Microbial and Disinfection Byproducts
Rule Revisions Working Group

Meeting 6: January 24, 2023, 11:00am-6:00pm ET

EPA

OFFICE OF GROUND WATER
AND DRINKING WATER

WELCOME

Rob Greenwood, Ross Strategic

Elizabeth Corr, DFO, U.S.EPA OGWDW

U.S. EPA OGWDW

OPENING REMARKS

Lisa Daniels & Andy Kricun, WG Co-Chairs

Segment 1: Agenda Review & Meeting Procedures

Rob Greenwood, Ross Strategic

Today's Virtual Meeting: Zoom Controls

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Public Attendees

- You are in listen only mode and will not be able to unmute. If you are having audio difficulties send an email to **taner.durusu@cadmusgroup.com**
- Any comments you may have can be sent to **MDBPRevisions@epa.gov** or to Public Docket: www.regulations.gov / Docket ID Number: EPA-HQ-OW-2020-0486

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Today's Agenda

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11:00-12:15	• Segment 1: Agenda Review and Meeting Procedures • Segment 2: Follow up on Problem Characterization Discussions Related to Environmental Justice.
	15 Minute Break (12:15-12:30 pm ET)
12:30-1:45	• Segment 3: Problem Characterization Relevant to MDBP Implementation and Compliance Challenges
	60 Minute Lunch Break (1:45-2:45 pm ET)
2:45-4:30	• Segment 4: Synthesis of OP and DBP Data and Analysis, and Preliminary Findings for Problem Characterization
	15 Minute Break (4:30-4:45 pm ET)
4:45-6:00	• Segment 4 continued • Segment 5: Meeting 7 Agenda & Next Steps

Segment 2:Follow up on Problem Characterization Discussions Related to Environmental Justice

Presentation, Technical Panel, and Facilitated Discussion

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Problem Characterization on OP, Residuals, and DBPs: Follow up Information

- Technical analysts who provided input to the responses on the following slides
  - Mark LeChevallier – Dr. Water Consulting LLC. Formerly with American Water
  - Shawn McElmurry – Wayne State University
  - Andrew Jacque – Water Quality Investigations
  - Chad Seidel - Corona Environmental Consulting
  - Zaid Chowdhury – Garver
  - Scott Summers - (University of Colorado - Boulder)
  - Chris Owen – Hazen and Sawyer

Problem Characterization on OP, Residuals, and DBPs: Follow up Information

- How are monitoring sites selected?
  - Disinfectant residual monitoring sites are linked to RTCR monitoring sites. For RTCR sites, they should be representative of the DS. Utilities often use maps of the system to choose transects that cover representative sites. The number of samples depends on the population (about 1 sample site for every 1,000 people). The final sampling plan must be reviewed and approved by the primacy agency. For systems with multiple pressure zones, at least one site per pressure zone may be required by the primacy agency.
    - Maps may not be commonly shared between systems and regulators.
  - RTCR monitoring sites need to be accessible to the sampler, so typically sample locations are from buildings that are open during business hours. Since repeat samples need to be collected within 5 service connections upstream and downstream of the original site, most sampling plans are limited to commercial areas where buildings are accessible.
    - Monitoring in buildings may not represent water quality in DS under utility control if proper sampling procedures are not followed.

Problem Characterization on OP, Residuals, and DBPs: Follow up Information

• How are monitoring sites selected (cont.)?

- Some systems use hydraulic models to help identify monitoring sites, but this may be not be feasible for systems with limited resources.
- For DBPs, sample sites are based on population served and what's known about the relative water age. This is described in the EPA Stage 2 D/DBPR guidance.
- For residential areas and other areas of the system where access to public buildings is problematic, some systems will install dedicated sampling stations that are plumbed directly to the distribution system mains.
  - Use of dedicated sampling stations can create the potential for the sample site to not be representative of first draw water that a consumer would see, which could affect the monitoring results reported.
- Site selection may be skewed toward familiar sample site locations.

Problem Characterization on OP, Residuals, and DBPs: Follow up Information

What are some of the implementation challenges for disadvantaged communities?

- Many challenges may exist, depending on the community. These slides describe only a few.
- Different challenges may exist for situations where the entire system serves disadvantaged populations versus a system where a relatively small proportion of the system serves a disadvantaged community.
  - Those with higher proportions of disadvantaged customers may have more limited resources (e.g., maintain the system, retain qualified personnel).
- For example, several large water systems in CA have a customer assistance program (CAP) for people having difficulty paying their water bills. Due to specific state laws, general ratepayer funds cannot be used to fund the CAP. Therefore, other revenue sources must be found.

Problem Characterization on OP, Residuals, and DBPs: Follow up Information

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• What are some of the implementation challenges for disadvantaged communities (cont.)?

- Some communities may experience significant economic changes which alter water demand (e.g., the loss of major industry) and in turn change system hydraulics. Despite these changes, sampling locations are rarely updated. As a result, communities that have experienced these changes may have water quality that is not adequately characterized by historical sampling locations.
    - Areas of lower water usage and higher water age may have degraded water quality and the potential for water quality violations. Sample locations with a high perceived potential for a water quality violation may be avoided by some utilities.
- In areas experiencing significant economic changes and/or where community trust in their public water systems may be lacking, it can be hard to find reliable access to monitoring sites.

Problem Characterization on OP, Residuals, and DBPs: Follow up Information

- ## What capacity limitations exist for disadvantaged communities?
  - Many capacity limitations may exist and they often relate to technical, managerial, and financial capacity. This slide presents only a few.
  - Some disadvantaged communities may be in proximity to sources of pollution without options to switch their source water. These issues of impaired source waters likely compound existing issues of regulatory noncompliance.
  - Some disadvantaged communities (disadvantaged at system level rather than localities within a system) may lack financial resources to make capital improvements and hire additional staff. As a result, they may not be able to meet the regulatory requirements and locate sample sites as well as collect samples that appropriately represent the full distribution system.
  - Lack of hydraulic models to aid in site selection.

Panel & Facilitated Discussion

- Mark LeChevallier
- Shawn McElmurry
- Chris Owen

Facilitated Discussion

- Clarifying questions.
- What additional Environmental Justice (EJ) considerations within the specific context of the MDBP rules are important to acknowledge?
- What are the predominant components of the MDBP rules that present opportunities to mitigate underlying EJ concerns?
- What communities can EPA look to as case studies of potential EJ concerns related to the MDBP rules?

15 Minute Break

12:15-12:30 pm ET

Segment 3: Problem Characterization Relevant to MDBP Implementation and Compliance Challenges

Presentations, Facilitated Discussion

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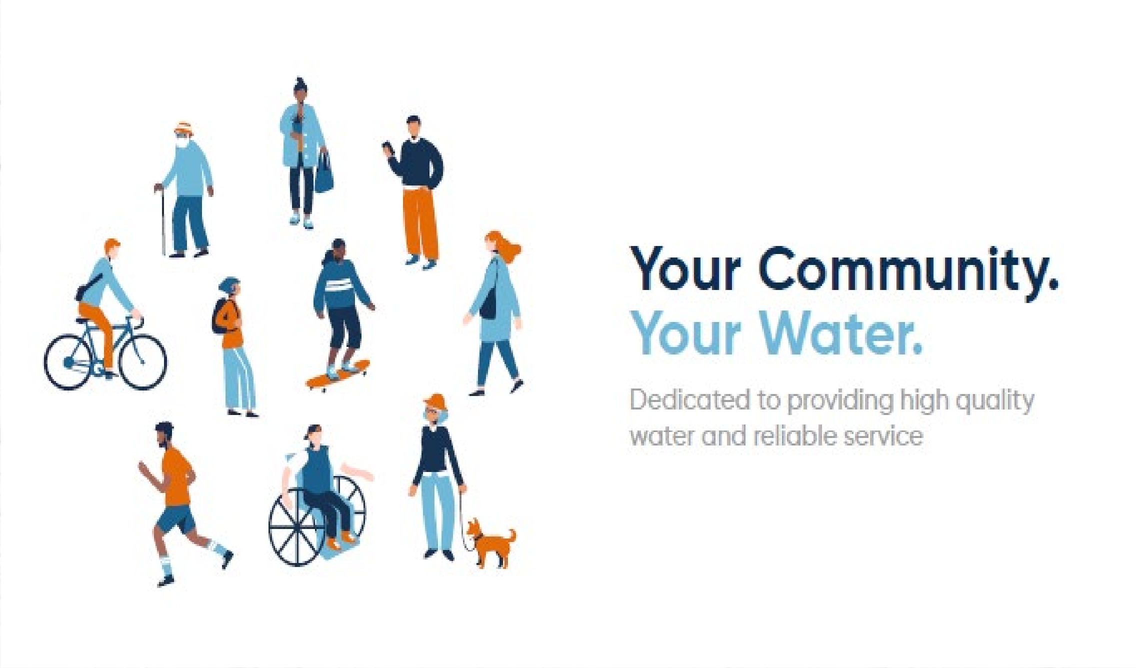
Large System Perspective MDBP Working Group Presentation January 24, 2023

