Microbial and Disinfection Byproducts
Rule Revisions Working Group

Meeting 4: November 3, 2022, 11:00am-6:00pm ET

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AND DRINKING WATER

WELCOME

Rob Greenwood, Ross Strategic
Elizabeth Corr, DFO, U.S.EPA OGWDW
Crystal Rodgers-Jenkins, U.S. EPA OGWDW

OPENING REMARKS

Lisa Daniels & Andy Kricun, WG Co-Chairs

Segment 1: Agenda Review & Meeting Procedures

Rob Greenwood, Ross Strategic

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Today's Virtual Meeting: Zoom Controls

This meeting is **not** being recorded

The Zoom menu bar appears at the bottom of the Zoom window once the meeting begins.

If you don't see the menu bar, move your mouse slightly and the bar will appear.

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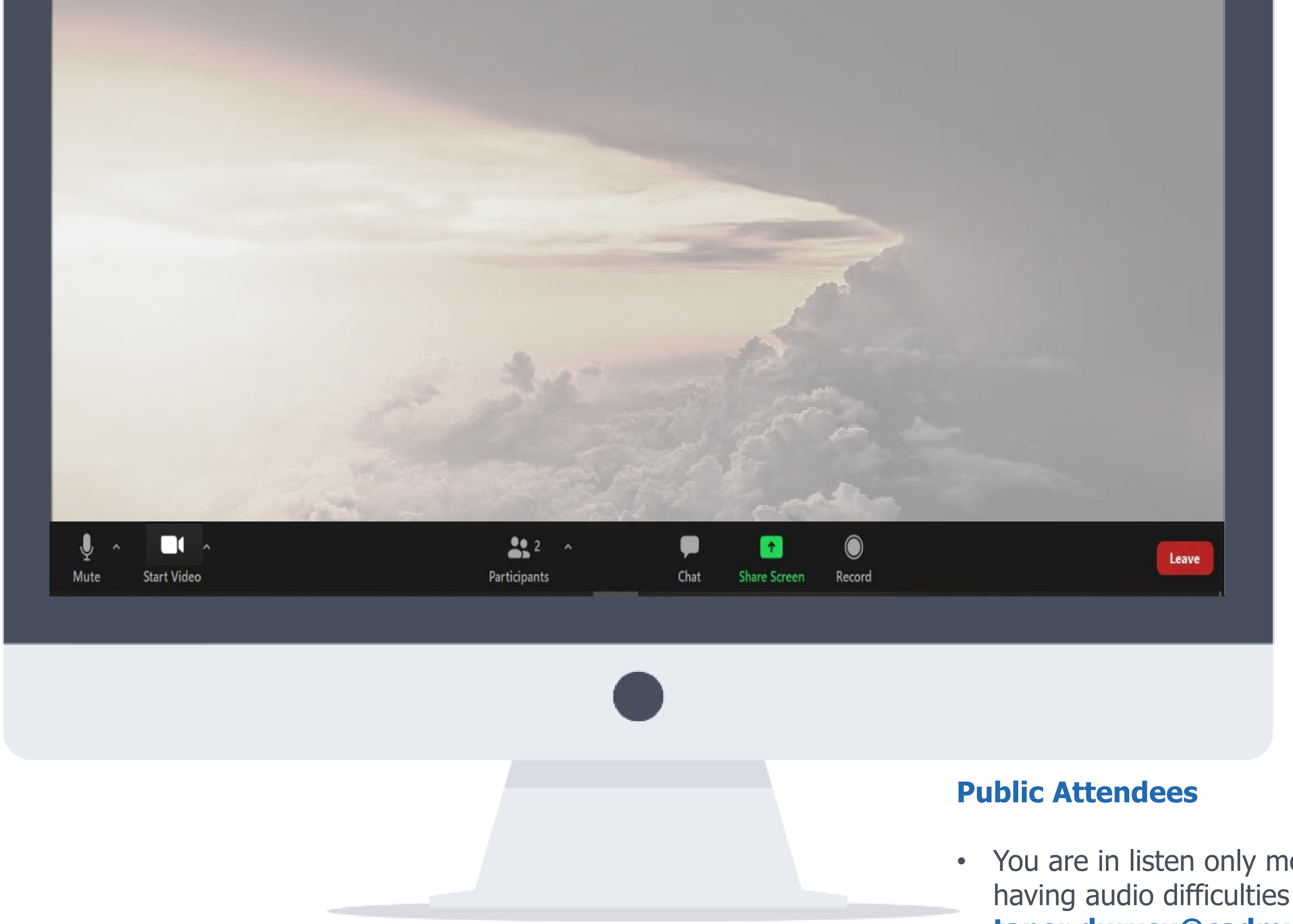

Public Attendees

- 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

EPA AND FACILITATION TEAM

Crystal Rodgers-Jenkins
EPA OGWDW, Associate Director, Standards and Risk Management Division

Ken Rotert
EPA OGWDW

Rich Weisman
EPA OGWDW

Rob Greenwood
Ross Strategic

Sarah Faust
Ross Strategic

Dana Stefan
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Leeland Gotlieb
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Erin Mateo
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Taner Durusu
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Christine DeRiuex
Cadmus

