



American Water Works
Association

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Critical Control Points for Monitoring Chlorine Residual



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Outline

- Role of disinfectant residual as an optimization parameter
- Partnership for Safe Water optimized sampling locations, parameters, and techniques



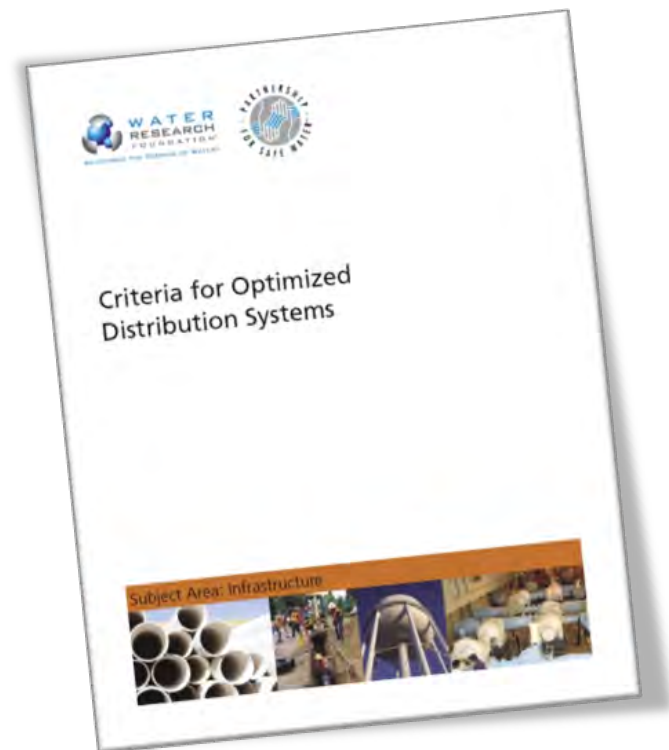
Partnership for Safe Water

- Optimization program for surface water treatment plants and distribution systems.
- Follows Composite Correction Program approach to help utilities:
 - Establish goals
 - Assess performance
 - Develop action plan to achieve optimization



PfSW - Key Distribution System Monitoring Parameters

- **Disinfectant residual**
 - *Water quality integrity*
- **Main break frequency**
 - *Physical integrity*
- **Pressure management**
 - *Hydraulic integrity*