SMCMUA
SOUTHEAST MORRIS COUNTY MUNICIPAL UTILITIES AUTHORITY

Laura Cummings, PE, Executive Director
Drew Saskowitz, LOR, Water Quality Superintendent

Agenda

- Challenges
- State Requirements and Initiatives
- SMCMUA
  - System Overview
  - Existing and Planned New Unit Treatment Processes
- Consecutive Systems
- Finished Water Quality



Challenges

- Risk and Resilience
  - Public Health
  - Public Safety
  - Natural Hazards
  - Cyber Security
  - Threats – Physical, etc.
  - Asset Management
- Water Rates
  - Full Life-Cycle Costs
- Staffing
- Feasibility Studies
  - Simultaneous Compliance for New Unit Treatment Process
  - Full Life-Cycle Cost Analyses

State Requirements and Initiatives

State Legislature

- S1006 – *Legionella*
  - 0.3 mg/L Free Chlorine
  - Building Water Management

New Jersey DEP

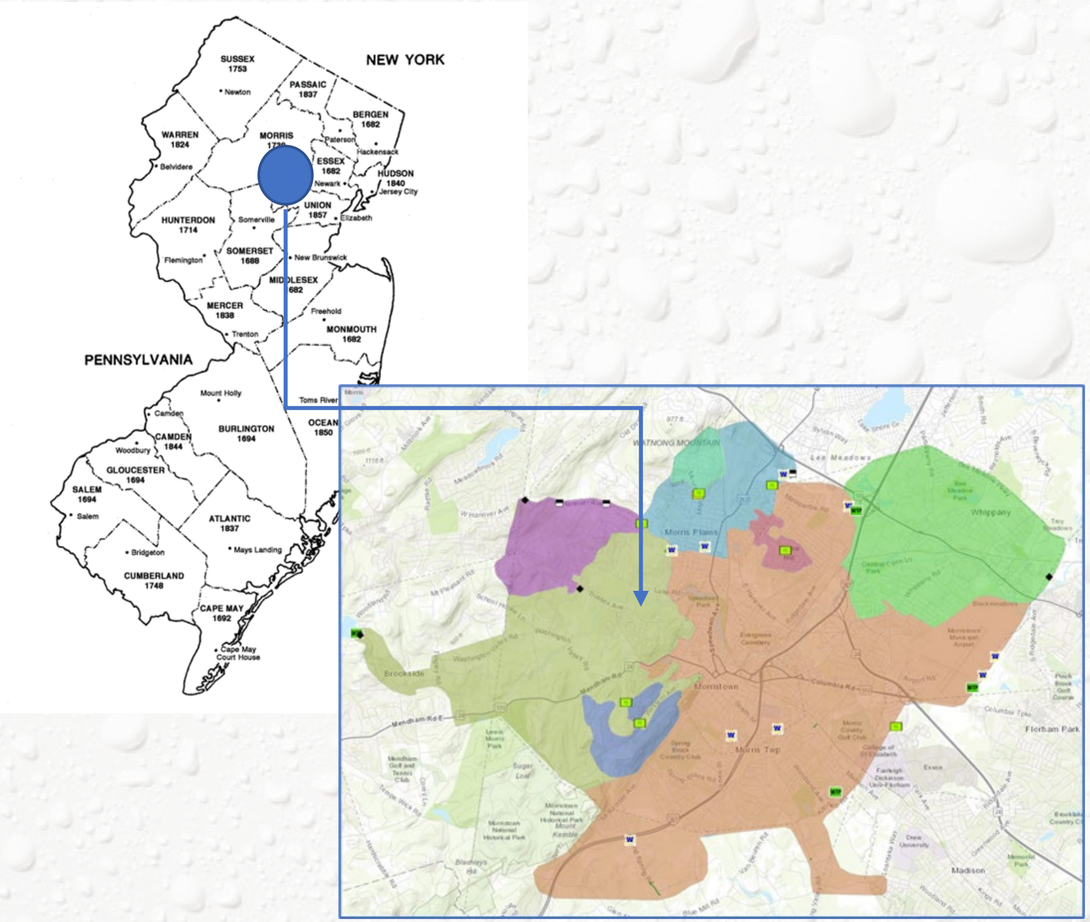
- Disinfection
  - Groundwater – Minimum of 5 min Chlorine or 30 min Combined Chlorine Contact Time
  - Surfacewater – Minimum of 30 min Free Chlorine Contact Time
- PFOA, PFOS & PFNA
- Lead Service Line Replacements – 2031/2036

Drinking Water Quality Institute

- 1,4 Dioxane

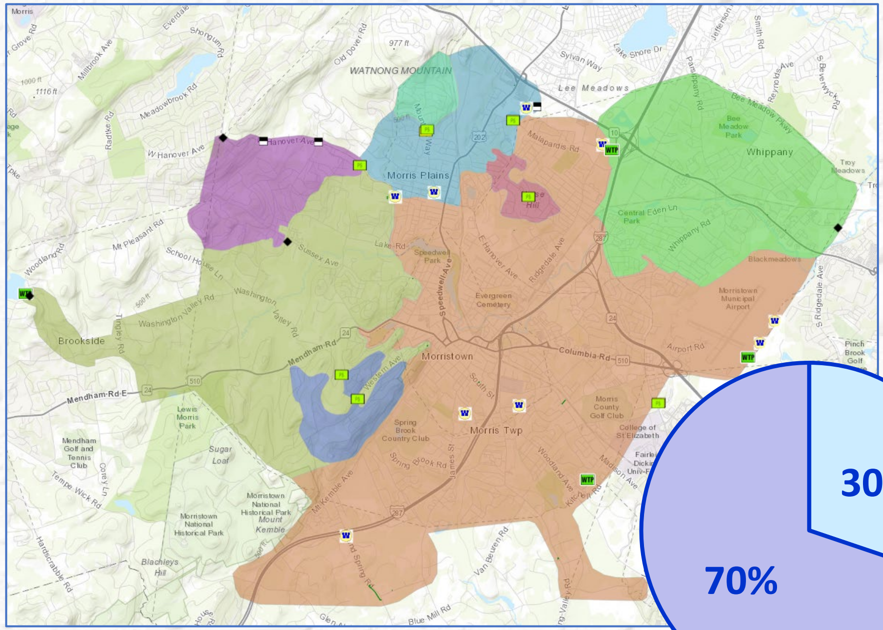
Board of Education - Lead Testing in Schools

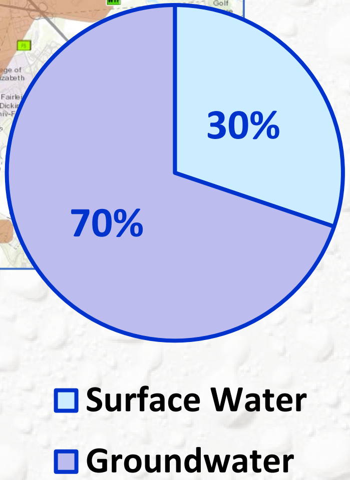
Service Area – Morris County NJ - Complex Water Supply



- 8 MGD Avg/16 MGD Peak
- 65,000 Population
- 17,500 Service Connections
- 38 Sq. Miles
  - 600’ Change in Elevation
  - 8 Hydraulic Gradients
    - 10 Inter-Gradient Transfer Locations
- 15 Water Storage Tanks
- 340 miles of Main

Source Water - 12 Sources Groundwater and/or Surface Water





- Owned
  - Reservoir
  - Nine (9) Wells
- Purchased
  - Passaic Valley Water Commission
    - 2 Points of Entry
    - PVWC, Advanced WTP – River and/or Reservoir *"and/or"*
    - North Jersey District Water Supply Commission, Conventional WTP – Reservoir
  - Morris County MUA
    - One Point of Entry
    - Groundwater