Today's Agenda

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11:00-12:45	• Agenda Review and Meeting Procedures • Follow up on problem characterization discussions on opportunistic pathogens and disinfectant residuals; Follow up on problem characterization discussion on disinfectants/disinfection byproducts
	15 Minute Break (12:30 – 12:45 pm ET)
12:45 – 4:10	• Regulatory and Policy Considerations for Risk Balancing/Interdependencies 60 Minute Lunch Break (1:30 – 2:30 pm ET) • Problem Characterization on Risk Balancing/Interdependencies
	10 Minute Break (4:10 – 4:25 pm ET)
4:25 – 6:00	• Cont.: Working Group Discussion Problem Characterization on DBPs • Meeting 5 Agenda & Next Steps

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Topics

1 Principles, Priority Areas, Challenge Areas

2 Problem Characterization

3 Interventions

4 Implementation Mechanisms

5a Findings

5b Recommendations

6 Final Report

Meeting Series

1 Introductions, Priorities, & WG Goals

2 Problem Characterization Areas

3 Problem Areas in More Detail (Part 1)

4 Problem Areas in More Detail (Part 2) ← We Are Here

5 Stepping Back – Wrap Up of Problem Characterization

6 Intervention Scoping & Evaluation Approach

7 Intervention Characterization (Part 1)

8 Intervention Characterization (Part 2)

9 Connect Preferred Interventions to Implementation

10 Translate Interventions to Recommendations

11 Draft Recommendations

12 Final Refinements to Recommendations

13 Final Report

Segment 2: Follow up on Problem Characterization

Kenneth Rotert, U.S. EPA OGWDW

Technical Presentation and Panel Discussion

November 3, 2022

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Problem Characterization on Opportunistic Pathogens and Disinfectant Residuals: Follow up information

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- Technical analysts who provided input to the responses on the following slides
  - Mark LeChevallier – Dr. Water Consulting LLC. Formerly with American Water.
  - Nancy Love – The University of Michigan
  - Shawn McElmurry – Wayne State University
  - Andrew Jacque – Water Quality Investigations
  - Steven Duranceau – University of Central Florida
  - Zaid Chowdhury – Garver
  - Susan Teefy – East Bay Municipal Utility District
  - Stuart Krasner – formerly with the Metropolitan Water District of Southern California
  - Chris Owen – Hazen and Sawyer

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

- How do sampling designs affect the occurrence of opportunistic pathogens?
  - Sampling design is always related to the questions being asked. For example, monitoring water that is consumed could be related to exposure or risk. Monitoring biofilms could be related to opportunities for growth. But finding microbes in biofilms doesn't necessarily mean that people are exposed to those microbes unless they are released from the biofilms. Compliance monitoring is designed so that similar data are collected from all systems.

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

- ## What leads to simultaneous compliance issues?
  - Many things could lead to simultaneous compliance issues. Lower pH will reduce THM but increase HAAs and vice versa. Lower pH could cause corrosion problems to worsen. Lower pH can also improve TOC removal in conventional treatment, leading to lower chlorinated DBPs upon subsequent chlorination. Similarly, increasing disinfectant residuals at the remote parts of the system will result in higher DBPs as discussed earlier.
  - Some technical analysts have differing viewpoints on the following:
    - The degree to which excessive presence of biofilm leads to increased DBP formation and increased corrosion of plumbing. Being unregulated, biofilm problems go unsolved or are only marginally corrected with current guidance.
    - How much biofilm is present and how continuous it is. Biofilms will be naturally present where nutrients exist. Numerous studies support this though various tests, such as PCR testing, DNA testing, swab tests. Surface type also matters, and shifting of biofilm type is seen in a system and within short stretches of the same system.
  - Additional considerations related to simultaneous compliance include control of nitrification; the impact of bulk-pipe wall conditions such as material of construction, workmanship, tubercle quantities/deposits and similar related items that impact system water quality dynamics; the feasibility of control approaches that may or may not exist; and the relative impacts of a specific technical concept being presented.

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

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- ## What leads to simultaneous compliance issues (cont.)?
  - Elevated ozone doses may be needed under some circumstances to achieve adequate disinfection, this can lead to formation of bromate.
  - Switching distribution systems residual disinfectant, for example from free chlorine to chloramine, can reduce chlorinated DBPs but can lead to problems complying with the lead and copper rule and the total coliform rule.
- ## What are the root causes for D/DBP Rule non-compliance?
  - In free chlorine systems DBP Rule non-compliance probably results mainly from lack of precursor removal and long water age (which leads to biofilm formation and secretion of DBP precursors).
  - In chloraminated systems DBP levels are often not an issue even if the precursor concentrations are high, but these systems face challenges in maintaining disinfectant residuals due to nitrification. Chloraminating systems will have more of an issue with currently unregulated DBPs (e.g., nitrosamines), especially in systems that do not have a free chlorine contact time prior to chloramine conversion.
  - High levels of precursors, especially bromide, which is not removed by coagulation or GAC. High water age, high water temperature.

