	-	(383,250)	-
Total	2,847,000	1,259,250	1,834,125
Difference	-	-	574,875

WQO= Water Quality Optimize-Max Revenue
Key Assumptions:
· 10-million-gallons-per-day average annual flow utility.
· 30 percent of total demand are customers that have inground irrigation systems and would be served reclaimed water.
· Lost reclaimed water revenue is recovered via customer expansion elsewhere.

and political cooperation, and support will be required to implement this class; the issue will create a challenge.

One advantage of the WQO concept is that no capital expense is required, other than the switching a homeowner's irrigation system connection back to the potable water meter. The meter switch would be performed in accordance with the utility's service connection policies and cross connection control plan per provisions of Chapter 62-555.360 of the Florida Administrative Code. If the customer's existing water meter were utilized, a declining block rate could be applied so the WQO customer would be charged a lower rate for the irrigation use, similar to the reclaimed water rate; therefore, the WQO customer would not see a higher rate impact.

Conclusions

Water quality issues are especially prevalent for chloramines disinfectant systems. To mitigate water quality issues in chloramines systems, utilities are flushing large quantities of water to help reduce water age, creating public opposition—especially during drought conditions, when reclaimed water supplies are low.

The novel approach introduced in this article uses water quality modeling to identify problem areas and design alternate demand uses to reduce system water age. Information will be provided to help implement these alternate demand uses.

Flushing quantities will be optimized and revenue will be realized for a significant part of former flushing quantities. Water age in the potable water system will be optimized based on using the water quality model to relocate, pinpoint, and optimize reduced flushing quantities. An added benefit is more reclaimed water supply for additional customers. Conclusions from a theoretical standpoint include:
1. Implementation of reclaimed water irrigation in a neighborhood can increase potable water distribution water age on the order of 100 percent.
2. Increased water age can result in regulatory compliance and public safety issues with chlorine residual, DBPs, and customer satisfaction in the form of nitrification or pipe wall re-equilibration.
3. High water age has been implicated as a major factor in the occurrence of nitrification in water distribution systems (AWWA, 2006)
4. Utilities should assess disinfectant decay, DBP formation and nitrification to set maximum water age targets in their potable water distribution systems.
5. Utilities should re-assess potable water distribution pipe sizing in areas that will be served with reclaimed water irrigation.
6. The WQO concept could provide significant positive revenue impacts in the form of captured flushing water revenue and potable water flushing savings.
7. The WQO concept would also produce a net reclaimed water savings which would free up capacity for new customers and produce an additional potable water savings.
8. The WQO concept would also help minimize public relations issues associated with flushing a potable water system during drought and water restriction periods.
9. Implementation issues will occur in the form of legal and regulatory classification of a new class of water customer. These challenges can be overcome with legal, engineering, regulatory and political support.

While the WQO concept is preliminary in nature, a cursory evaluation demonstrates that there is merit to a holistic water demand management approach that could include outside-the-box ideas such as this. The WQO concept could play an important role in enhancing the symbiotic relationship of potable and reclaimed water supplies in a future world of integrated water resource management.

References

· John Riera, 2006. City of St. Petersburg's Flushing Program. Distribution System Water Loss Control and Systems Maintenance Workshop, Florida Section American Water Works Association, July 25, 2006.
· Tony Reed, 2006. System Maintenance Flushing Program Challenges – Pinellas County Utilities. Distribution System Water Loss Control and Systems Maintenance Workshop, Florida Section American Water Works Association, July 25, 2006.
· AWWA Manual of Water Supply Practices – M56. Fundamentals and Control of Nitrification in Chloraminated Drinking Water Distribution Systems. First edition. American Water Works Association, 2006. ⬦