Identified in WRF 4109 – Criteria for Optimized Distribution Systems



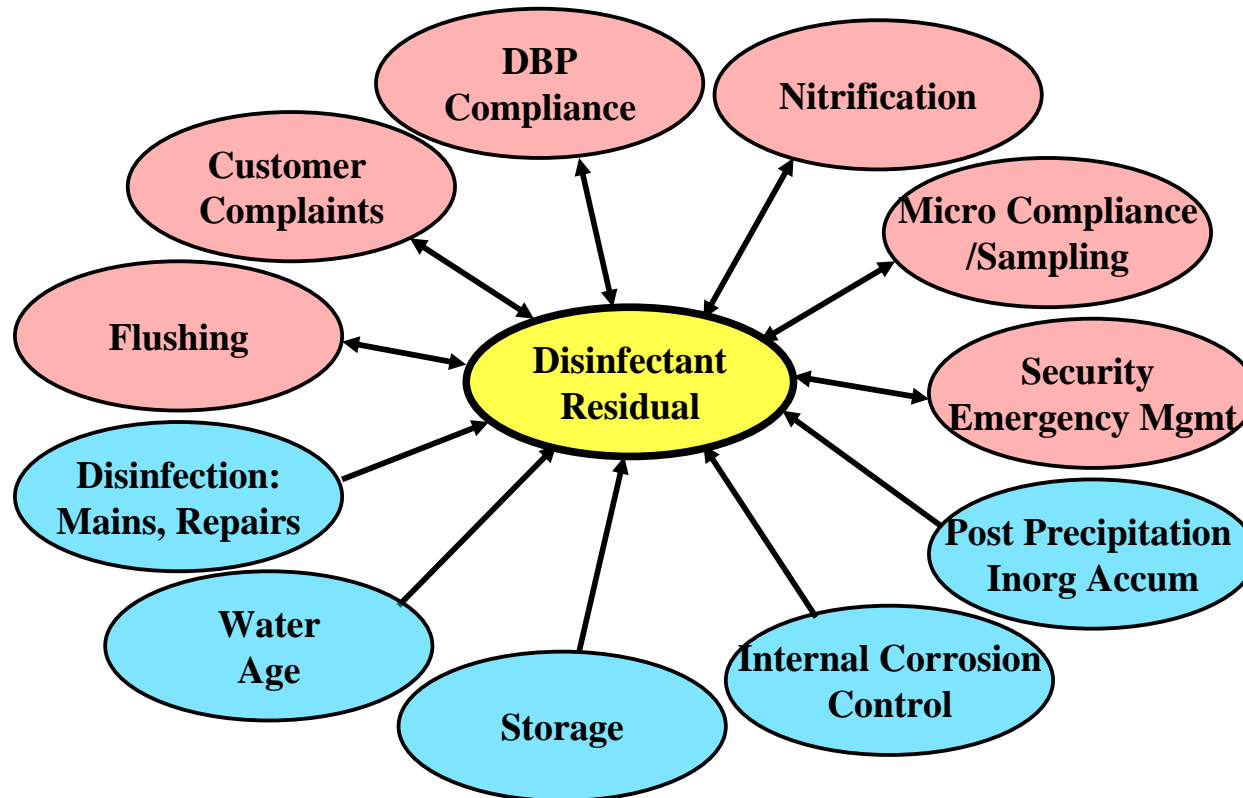
PfSW - Distribution System

Performance Improvement Variables

- Disinfectant Residual
- Cross-Connection Control
- Customer Complaints
- DBP Control
- Energy Management
- External Corrosion Control
- Flushing
- Hydrant and Valve Maintenance
- Internal Corrosion Control
- Main Breaks
- Nitrification
- Pipe Rehabilitation and Replacement
- Inorganic Accumulation Control
- Pressure Management
- Security and Online Monitoring
- Storage Tank O&M
- Water Age Management
- Water Loss Control
- Water Sampling and Response



Influence Diagram: Disinfectant Residual



Phase III – Self-Assessment Data

Self-Assessment Data Requirements

Minimum daily disinfectant residual for 12 months at distribution system routine sample locations, storage tanks, and entry points. Use Data Collection Software provided by the PSW.

All TTHM and HAA5 routine test results for 12 months. Annual DBP trending indicating RAA. Use PSW software.

Daily minimum pressure readings from permanent sensors for the most recent 12 months – ideally at 2 locations in each pressure zone (low and high). Use PSW software.

Main break records for several years – 10 years is ideal. Use PSW software.

Records of the annual number of technical water quality complaints. Record of the number of accounts for the utility.

Flushing velocity, disinfectant residual (before and after), for procedures that are initiated to correct low disinfectant residuals.

Valve and hydrant exercise (inspection) records with the total number in the system and the number exercised annually.

Hydrant repair record and calculated time to restore service after detection.

Internal corrosion testing practices with the number of tests performed annually.

Free ammonia, nitrate, nitrite, results summary for distribution systems using chloramines.

Phase III - Self-Assessment Data

Self-Assessment Data Requirements (Continued)

Pipeline renewal and replacement rate. The annual miles of pipeline replaced and the miles of pipe in the entire distribution system. The miles of unlined metal pipe and the miles replaced. The miles of pipe more than 75 years old.

Storage tank cleaning records that show the frequency and any observations

Water age records at key sites demonstrating the annual maximum water age

Calculation of the volume of annual real losses, real losses expressed as gallons/service connections/day, and ILI using the AWWA/IWA water audit method.