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

- ## What are the common factors between DBP and OP occurrence?
  - Stagnation tends to increase THM levels, decrease disinfectant residuals, and provide opportunities for OP growth. However, other DBPs (like HAAs) can decrease due to biodegradation. Long water age and consecutive systems will have the same effect.
  - Biofilms secrete DBP precursors and create a home for OPs to hide and thrive.
  - Precursor source also is relevant in considering DBP formation and OP occurrence. For example, humic and high-molecular-weight TOC is a source of THM and HAA precursors, whereas low-molecular-weight and non-humic TOC is a source of biodegradable organic matter.

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

- ## How useful are the existing IDSEs?
  - If the IDSEs are updated as stipulated in the original rule, they could be valuable, however, a system is never static and IDSE for one scenario or season may not be accurate for another period.
- ## What are the impacts of high chlorine doses close to plants?
  - The issue with high chlorine residual close to the plant is the chlorinous taste and smell of the water that is often not acceptable to customers. Utilities try not to expose customers close to the plant to excessive chlorine levels. Rechlorination points in the system are a better option if needed.
  - Exceeding the MRDLs is also more likely. Additionally, the rate of DBP formation will significantly increase at higher chlorine residual conditions.
  - Boosting monochloramine can be done, but it is not straightforward and requires significant operational oversight. If done incorrectly it can lead to loss of disinfectant residual and increases in DBPs. Boosting free chlorine is less complex but can result in higher DBPs.

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

- To what extent do reduced monitoring provisions result in missing DBP problems?
  - No responses provided
- How frequently are monitoring plans reviewed?
  - No responses provided
- How much are users responsible for water quality?
  - Owners and operators of large buildings should have a building water management plan in accordance with ANSI/ASHRAE Standard 188; this is a best practice but not required other than in New York and in VA hospitals.
  - Owners that oversize plumbing for future expansion create the potential for water quality degradation and subsequent WQ issues.
  - Consider delineation between the utility-owned component and the property/building owner component.

Legionnaires' Disease in the United States

Chris Edens, PhD

Epidemiologist, NCIRD/DBD/RDB

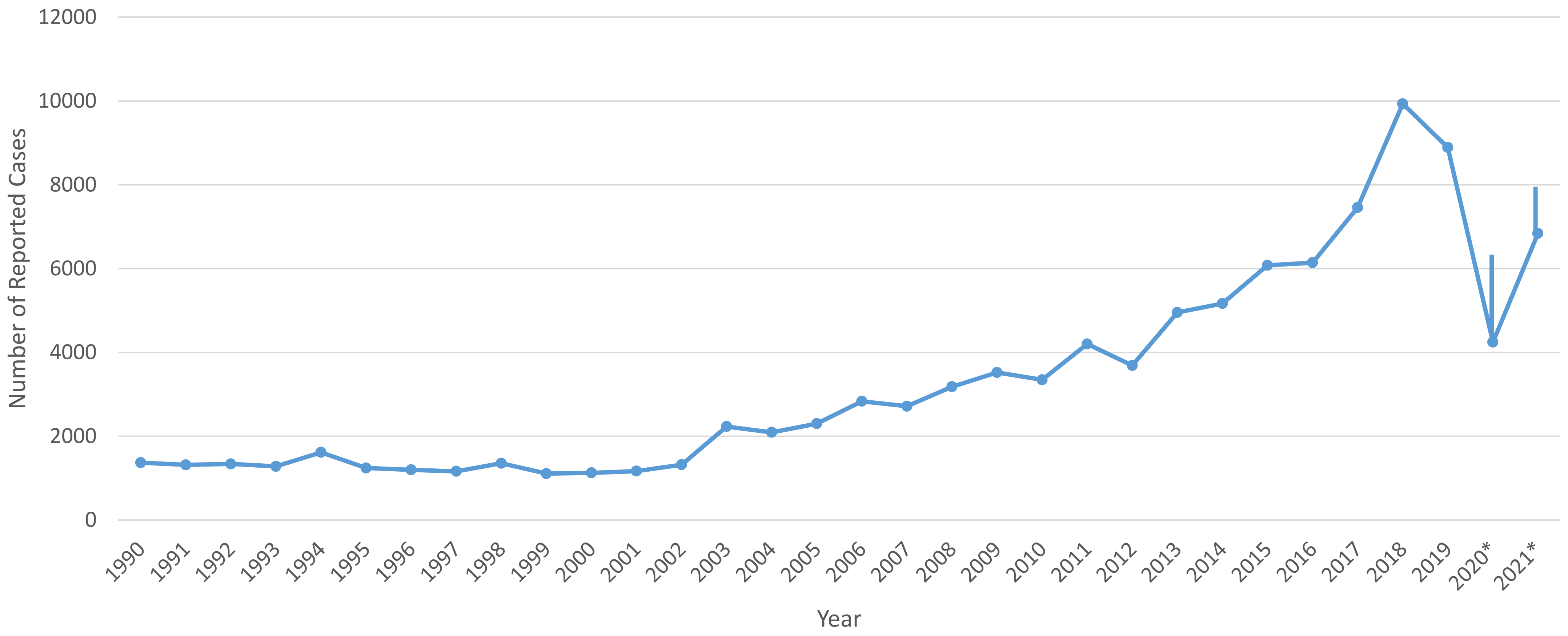
Centers for Disease Control and Prevention