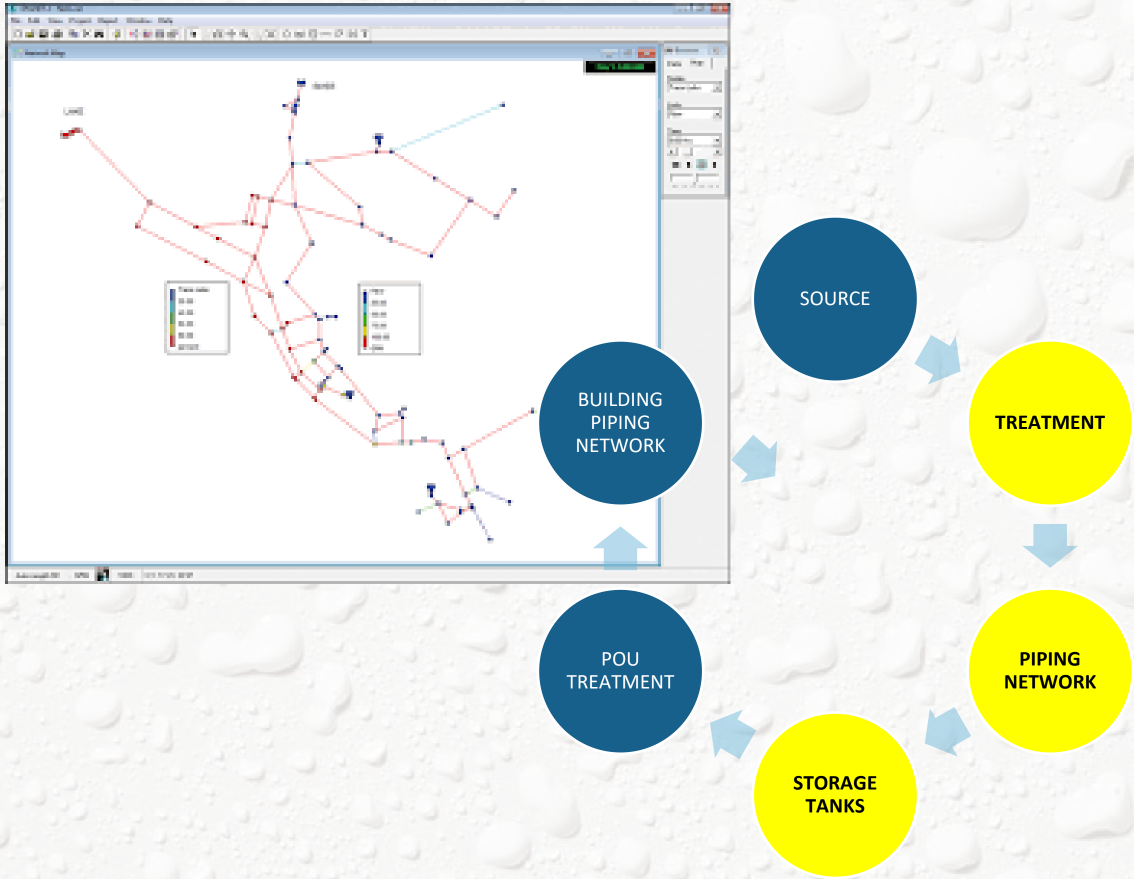
Owned Reservoir Supply

Treatment Goals		Feasibility Study	Design Completed
Reduce Manganese at Intake	-	Relocate WTP Recycle Stream	
Improve Manganese Oxidation	Improve Algal Control	Add New Hypolimnetic Aeration	
Cyanotoxin Removal	Taste and Odor Control	Add GAC Adsorber Capacity	
Reduce DBP Precursors Stage 2 DBPs	-	Optimize Existing or Add New Unit Treatment Process	
Improve Primary Disinfection	-	Increase Free Chlorine Contact Time	
Reduce Corrosivity		-	pH control and Corrosion Inhibitor
PFAS	-	No NJDEP/X EPA @ Det Limit	

Owned Groundwater Wells

Well	Existing Treatment				Feasibility Study		
#	Manganese	VOCs	Corrosion Control	Secondary Free Chlorine Disinfection	Hardness	PFAS NJ / EPA @ Detection Limit	1,4 Dioxane DWQI NJ / EPA
1	-	-	X	X	-	No / X	No / TBD
2	-	-	X	X	-	X / X	No / TBD
3	-	-	X	X	X	X / X	No / TBD
4	-	-	X	X	X	No / X	No / TBD
5	-	-	X	X	-	X / X	No / TBD
6	X	-	X	X	X	No / X	No / TBD
7	-	X	X	X	X	No / X	X / TBD
8 & 9	X	X	X	X	X	No / X	X / TBD

System Overview: Finished Water Disinfectant Residual



- Define Design Point
  - 0.3 mg/L Free NJ or
  - 0.2 mg/L EPA
- Upgrade or Design New UTPs
  - POE and Booster
- Water Storage Tank
  - Improve Mixing
- Reduce Water Age
  - Water Storage – Impact Fire Demand
  - Flushing – Conservation, Allocation and Lost Revenue

Consecutive Systems – SMCMUA Point-of-Entry Treatment

Purchased Supply	Treatment Goals	Under Construction
Morris County MUA Finished Groundwater Source (Wholesale System)	-	-
-	Reduce Corrosivity	Corrosion Inhibitor
-	Improve Distribution Free Chlorine	Booster Chlorination
-	-	-
-	-	-
-	-	-

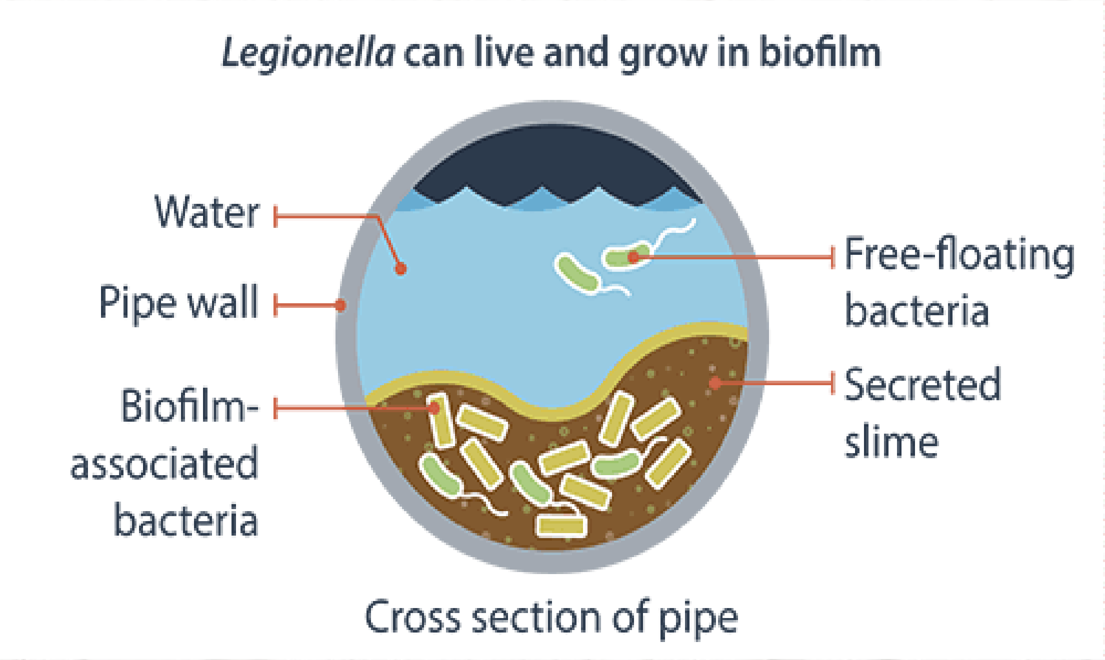
Consecutive Systems – SMCMUA Point-of-Entry Treatment

Purchased Supply	Treatment Goals and Unit Treatment Processes	
Passaic Valley Water Commission – Retail and Bulk Supplier	Two (2) Points of Entry	
-	Either, or a Blend, of Two (2) Finished Surface Water Sources	
PVWC Water Treatment Plant	-	**Feasibility Study**
NJDWSC Water Treatment Plant (Wholesale System)	Reduce DBPs	
-	Reduce Taste and Odor	
Combined	Booster Chlorination	

Concepts for Consecutive System Monitoring at Point of Entry

- Wholesale/Bulk Suppliers
  - DBP and disinfectant residual monitoring at all Points-of-Entry (POE) for contracted customers, i.e.
  - Modified DBP Operational Evaluation Level (OEL)
    - If OEL >80% of MCL
    - Supplier Treatment process evaluation
    - Consecutive system operational evaluation
  - Point of Entry disinfectant residual >= Required Minimum, i.e. 0.2 mg/L, 0.3 mg/L
    - Booster disinfection would be required by purchaser

Building Water Management



https://www.cdc.gov/legionella/wmp/overview/growth-and-spread.html

- New Jersey S1006
  - Applies to certain health care facilities and buildings, including if 10 or more stories high
  - Requires written program compliant with ASHRAE Standard 188-2018 or comparable
  - *Legionella* Testing Requirements
  - DOH, DEP and DCA Annual Report to the Governor
  - DOH public awareness campaign

Challenges

- SDWA Simultaneous Compliance
- Design points
  - Similar unit treatment processes used for the same or different purposes (i.e. GAC for PFAS removal or DBP precursor reduction) and on different compliance schedules
  - Differing State and Federal regulations
- Regulatory compliance schedules
  - Provide time for design, construction and implementation and stakeholder communications
- Consecutive Systems –POE Monitoring
- Full life-cycle cost analyses
- Staffing