Distribution system schematic (map)

Asset inventory

Distribution system pipeline type inventory and installation dates

Storage facility type and installation dates

Pump type, size, and installation dates

Valve and hydrant number and installation dates

Calculations for the following benchmarks (reporting is optional): debt ratio, O&M cost per account, system renewal rate, training hours per employee, interest % of budget

Phase III: Example Questions

Disinfectant Residual

Self-Assessment Category	Questions for Gauging Optimization Status
Individual Site Testing	Does the utility have a system sampling map? Are sample collection sites representative of the overall distribution system? Does the utility track sites that repeatedly have low disinfectant residuals? Are performance improvement variables (chapter 3) used to reduce low residual recurrence? Are non-routine low residual sites added to the next year's routine sample location schedule? Are there any consecutive disinfectant residual measurements at optimized routine sample locations below the residual goals?
Residual Test Methods and Procedures	Is disinfectant residual testing performed using approved methods and digital testing equipment? Are values recorded to two decimal places? Are there on-line continuous monitors in use throughout the distribution system? Is data collected and continuously displayed for operators by the SCADA system?
Chlorine and Chloramine Interaction	Does the system monitor and operate to minimize odors and other interaction by-products? Is free ammonia monitored where interaction may cause breakpoint issues?



Performance Goals: Disinfectant Residual

- Disinfectant Residual (>95% of meas.)
 - Free Chlorine: ≥ 0.20 and ≤ 4.0 mg/L
 - Total Chlorine: ≥ 0.50 and ≤ 4.0 mg/L
- No *consecutive* residual measurements outside target concentrations at optimized routine sample locations
- DBPs within regulatory requirements



What are Optimized Routine Sample Locations?

- Routine/regulatory sampling locations
- Locations with opportunities for improvement
- High risk sampling locations
 - Locations at a high risk of exhibiting low chlorine residual concentrations, microbial growth, or nitrification

Partnership for Safe Water systems rank the optimization of sampling locations on a scale of 1-5.



Disinfectant Sampling Locations

- Optimized (high-risk) locations include:
 - Finished water entry points and metering points to other systems
 - Stage 1 and/or Stage 2 DBP sites
 - IDSE or IDSE-type sites
 - Downstream of storage facilities
 - Upstream/downstream of boosters
 - Low flow areas
 - Unlined cast iron mains
 - High HRT areas/other concerns
 - Potential areas of mixing



Disinfectant Sampling Locations

- Special studies may identify opportunities for additional sampling
 - Deeper dive into a specific problem applying scientific method
- Special study application examples
 - Low residual area
 - Storage tank water quality
 - Determination of sampling frequency

TOPIC DEVELOPMENT SHEET	
Topic / Issue:	
Benefits:	
Possible Obstacles:	Possible Solutions:
Action Steps:*	



Site Selection

- **Sample quality**
- **Data quality**
- Coverage of system (map sites)
- Practicality
- Availability of power, communications, drain (if needed)
- Maintenance concerns

Document how and why sample sites are selected.
Software tool provided with WRF 4109 can help with site selection.



Parameters

- **Free Chlorine**
- **Total Chlorine** and chloramine-related parameters
 - Free and total ammonia, nitrite, nitrate
 - Monochloramine, total chlorine
- DBPs
- HPC
- pH
- Site-specific parameters
- **Grab samples or online analyzers?**



Sampling Frequency

- How often should samples be collected?
 - Weekly
 - Bi-weekly
 - Monthly
 - Continuously
- Sufficient to reflect system performance under normal conditions and establish trends



Data Handling and Analysis

- Summarize data in Partnership data collection spreadsheets or similar summary tool to identify trends