EPA NDWAC WG

November 3, 2022

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

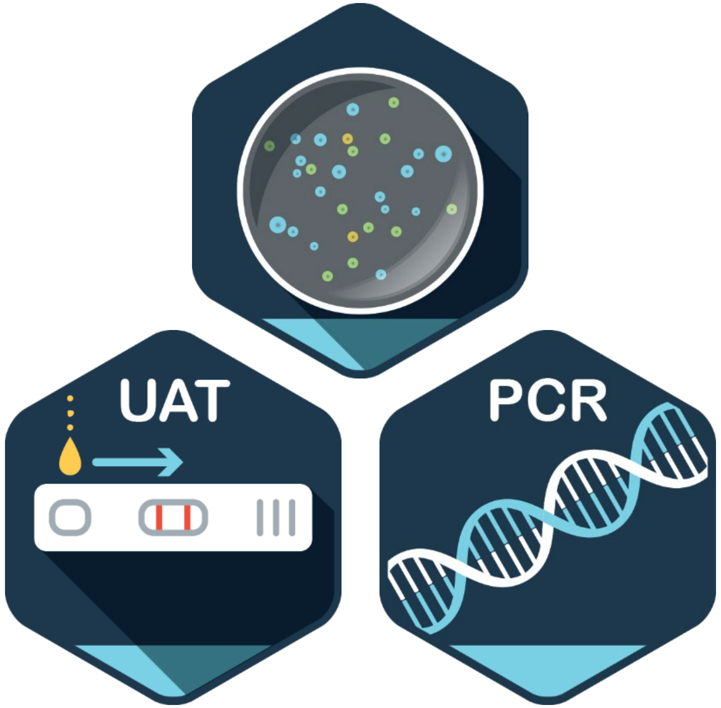
Number of Reported LD Cases, National Notifiable Diseases Surveillance System (NNDSS), 1990–2021