Discussion

Small and Rural Water System
MDBP Regulation Implementation Challenges

NDWAC MDBP Working Group Meeting 6, Segment 3

January 24, 2023

Presentation Topics

- System characteristics that contribute to implementation challenges
- MDBP Rule features that are particularly challenging
- Treatment techniques that complicate compliance efforts
- Economic/market factors affecting implementation

System Characteristics – Rural Water Systems

- Low customer density
  - Can be one customer per square mile – many miles of pipe to serve a few customers
  - “Size” can range between “small” and “large”
- Multiple Water Sources
  - Substantial differences in water chemistry
- Branched distribution system
  - Long water age that leads to disinfectant residual decay, disinfectant by-production formation and increased risk for opportunistic organism growth
- Consecutive systems
  - Many do not provide additional treatment
  - Water quality that is MDBP compliant at the delivery point can become non-compliant with additional age in the consecutive system

System Characteristics – Small Water Systems

- Low customer population
  - BAT is in many cases not affordable
- Old infrastructure
  - Deterioration leads to water quality issues that contribute disinfectant residual demand
- Difficult to employ qualified operator
  - Major effort to “collect samples” and minimal reporting
  - O&M is frequently ignored
- Site-specific nature of water sources
  - Ground water vs. surface water is a geographic feature
  - Ground water contains a combination of organic matter, naturally occurring ammonia and inorganic contaminants that complicates MDBP treatment
  - Ground water systems are having issues – not just surface water.

Challenging MDBP Rule Features

- Treatment techniques to minimize DBP cause water quality issues
  - Difficult to hold a sufficient chloramine residual that prevents microorganism growth
  - Chloraminated water can nitrify in premise plumbing, depressing pH and cause corrosion
- Disinfection treatment techniques cause water quality issues
  - Simple chlorination of a well is not so simple!
  - Ammonia and organic matter in ground water can cause complex operational issues that seem insurmountable to a small system operator.
- Consecutive system challenges
  - Many consecutive systems are small – they connected to the wholesaler as a way to obtain a reliable source of water without needing to treat it
  - DBP Rule compliance remains a significant concern – depend on the good graces of the wholesaler to treat water to achieve DBP Rule compliance in the consecutive system

Treatment Techniques that Complicate Compliance Efforts

- Chloramination
  - Fear that unknown or unregulated chloramination DBPs will eliminate this option as a DBP control technique
  - Difficult for small system operators to implement successful chloramination
- BATs for disinfection or organic removal to minimize DBPs
  - In many cases are not cost effective/efficient or affordable for small systems

Economic/Market Factors Affecting Implementation

- Supply chain issues
  - Treatment chemicals – who is defending the supply chain? Will vendors drop small systems?
  - More difficult to get replacement parts, or equipment is not supported.
- Small systems
  - Many are in economically disadvantaged communities
  - Cannot financially support operations
  - Cannot afford escalating maintenance or capital improvement costs
- “one-size fits all” MDBP MCLs
  - Small systems not “convinced” that their system compliance needs are the same as large systems

Facilitated Discussion

- Clarifying questions
- Do you have additions or refinements to characterization of implementation challenges?
- What additional information will be helpful to further understand implementation challenges?
- Within the drinking water value chain, what do you believe are the most prominent root causes of implementation challenges?

60 Minute Lunch Break

1:45-2:45 pm ET

MDBP Problem Characterization (Topics 1-5) [DRAFT]

Presented By Facilitators

January 24, 2023
MDBP WG Meeting 6

Meeting 6 Problem Characterization Topics
Topic 1: Drinking water system pathogen-related public health impacts – evidence and root causes related to water quality conditions in distribution systems and their relationship to outbreaks/illness. (NDWAC charge areas 1, 2)
Topic 2: Premise plumbing pathogen-related public health impacts – evidence and root causes related to water quality conditions in premise plumbing and their relationship to pathogen-related outbreaks/illness. (NDWAC charge areas 1, 2)
Topic 3: Distribution system water quality conditions related to pathogens – evidence and root causes of variable conditions and related vulnerabilities within the distribution system. (NDWAC charge areas 1, 2)

Meeting 6 Problem Characterization Topics

Topic 4: Drinking water system DBP-related public health impacts – evidence and root causes related to DBPs in drinking water and their relationship to public health risks. (NDWAC charge areas 1, 2)

Topic 5: Distribution system water quality conditions related to DBP formation – evidence and root causes of the occurrence of DBPs in drinking water. (NDWAC charge areas 1, 2)

Topic 1: Drinking water system pathogen-related public health impacts – evidence and root causes related to water quality conditions in distribution systems and their relationship to outbreaks/illness. (NDWAC charge areas 1, 2)

- Waterborne-related disease from all water exposures has been steadily increasing.
  - Each year 7.2 million people get sick, 120,000 people are hospitalized, and 7,000 die from waterborne disease. The contribution of drinking water to the total burden of all water sources is unknown. (1)
  - Cases of Legionnaires' Disease (LD) and Non-tuberculous *Mycobacteria* (NTM) disease each showed an increasing trend for the years covered (exception in 2020 for LD). (2)
    - Reported LD outbreaks have increased nearly nine times since 2000 (585 outbreaks 2001-2020 with 3,770 illnesses, 1,954 hospitalizations, and 250 deaths).(3)
    - Collier et al. (2021) estimated 11,000 cases of LD (995 deaths), 68,900 NTM infections (3,800 deaths), and 15,900 cases of Pseudomonas pneumonia (730 deaths) for 2014; (4) A National Academies of Science, Engineering, and Medicine committee estimate 52,000-70,000 cases of LD annually, with 3-33% being fatal. (5)
    - Cases of NTM increased by 60% from 2008-2013. This includes non-drinking water exposures, such as soil, food, and non-potable water sources.(6)
    - Geographic disparities exist, with the North and Middle Atlantic coast and Great Lakes regions having the most reported outbreaks. (7)
    - It is generally accepted that caseloads are underestimated (e.g., only 4% of LD cases are associated with outbreaks).(8)
    - LD under-diagnosed in part because it presents similarly to pneumonia.(9)
    - People with underlying conditions (e.g., lung conditions, current or former smokers) are at risk of illness, and race has been shown to be a factor in the incidence. (10)
    - Exposure is through inhalation of aerosolized water or aspiration. Aerosol-generating devices contribute to exposure risks. (11)

Topic 1: Drinking water system pathogen-related public health impacts – evidence and root causes related to water quality conditions in distribution systems and their relationship to outbreaks/illness. (NDWAC charge areas 1, 2)

- Biofilm pathogens (*Legionella*, MAC, *P. aeruginosa*) are a factor in waterborne disease, with *Legionella* being the most understood.
  - Nearly all known cases of LD from waterborne exposures caused by *L. pneumophila.(12)*
  - Biofilm pathogens associated with drinking water are known contributors to disease occurrence and account for a majority of the most severe outcomes. (13)
    - Biofilm pathogens account for 1% of overall illness from waterborne disease, but 70% of the hospitalizations and 94% of deaths attributed to waterborne disease. (13)
- Drinking water distribution system water quality has been linked to disease occurrence.
  - There have been 192 drinking water associated outbreaks* reported by CDC, with approximately 9% attributed to distribution system deficiencies.(14)
  - Distribution system water quality has been linked to at least four outbreaks of LD, with at least two of them presumptively associated with low disinfectant residuals in finished water storage tanks.**
  - LD outbreak contributing factors from a public water system were identified from distribution systems in 68/470 (14.5%), from source waters in 49/470 (10.4%), and from treatment in 45/470 (9.6%) as documented or suspected for 2015-2020 outbreaks. (15)
    - Contributing factors included low chlorine levels, aging infrastructure, contamination during main repairs, low water pressure, and high water age (15).