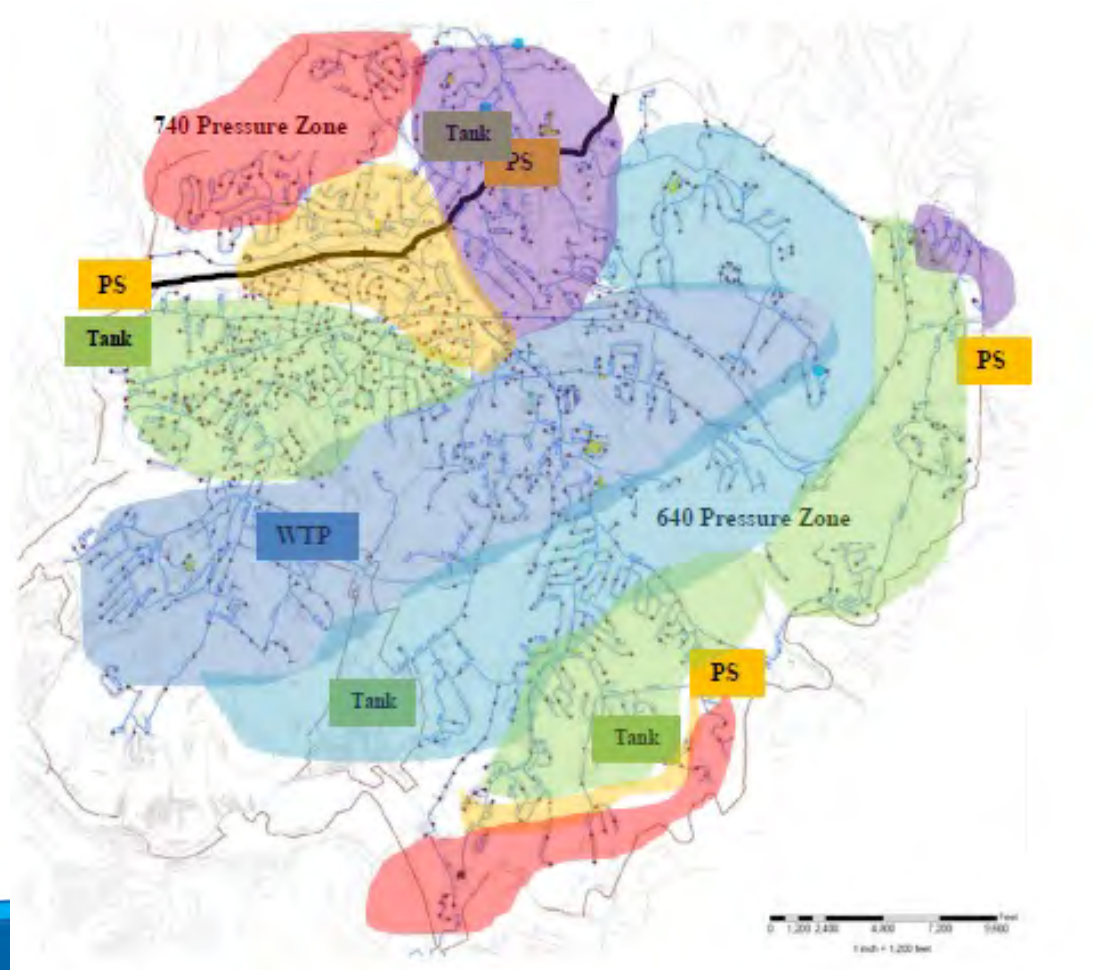
Secondary Residual Disinfectant- free chlorine or total chlorine or chlorine dioxide
 Applicable Routine Sample Goals- free chlorine ≥ 0.20 mg/L and ≤ 4.0 mg/L, total chlorine ≥ 0.50 mg/L and ≤ 4.0 mg/L, mg/L
 chlorine dioxide ≥ 0.20 mg/L and ≤ 0.80 mg/L

	Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Entry Points Residual Average (mg/L)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Number of Routine Samples	730	62	56	62	60	62	60	62	62	60	62	60	62
Number of Routine Test Results Not meeting Goals	3	3	0	0	0	0	0	0	0	0	0	0	0
% Routine Test Results Not Meeting Goals	0.41	4.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum Daily Residual Value (mg/L)	0.18	0.18	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Number of repeat non-conforming sites	0	0	0	0	0	0	0	0	0	0	0	0	0
TTHM Maximum ($\mu\text{g/L}$)													
HAA5 Maximum ($\mu\text{g/L}$)													



Data Handling and Analysis

- Chlorine residual mapping



Data Handling and Analysis

- Data correlation – can the root cause of low disinfectant residual be correlated with:
 - Cross connection
 - Main breaks
 - Water age
 - Customer complaints
 - Biofilm/sediment accumulation
 - Pipe material
 - Blending of free chlorine/chloraminated water



Next Steps/Action Planning

- Sites and/or sample frequency may change based on the information collected through routine sampling and special studies
- Data sufficiency may be addressed in the action planning process
- Disinfectant data can help optimization efforts in other areas of self-assessment



Questions?

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