*Week 52 provisional total; | Estimate accounting for reporting delay

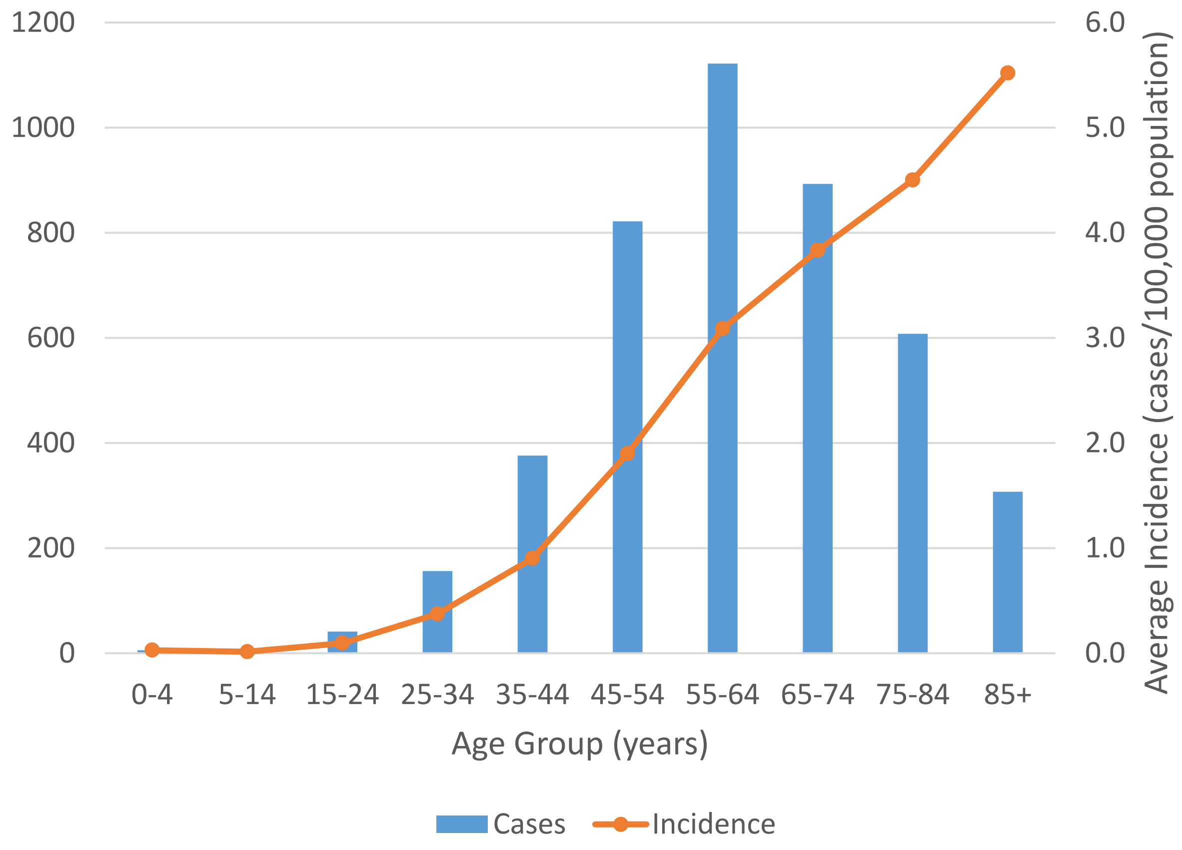
LD Testing

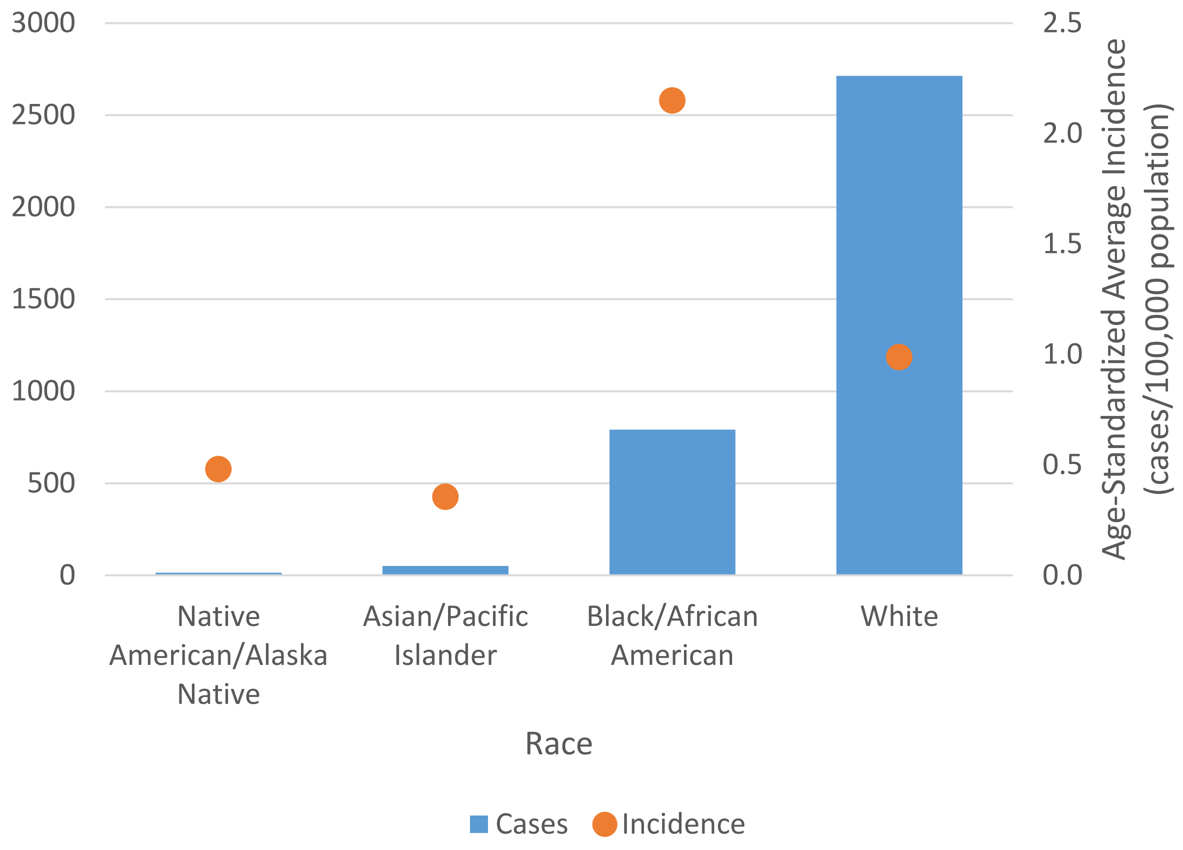
- *Legionella* UAT is rapid and detects *L. pneumophila* serogroup 1, the most common cause of disease
- PCR performed on lower respiratory specimens (e.g., sputum) or pathologic specimens not conducive to culture (e.g., formalin-fixed lung tissue)
- Culture performed on lower respiratory specimens (e.g., sputum) detects all species and serogroups and allows for comparison of clinical and environmental isolates during outbreak investigations



If *Legionella* infection is suspected, collect lower respiratory specimens for diagnostic testing, and consider retaining for public health purposes