Topic 1: Drinking water system pathogen-related public health impacts – evidence and root causes related to water quality conditions in distribution systems and their relationship to outbreaks/illness. (NDWAC charge areas 1, 2)

- Distribution system water quality has been linked to outbreaks of LD

Flint, MI

- Inadequate Disinfectant Residual in the Distribution System Contributed to *Legionella* growth in the Flint, Michigan Legionnaire' Disease outbreak (NAS, 2020)
- Iron release contributed to loss of chlorine residual.(16)
- Iron is a required nutrient (Reeves et al., 1981; States et al., 1985; Warren and Miller, 1979), and was hypothesized to stimulate Legionella growth (Rhoads et al., 2017a).
- Multiple water parameters conducive to *L. pneumophila* persistence or growth were reported, including slightly elevated distribution water temperature, elevated organic matter, high iron concentrations, and elevated or depleted chlorine residual (Masten et al., 2016; Rhoads et al., 2017; Zahran et al., 2018).
- The outbreak is an example of the failure of treatment of the building water system and highlights the role of drinking water utilities in creating conditions conducive to *Legionella* proliferation in premise plumbing. (17)

Topic 1: Drinking water system pathogen-related public health impacts – evidence and root causes related to water quality conditions in distribution systems and their relationship to outbreaks/illness. (NDWAC charge areas 1, 2)

New Jersey (unidentified location)(18)

- During 2006-2007, two legionellosis outbreaks occurred; one at a geriatric center and the other in high-rise housing for seniors a short distance away. Additional cases occurred in smaller residential settings close by from 2003–2007. This occurred in the same area of a community water system storage tank.
- The origin of the outbreak could be the community water system. *Legionella* growth conditions were present including low chlorine residual levels in mains during warm months, stagnant water in the storage tank, and no flushing program to clear sediment from water mains.
- The five-year rate of LD in the area of the community water system near a storage tank was eight times higher than the rest of the service area and almost 20 times higher than the rest of the state.

Topic 1: Drinking water system pathogen-related public health impacts – evidence and root causes related to water quality conditions in distribution systems and their relationship to outbreaks/illness. (NDWAC charge areas 1, 2)

Trenton, NJ (https://www.nj.gov/health/news/2022/approved/20221015a.shtml)

- The presence of *Legionella* bacteria was identified in water samples collected from more than half of 30 homes within several municipalities served by Trenton Water Works (TWW), including homes from Trenton, Ewing, and parts of Lawrence and Hopewell Township served by TWW.
- The homes tested were part of an ongoing investigation to determine potential causes of Legionnaires' disease previously detected in Hamilton Township, with five cases including one death reported since December 2021.
- NJDEP found significant concerns with TWW's operations and management, including intermittent failures to fully maintain treatment processes, monitor water quality, employ adequately trained operating personnel, and invest in required maintenance and capital needs such as upgrades to aging infrastructure.

Topic 1: Drinking water system pathogen-related public health impacts – evidence and root causes related to water quality conditions in distribution systems and their relationship to outbreaks/illness. (NDWAC charge areas 1, 2)

- Free living amoeba (*Naegleria*, *Acanthamoeba*)
  - *Legionella* bacteria are ingested by some amoeba where they can multiply and become more virulent. *Legionella* bacteria are protected from disinfection within the amoeba. *Legionella* can be released from the amoeba at high numbers in the water systems or within the lungs.(19)
  - Free living amoeba can themselves cause disease through waterborne exposures.(20)
  - The State of Louisiana issued a higher required disinfectant residual requirement as a result of *Naegleria fowleri* detections in two public water supplies.(21)
- Frank pathogens (*Cryptosporidium*, *Giardia*, viruses)
  - Some ground water sources impacted by surface water may not have been characterized as ground water under direct influence of surface water (GWUDI), resulting in them being untreated and leading to potentially increased risks from frank pathogens, such as *Cryptosporidium* or *Giardia*.(22)
  - Since the implementation of the LT2SWTR, outbreaks due to *Giardia*, *Cryptosporidium* and viruses are rare and related to systems not intended as potable supplies or not compliant with existing regulations.(23)

Topic 2: Premise plumbing pathogen-related public health impacts – evidence and root causes related to water quality conditions in premise plumbing and their relationship to pathogen-related outbreaks/illness. (NDWAC charge areas 1, 2)

- Opportunistic pathogen risks in some building water systems (BWS) can be significant.
- Growth of opportunistic pathogens in BWS can and do occur under certain conditions.(24)
- Some code requirements may create conditions enabling the growth of opportunistic pathogens.(25)
- Limited regulatory oversight exists in BWS unless the BWS add treatment.(26)
- Limited resources (e.g., financial, technical capability) may contribute to opportunistic pathogen risks in BWS.(27)
- Water quality communication challenges between the municipal supplies and BWS exist.(28)
- Responsibility for water quality overall is shared, with the public supply and BWS each being responsible for their portions.(29)

Topic 2: Premise plumbing pathogen-related public health impacts – evidence and root causes related to water quality conditions in premise plumbing and their relationship to pathogen-related outbreaks/illness. (NDWAC charge areas 1, 2)

- Most outbreaks of LD have been documented as associated with building water systems (BWS).
  - 48% of all reported drinking water associated outbreaks were from *Legionella* in premise plumbing.(30)
  - Municipal supplies do not provide sterile water, so OPs in the water may grow in BWS where favorable conditions exist. Municipal supplies have no direct control over favorable conditions introduced in the BWS. (31)
- Drinking water regulatory agencies have limited oversight of BWS.
  - BWS adding treatment are considered regulated public water systems by SDWA, but implementation and enforcement varies widely among the states.
  - "Treatment" is not defined under SDWA – EPA has issued a clarification memorandum describing treatment, but state uptake and practice varies.
- Water quality can change in BWS where conditions can favor the growth of OPs, where the PWS has limited control.(32)
  - This includes water temperature, sediment and biofilm accumulation, loss of disinfectant residuals, corrosion, and high water age.
- Maintenance, operations, and management within BWS (e.g., water stagnation) can be challenging due to resource limitations.
- Some code-driven plumbing design conditions (e.g., oversized pipes) or water temperature limits can contribute to problems leading to opportunistic pathogen growth.(33(

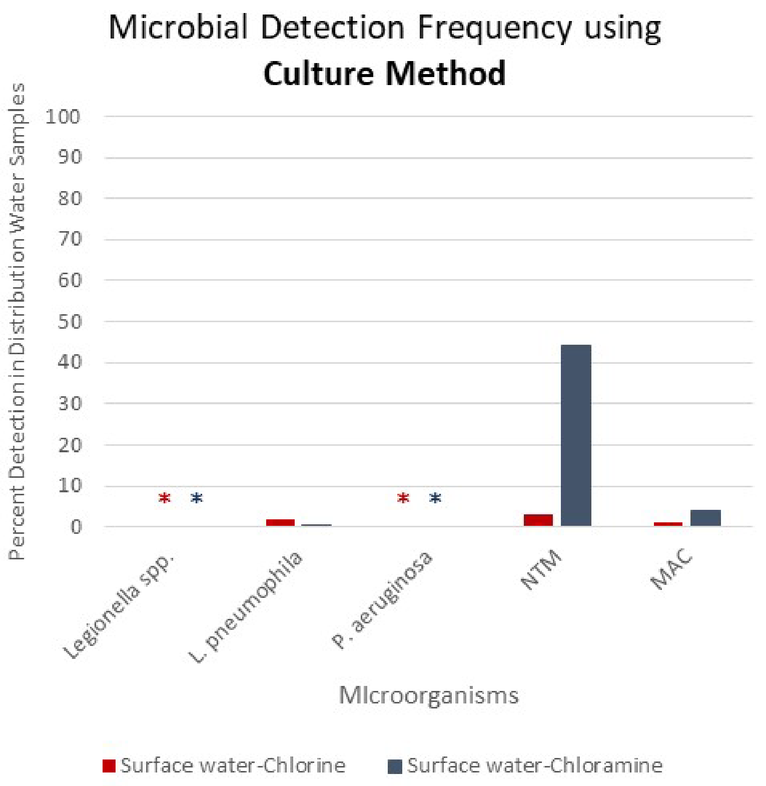
Topic 3: Distribution system water quality conditions related to pathogens – evidence and root causes of variable conditions and related vulnerabilities within the distribution system. (NDWAC charge areas 1, 2)