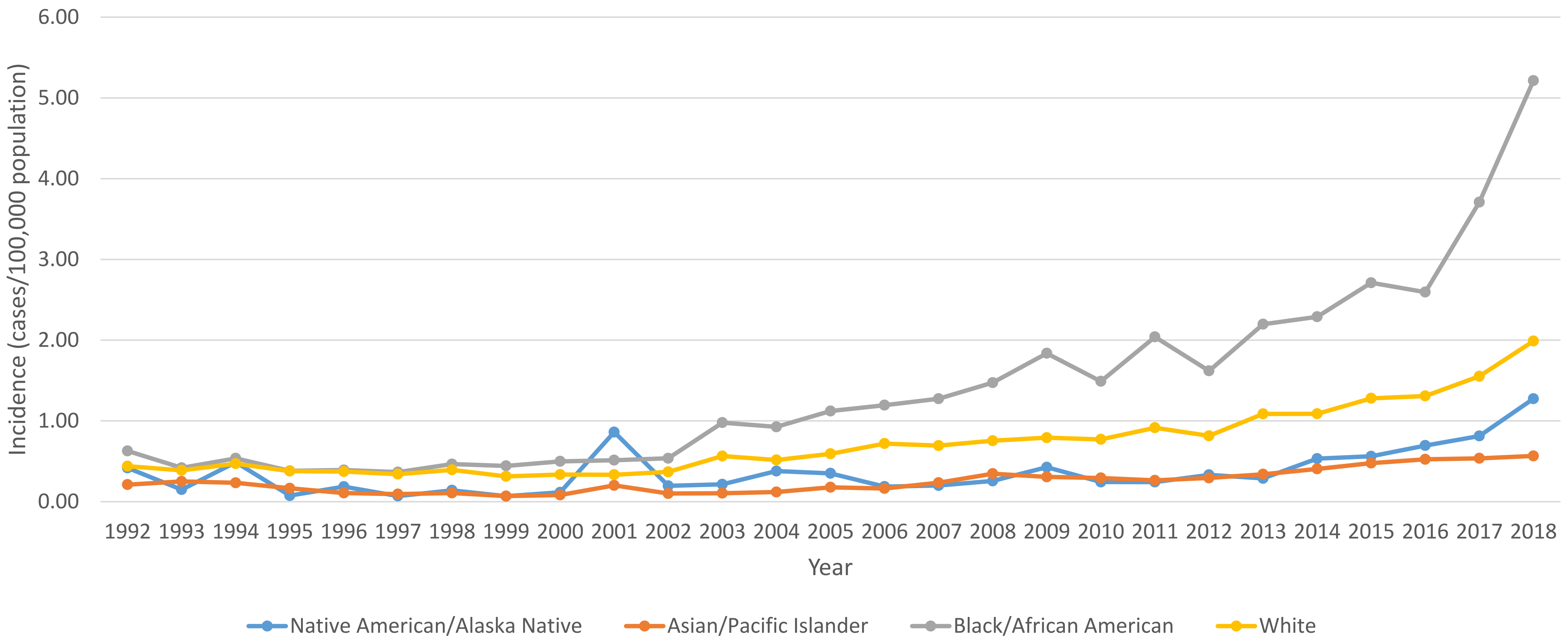
Cases and Incidence by Age Group and Race, 2003–2018





Barskey AE, et al. Rising Incidence of Legionnaires' Disease and Associated Epidemiologic Patterns, United States, 1992–2018. *Emerg Infect Dis*. 2022 Mar;28(3):527-538.