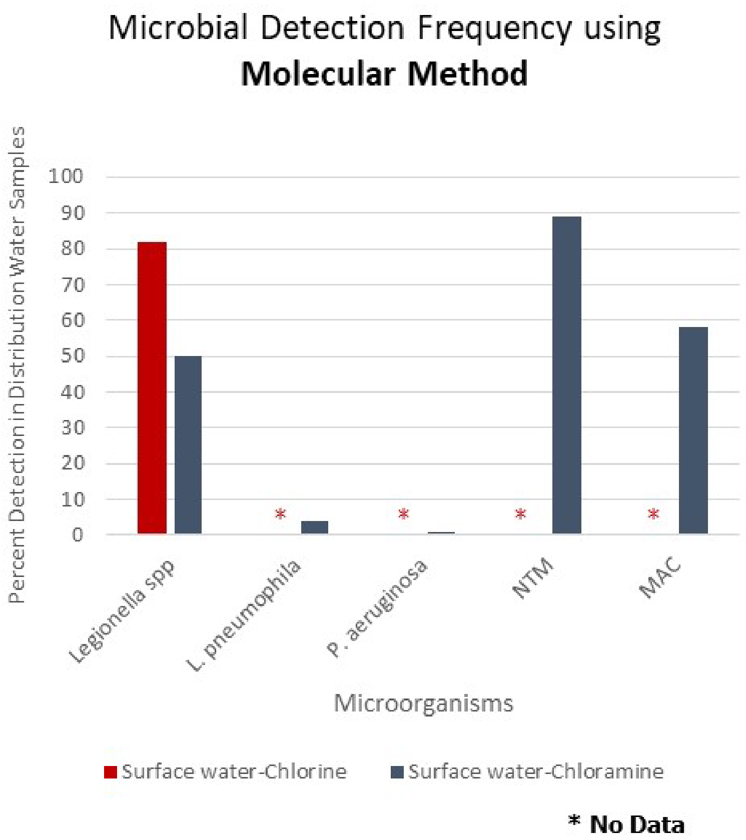
- Finished drinking water is not sterile, however controlling the conditions for OP growth in the DS can help limit the number of OPs entering buildings from the DS.(34)
- Opportunistic pathogens are naturally occurring, and amplification can occur in DS and premise plumbing under favorable conditions. (35)
- Preventing all OP occurrence in DS and building water systems is not achievable, but growth of OP in DS and building water systems can be controlled. (36)
- If conditions are suitable for further growth in the building plumbing, even low levels of OPs entering from the DS can be problematic. (37)

Topic 3: Distribution system water quality conditions related to pathogens – evidence and root causes of variable conditions and related vulnerabilities within the distribution system. (NDWAC charge areas 1, 2)

- Monitoring of OPs is not required, so few studies conducted on opportunistic pathogen occurrence in DS.(38)
- Culture methods are most commonly used to detect occurrence of opportunistic pathogens. However molecular methods show occurrence rates up to an order of magnitude higher than rates using culture methods.
  - Culture methods do not detect all species that may be present, or those that may be in a dormant state. Not all species are pathogenic.
  - Molecular methods don’t differentiate between live bacteria and the presence of inactive genetic material.
- Summary tables (drawn from the Meeting 2 slide presentation) for occurrence follow below.

Comparison of Microbial Detection Frequencies in Surface Water using Culture and Molecular Methods (39)





Surface water:

In chlorine treated water, NTM has the highest detection frequency of 3% by culture methods, and *Legionella spp.* has the highest detection frequency of 82% by molecular methods.

In chloramine treated water, NTM has the highest detection frequency of 44% and 89%, by culture and molecular methods.

Summary of *Legionella pneumophila* Occurrence Studies by Source Water and Secondary Disinfectant Type (40)

- In Surface water-Chlorine, *Legionella pneumophila* was detected on average in 2% of samples, using culture methods.
- In Surface water-Chloramine, *Legionella pneumophila* was detected on average in 0.2% of samples, using culture methods.
- In Groundwater-Chloramine, *Legionella pneumophila* was detected on average in 2% of samples, using culture methods.

Legionella pneumophila **Occurrence Studies Focused on Distribution Water**					
Source Water-Secondary Disinfectant	**# Studies**	**# Total Distribution Systems**	**# Distribution Systems with a positive sample**	**%, *L. pneumophila* # positive samples (Culture methods)**	**%, *L. pneumophila* # positive samples (Molecular methods)**
Surface water-Chlorine	4	13	38%, 5/13	2%, 29/1235	*
Surface water-Chloramine	4	14	7%, 1/14	0.2%, 1/499	4%, 6/134
Groundwater-Chlorine	1	1	1/1	2%, 1/53	*
Blended-Chloramine	1	1	1/1	*	6%, 3/54
Unknown	1	1	1/1	*	2%, 1/41
* No Data					

Summary of *Legionella* spp. Occurrence Studies by Source Water and Secondary Disinfectant Type (41)

- In Surface water-Chlorine, *Legionella* spp. was detected on average in 82% of samples, using molecular methods.
- In Surface water-Chloramine, *Legionella* spp. was detected on average in 50% of samples, using molecular methods.
- In Groundwater-Chloramine, *Legionella* spp. was detected on average in 100% of samples, using molecular methods.

Legionella spp. Occurrence Studies Focused on Distribution Water				
Source Water-Secondary Disinfectant	**# Studies**	**# Total Distribution Systems**	**# Distribution Systems with a positive sample**	***Legionella spp.*** **%, # positive samples (Molecular methods)**
		-		
Surface water-Chlorine	1	1	1/1	82%, 448/544
Surface water-Chloramine	2	2	2/2	50%, 67/134
Groundwater-Chloramine	1	1	1/1	100%, 16/16
Blended-Chloramine	1	1	1/1	83%, 45/54
Unknown	1	1	1/1	56%, 23/41

Summary of *Pseudomonas aeruginosa* Occurrence Studies by Source Water and Secondary Disinfectant Type (43)

- In Surface water-Chloramine, *Pseudomonas aeruginosa* was detected on average in 1% of samples, using molecular methods.
- In Blended-Chloramine, *Pseudomonas aeruginosa* was detected on average in 6% of samples, using molecular methods.…

P. aeruginosa Occurrence Studies Focused on Distribution Water				
Source Water-Secondary Disinfectant	**# Studies**	**# Total Distribution Systems**	**# Distribution Systems with a positive sample**	***P. aeruginosa*** **%, # positive samples (Molecular methods)**
Surface Water-Chlorine	*	*	*	*
Surface water-Chloramine	1	1	1/1	1%, 1/90
Groundwater-Chloramine	*	*	*	*
Blended-Chloramine	1	1	1/1	6%, 3/54
Unknown	1	1	1/1	24%, 10/41
* No Data				

Summary of *Mycobacterium avium* Complex (MAC) Occurrence Studies by Source Water and Secondary Disinfectant Type (44)

- In Surface water-Chlorine, MAC was detected on average in 1% of samples, using culture methods.
- In Surface water-Chloramine, MAC was detected on average in 4% of samples, using culture methods.
- In Groundwater-Chlorine and Chloramine, MAC was detected on average in 0% of samples, using culture methods
- MAC molecular detection is 15X greater than culture detection.

MAC Occurrence Studies Focused on Distribution Water					
Source Water-Secondary Disinfectant	**# Studies**	**# Total Distribution Systems**	**# Distribution Systems with a positive sample**	**MAC %, # positive samples (Culture methods)**	**MAC %, # positive samples (Molecular methods)**
Surface water-Chlorine	1	3	1/3	1%, 1/106	*
Surface water-Chloramine	2	4	Culture: 4/4 Molecular: 3/3	4%, 6/154	58%, 28/48
Groundwater-Chlorine	2	2	Culture: 1/1 Molecular: 1/1	0%, 0/34	9%, 8/90
Groundwater- Chloramine	1	1	1/1	0% 0/16	19%, 3/16
Blended-Chloramine	1	1	1/1	*	10%, 8/80

* No Data

Topic 3: Distribution system water quality conditions related to pathogens – evidence and root causes of variable conditions and related vulnerabilities within the distribution system. (NDWAC charge areas 1, 2)

- The current SWTRs allow for variable DS water quality conditions even where compliance is fully demonstrated.(45)
- Conditions (root causes) specifically conducive to opportunistic pathogen growth or subsequent release include:
  - No or low disinfectant residual in portions of DS;
  - Sediment and biofilm accumulation;
  - Presence of Amoeba;
  - High water age;
  - Water temperature;
  - Corrosion and Infrastructure Conditions;
  - Nitrification;
  - Water Hammer.

Disinfectant Residuals

- Purpose (46)
  - Ensure that the distribution system is properly maintained and identify and limit contamination from outside the DS system when it might occur.
  - Limit growth of heterotrophic bacteria and *Legionella* within the DS.
  - Provide a quantifiable minimum target which, if exceeded, would trigger remedial action.
- LeChevallier (2019) observed that most of the samples positive for *L. pneumophila* and the highest concentrations occurred when free chlorine residual levels were below 0.1 mg/L.

Topic 3: Distribution system water quality conditions related to pathogens – evidence and root causes of variable conditions and related vulnerabilities within the distribution system. (NDWAC charge areas 1, 2)

Disinfectant Residuals, cont.

- Higher percentage of total coliform positives when residual levels are low or below detection. (47)
- May not remain at far reaches of a DS or in other areas of high-water age. (48)
- The current number and location of residual sampling locations may not be adequate to identify areas of the DS that are of concern for bacterial growth – current practice seeks sites that are representative of DS for monitoring for potential fecal contamination under the RTCR. Disinfection residual monitoring is conducted at the same time and locations as total coliform monitoring.(49)
- Current provision for 5% of DS to not meet disinfection residual targets can allow for variable conditions throughout the DS even though the system is compliant. Some areas of a DS may never see a residual.(50)
- Use of booster disinfection in a DS is capable in only 30% of systems according to one survey. It is not a common practice and can be challenging.(51)
- Systems using chloramines may have challenges with getting the optimal chlorine to ammonia ratio and prevention of nitrification.(52)

Topic 3: Distribution system water quality conditions related to pathogens – evidence and root causes of variable conditions and related vulnerabilities within the distribution system. (NDWAC charge areas 1, 2)

Disinfectant residuals, cont.

- Variations among states in requirements for minimum residual levels.
  - Approximately 50% of states have numeric disinfectant residual requirements, which vary from <0.1 to >1 mg/L. (53)
  - Remaining states require a detectable disinfectant residual under SWTR. (53)
  - National data shows percent of systems not meeting example residual levels.(54)
    - Example shows 11-12% of free chlorine CWSs not meeting 0.2 mg/L.
    - Data differ based on whether state has numeric requirement (e.g., 21-23% CWSs not meeting 0.2 mg/L in detectable states vs 5-8% in numeric states).
  - Example for Colorado showed increase in free chlorine residual levels after state changed to a numeric residual level.(55)
- False positives may be of concern when organic chloramines are detected rather than the presence of an active disinfectant residual (i.e., monochloramine).(56)
- States do not necessarily manage disinfectant residual data in the same way as other drinking water compliance data, making comparative analysis challenging.(57)

Topic 3: Distribution system water quality conditions related to pathogens – evidence and root causes of variable conditions and related vulnerabilities within the distribution system. (NDWAC charge areas 1, 2)

Sediment and Biofilm Accumulation

- Can provide a habitat for growth of OPs and protection from disinfectant residuals. (58)
- Sediments can arise from corrosion products, treatment media breakthrough, source waters, and matter entering through leaks and breaks.(59)
- Biofilms grow on wetted surfaces and can act as a nutrient source for microbial growth (including some OPs). Become a problem when growth is uncontrolled.(60)

Presence of Amoeba: *Legionella* can grow within the amoeba and be released at higher numbers. (61)

Topic 3: Distribution system water quality conditions related to pathogens – evidence and root causes of variable conditions and related vulnerabilities within the distribution system. (NDWAC charge areas 1, 2)

Water Age

- Oversized systems can have concerns about areas with low flow and stagnation that can lead to increased water age and loss of residuals; oversizing occurs associated with meeting fire flow requirements, anticipated system growth, or depopulation. (62)
- High water age can also lead to problems associated with accumulation of biofilms and sediments, nitrification, and compliance with D/DBPRs and microbial regulations (e.g., RTCR). (63)
- An average distribution system retention time of 1.3 days was obtained from a survey of more than 800 U.S. utilities, but water ages of up to 25 days have been also reported, particularly at dead-end nodes (Cherchi et al 2015 citing AWWA WIDB 1992).(64)

Topic 3: Distribution system water quality conditions related to pathogens – evidence and root causes of variable conditions and related vulnerabilities within the distribution system. (NDWAC charge areas 1, 2)

Water Temperature

- The optimal growth temperature for *Legionella* in water is from 20 to 45 degrees C (68 to 113 degrees F).(65)
- LeChevallier (2019) observed *L. pneumophila* in 2.4% of distribution samples, especially when the water was over 18 degrees C. (66)
- Some systems may experience water temperatures in this range for at least parts of the year, especially in elevated storage tanks. (67)

Corrosion and Infrastructure Condition

- Iron corrosion may deplete disinfectant residuals, increase iron bioavailability, increase *Legionella* virulence, enhance biofilm growth, and create a habitat where *Legionella* is protected from disinfection (68)
- Breaches related to infrastructure conditions can provide a pathway for microbial entry - this may be more of a concern for fecal contamination.(69)

Topic 3: Distribution system water quality conditions related to pathogens – evidence and root causes of variable conditions and related vulnerabilities within the distribution system. (NDWAC charge areas 1, 2)

Nitrification

- Can result from conditions in the source water, type of treatment, disinfectant used, TOC concentration, ammonia concentration, organic nitrogen concentration, and water system configuration.(70)

Water Hammer

- Can result in the release of biofilms, scales, and sediments, along with any contaminants they may contain.(71)

Topic 4: Drinking water DBP-related public health impacts – evidence and root causes related to DBPs in drinking water and their relationship to public health risks. (NDWAC charge areas 1, 2)

- EPA promulgated Stage 1 and 2 D/DBPRs based on bladder cancer lifetime risk associated with chlorination DBPs of 2 to 17 percent.
  - Health effects other than bladder cancer were not quantified under Stage 2 D/DBPR due to insufficient data at that time.
  - At the time of Stage 1 D/DBPR, available occurrence data were limited to HAA5 due to lack of methods and standards. EPA approved methods in 2003 and 2009 for HAA9.
- The past 10 years of implementation of Stage 2 (and RTCR) has seen an increased use of chloramine and advanced disinfectants.
  - Chloramination of drinking water forms relatively lower concentrations of regulated trihalomethanes (THMs) and haloacetic acids (HAAs). (72)
  - Some researchers have suggested that chloramination may result in increased overall toxicity of the DBP mixture.(73)
- Implementation of the Stage 1 and Stage 2 D/DBPRs has reduced THM levels and potential bladder cancer cases attributed to DBPs (Richardson, EHP, 2022), particularly among systems with previously elevated DBP levels. (74)

Topic 4: Drinking water DBP-related public health impacts – evidence and root causes related to DBPs in drinking water and their relationship to public health risks. (NDWAC charge areas 1, 2)

- Since the completion of the Stage 1 and Stage 2 D/DBPRs, additional data and analysis have emerged that further inform the occurrence and risk profile of regulated and unregulated DBPs (e.g., occurrence of unregulated brominated HAAs [UCMR4], chlorate [UCMR3], and nitrosamines [UCMR2] in water systems)(75).

- The new information indicates there are unaddressed risks associated with the occurrence of both regulated and unregulated DBPs in drinking water (e.g., 10 percent of bladder cancer cases may still be potentially attributable to chlorination DBPs in drinking water). (76)

Cancers (e.g., bladder, colorectal, liver, kidney)

- Epidemiology studies support a potential association between exposures to elevated DBP levels and cancer; the most consistent evidence is for bladder cancer.(77)
- Studies indicate that non-ingestion routes of exposure from some brominated DBPs may play a significant role in influencing increased bladder cancer risk, and that there may be greater concern about sub-populations with certain genetic characteristics (polymorphisms). (78)

Topic 4: Drinking water DBP-related public health impacts – evidence and root causes related to DBPs in drinking water and their relationship to public health risks. (NDWAC charge areas 1, 2)

Cytotoxicity, genotoxicity, mutagenicity, and teratogenicity as indicated by in vitro bioassays

- Relative trends in potency observed for single chemical studies shows increased toxicity of brominated DBPs compared to chlorinated DBPs, with the overall trends following I>Br>>Cl and nitrogenous>carbonaceous DBPs.(79)
- Cell-based assays are examples of one endpoint and may not fully account for metabolism that would occur in the human body. (80)

Additionally, multiple studies have been conducted since Stage 2 that further inform an understanding of the possible association between adverse reproductive and developmental health effects (short-term acute risks) and exposure to chlorinated drinking water (81)

Topic 4: Drinking water DBP-related public health impacts – evidence and root causes related to DBPs in drinking water and their relationship to public health risks. (NDWAC charge areas 1, 2)

Haloacetic Acids

- The National Toxicology Program (NTP) has concluded that the unregulated brominated HAAs are "reasonably anticipated to be human carcinogens based on sufficient evidence from studies in experimental animals and supporting mechanistic data that demonstrate biological plausibility of its carcinogenicity in humans".(82)
- There is evidence of liver cancer in animals for all four unregulated, brominated HAAs.(83)
- EPA is currently conducting a systematic literature review of the four unregulated brominated HAAs.(84)
- Recent study by Samson and Seidel examined potential impacts of an HAA9 regulation (2022). (85)

Topic 4: Drinking water DBP-related public health impacts – evidence and root causes related to DBPs in drinking water and their relationship to public health risks. (NDWAC charge areas 1, 2)

Nitrosamines (86)

- Six nitrosamine compounds were monitored in national drinking water systems between 2008-2010 under the Second Unregulated Contaminant Monitoring Rule (UCMR2).
- In addition to drinking water, exposure to nitrosamines can originate from food and beverages, as well as form endogenously in the digestive tract.
- EPA classified N-Nitrosodimethylamine (NDMA) as likely to be carcinogenic to humans by a mutagenic mode of action under the Guidelines for Carcinogen Risk Assessment, based on evidence for human carcinogenicity in epidemiologic studies and substantial animal data demonstrating carcinogenicity.