Age-standardized Incidence by Race and Year

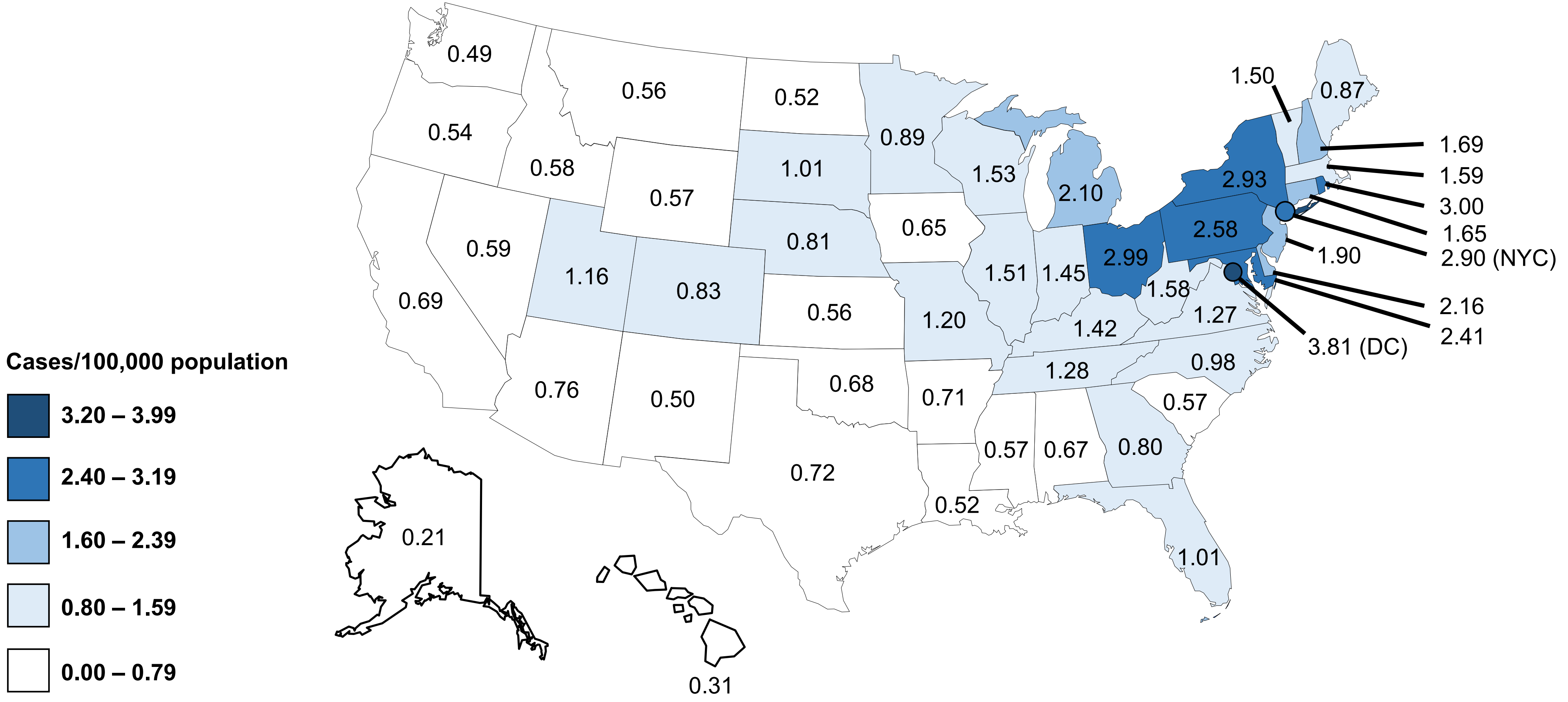


Barskey AE, et al. Rising Incidence of Legionnaires' Disease and Associated Epidemiologic Patterns, United States, 1992–2018. *Emerg Infect Dis*. 2022 Mar;28(3):527-538.

Disparate impact of LD

- Cause of racial disparities is likely multifactorial and worsening
  - Certain comorbidities associated with an increased risk for LD are more common among Black or African American persons
    - Diabetes, end-stage renal disease, and some cancers
  - Social determinants of health
    - Census tracts with higher poverty and lower education levels had a higher incidence of LD
    - Proximity to cooling towers, construction sites, and certain industries were risk factors for LD
    - Residence in areas with more vacant housing, more renter-occupied homes, and more homes built before 1970 were identified as risk factors for LD
    - More cases of LD were reported among people working in hazardous or service industries (such as transportation, repair, protective services, cleaning, and construction)

Age-standardized Average Incidence by Jurisdiction, 2003–2018



Barskey AE, et al. Rising Incidence of Legionnaires' Disease and Associated Epidemiologic Patterns, United States, 1992–2018. *Emerg Infect Dis*. 2022 Mar;28(3):527-538.