Topic 4: Drinking water DBP-related public health impacts – evidence and root causes related to DBPs in drinking water and their relationship to public health risks. (NDWAC charge areas 1, 2)

Chlorate and Chlorite (87)

- Chlorate and chlorite form when chlorine dioxide disinfection is used, and chlorate forms when hypochlorite disinfection is used, especially from bulk hypochlorite solutions (after storage) or on-site chlorine generation.
- Under the D/DBPRs, water systems using chlorine dioxide are required not to exceed the MCL for chlorite at 1 mg/L.
- Potential health effects of chlorate (unregulated) and chlorite (regulated): Both may have common health effects (e.g., thyroid effects) and health effects of chlorate include hemolysis and interference of iodine uptake by the thyroid. RW – see references in notes section.

Topic 4: Drinking water DBP-related public health impacts – evidence and root causes related to DBPs in drinking water and their relationship to public health risks. (NDWAC charge areas 1, 2)

- Other unregulated DBPs (e.g., haloacetonitriles, iodinated acetic acids, haloacetamides, and halonitromethanes) have been suggested for further research. (88)
- Studies have examined relative cytotoxicity using the CHO assay of regulated and unregulated DBPs (e.g., Allen et al., 2022); unregulated haloacetonitriles, particularly dihaloacetonitriles, were found to be important toxicity drivers based on use of the CHO assay to assess relative toxicity.

Topic 5: Distribution system water quality conditions related to DBP formation – evidence and root causes of the occurrence of DBPs in drinking water. (NDWAC charge areas 1, 2)

- Certain conditions in public water systems, precursor availability and high disinfectant residual levels, can contribute to increased DBP formation (both regulated and unregulated).(89)
- Prolonged residence times (high water age) can occur in storage tanks and oversized distribution systems (90) and are associated with the increased formation of some DBPs, (91) while they may decrease formation of others (e.g., haloacetonitriles (HANs)).(92)
- DBP precursors can be present in sediments and biofilms in distribution systems.

Topic 5: Distribution system water quality conditions related to DBP formation – evidence and root causes of the occurrence of DBPs in drinking water. (NDWAC charge areas 1, 2)

Haloacetic Acid Occurrence (94)

- Among systems in compliance with the existing HAA5 MCL (60 µg/L), ~ 2% of systems had HAA9 > 60 µg/L*. In most cases of high HAA9 levels, HAA6Br was not a major contributor.
- High bromide levels in source water contribute to high levels of HAA6Br, but not necessarily to high HAA9 where the three chlorinated HAAs are the major driver of elevated HAA9.
- No close relationship observed between THM4 and HAA9 occurrence, however this is not unexpected since these DBPs have different precursors.

**Cutoffs are for illustration only and are not suggestive of potential regulatory limits. HAA5 was regulated at 60 ug/L based on what was determined to be technically and economically feasible.*

Topic 5: Distribution system water quality conditions related to DBP formation – evidence and root causes of the occurrence of DBPs in drinking water. (NDWAC charge areas 1, 2)

Nitrosamine Occurrence (95)

- The UCMR2 dataset indicated that approximately 7.5% of public water systems had a mean concentration of NDMA exceeding the health reference level (HRL) of 0.6 ng/L which was derived at the risk level of one cancer case per one million of general population (i.e., 10-6 risk level).
- Chloramination of drinking water forms relatively higher concentrations of nitrosamines than chlorine (UCMR 2 detection rate for NDMA in chloramine plants was 34.1% versus 4% for chlorine plants). Chloramination without a period of free chlorine may result in even higher concentrations of nitrosamines.
- NDMA precursors include treated wastewater effluent, organic matter, certain pharmaceuticals, certain coagulation polymers (e.g., polyDADMAC), and certain anion resins.

Chlorate and Chlorite Occurrence

- Chlorate and chlorite can co-occur in treated water, and chlorate was nationally monitored between 2013-2015, under the UCMR3.(96)
- UCMR3 data showed that about 17 percent of sampling locations nationally would have average chlorate concentrations above the HRL (chlorate HRL was 210 µg/L).(97)

Topic 5: Distribution system water quality conditions related to DBP formation – evidence and root causes of the occurrence of DBPs in drinking water. (NDWAC charge areas 1, 2)

Root Causes: In chemically disinfected water systems, source water quality, treatment operation, and DS management practices collectively affect site-specific conditions for formation (or degradation) of DBPs.

Source Water Quality

- Higher levels of organics and nutrients in the water entering DS can contribute to elevated levels of DBPs in DS, in addition to more microbial activity.(98)
- Elevated bromide levels have been related to increased levels of brominated DBPs, resulting in regulatory exceedances of DBPs.(99)
- TOC and bromide concentrations strongly impact the selection of distribution system disinfectant (i.e., high levels favor chloramine use) and regulated DBP formation.(100)

Topic 5: Distribution system water quality conditions related to DBP formation – evidence and root causes of the occurrence of DBPs in drinking water. (NDWAC charge areas 1, 2)

Treatment Operations (101)

- Increasing disinfectant doses in the water entering DS or through operation of boosters in DS can increase DBP formation.
- The sequence of free chlorine and ammonia addition is an important factor in DBP formation.

DS Management Practices

- Disinfectant type and residual levels affect type and level of DBPs.(102)
- The materials released from biofilm-can serve as precursors for DBP formation.(102)
- Higher water temperature yields more rapid DBP formation.(102)
- Precursors can be present in sediments and biofilms in distribution systems.(102)
- Prolonged water residence time can lead to elevated levels of DBPs in DS:
    - Stagnation of water in storage tanks and pipes(103)
    - Extended water ages in consecutive systems (104)

Additional Problem Characterization Topics
Topic 6: Source water conditions and related treatment requirements – evidence and root causes of challenges posed by source water quality. (NDWAC charge areas 1, 2)
Topic 7: Storage tanks – evidence and root causes related to negative water quality impacts resulting from contaminant entry, formation, or growth due to improper or inadequate storage tank maintenance, operations, and management. (NDWAC charge areas 1, 2)
Topic 8: Consecutive systems – evidence and root causes related to negative water quality impacts related to the unique circumstances of consecutive systems. (NDWAC Charge Areas 1, 2)

Additional Problem Characterization Topics

Topic 9: Environmental justice impacts related to drinking water system water quality, maintenance, operations, and management in the context of pathogens and DBP risks. (NDWAC Charge Area 6)

Topic 10: Areas that may introduce implementation or compliance challenges for drinking water systems/communities related to regulation and management of pathogens and DBPs. (NDWAC Charge Area 6)

Topic 11: Data and analysis gaps.

WG Feedback on Possible Topics

- Overall distribution system management
- Working Group Charge 4: Ensuring efficient simultaneous compliance with other drinking water regulations when implementing any proposed revisions to the MDBP rules – simultaneous compliance implications for public health impacts.
- Implementation Challenges:
    - Risk identification and response:
        - Are the current MDBP requirements identifying water systems with MDBP risks
        - Identifying those on a meaningful/urgent timeline
        - Providing effective interventions for reducing MDBP risks on a timeline that provides a meaningful reduction in risk
        - Is the public adequately informed on a timeline that allows residents to take meaningful action to protect their own health
    - State of non-regulatory but critical supporting programs (e.g., those that address technical, financial, and managerial capacity) that enable water systems to meet compliance
- Key areas of non-compliance with current MDBP regulations and related root causes
- Articulate the premise for each finding topic

Discussion Questions

- For Opportunistic Pathogens (e.g., *Legionella*, MAC, *P. aeruginosa*), based on the presentations, resource material and discussions to date, what conclusions are emerging for you with respect to: public health outcomes; the primary root causes; and the degree of certainty we have for these conclusions?

Discussion Questions

- For regulated DBPs (e.g., THM4, HAA5) and unregulated DBPs (e.g., Brominated HAAs, Haloacetonitriles, Iodinated DBPs, Nitrosamines, Chlorate) based on the presentations, resource material and discussions to date, what conclusions are emerging for you with respect to public health outcomes; the primary root causes; and the degree of certainty we have for these conclusions?

15 Minute Break

4:30-4:45 pm ET

Segment 4: Continued

Panel Discussion, Facilitated Discussion

January 24, 2023

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Discussion Questions

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Segment 5: Meeting 7 Agenda & Next Steps

Co-Chairs Andy Kricun & Lisa Daniels
Rob Greenwood, Ross Strategic

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Proposed Meeting 7 Topics & Next Steps

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- Revisit implementation challenges
- Continue focused problem characterization discussions
- Introduce the interventions phase of discussions

Facilitated Discussion

- Do you have additions or refinements to the proposed topics?
- What background materials, presentations, or other resources will be helpful to you to prepare for the Meeting 7 discussions?
- Mindful of time and resource limitations prior to the next meetings, what supplemental technical analyses would you like on the topics to help inform discussions?

CLOSING REMARKS

CO-CHAIRS LISA DANIELS AND ANDY KRICUN

MEETING CLOSURE

ELIZABETH CORR, U.S.EPA, DFO