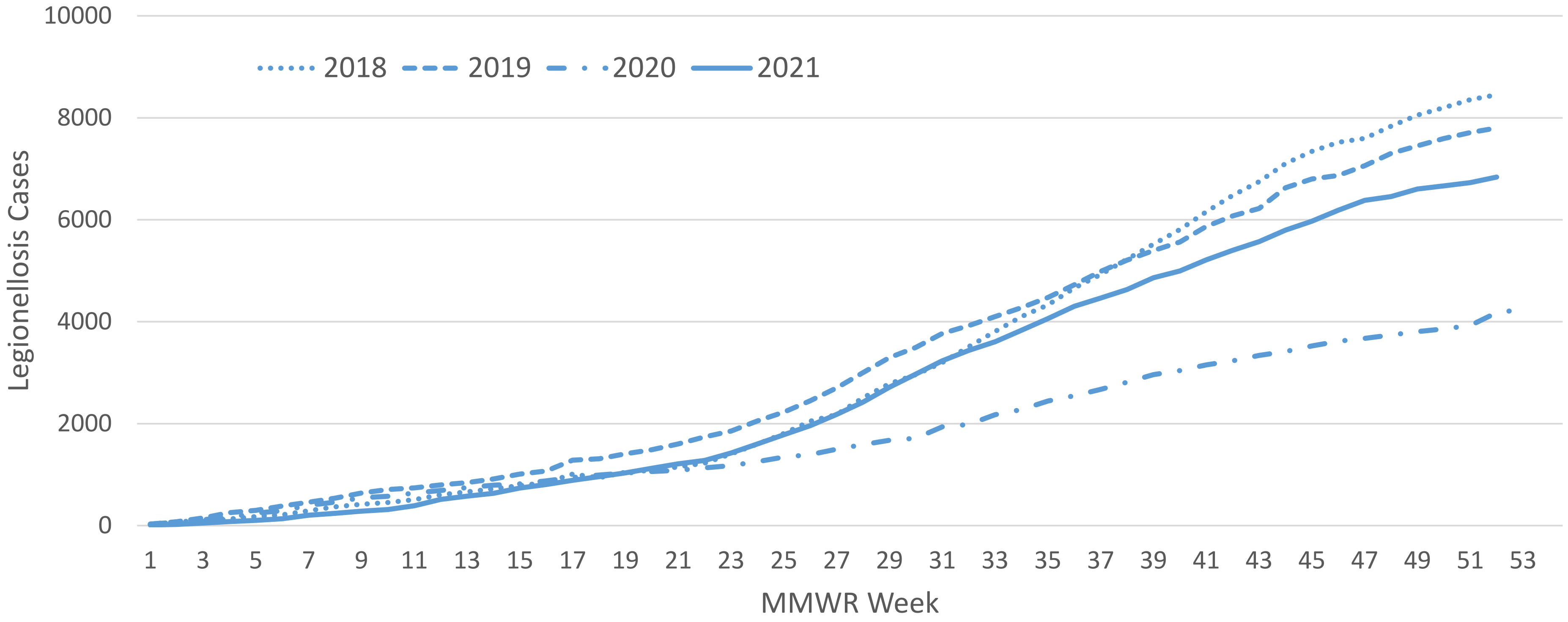
Cases and outbreaks

- Majority of LD cases reported to CDC are not associated with a known cluster
  - <5% are part of an outbreak
  - >60% have no reported exposures (hot tub, travel, healthcare)
- Likely an underestimate of the true burden of outbreak-associated disease
  - GA enhanced their case questionnaire in 2017
    - Outbreak-associated cases jumped to 14%
- Outbreak reporting to CDC is voluntary
  - Huge variability in % of identified outbreaks reported by state

Potential COVID-19 impacts on LD cases and surveillance

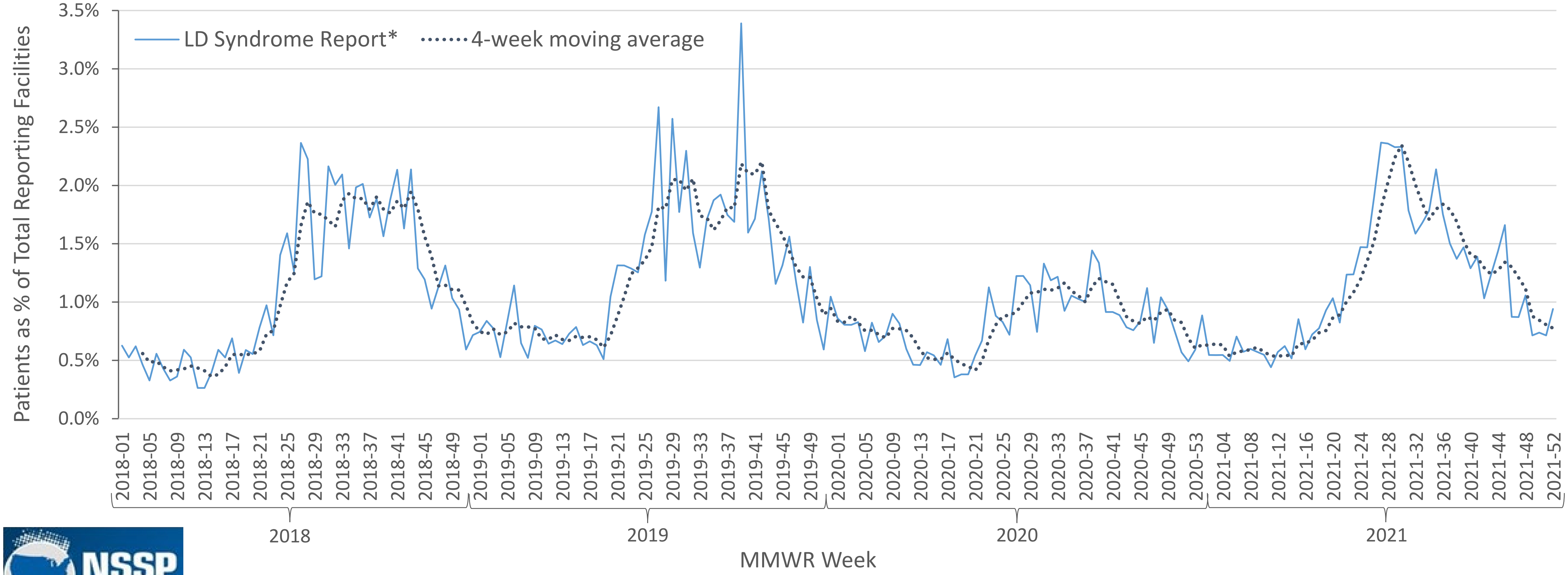
Changes in Reported Cases

Cumulative LD Cases Reported to NNDSS by MMWR Week, 2018–2021



These are preliminary data reported into NNDSS weekly and available through CDC WONDER. These are not final data for any of the years presented.

Changes in Incidence
ED Visits Meeting LD Syndrome in the US, 2018–2021



*Adjusted by total number of facilities reporting syndromic surveillance data to NSSP

Changes in Epidemiology in 2020

Potential to reduce LD incidence

- Reduction in travel overall
- Reduction in healthcare exposures

Potential to increase LD incidence

- Changes in travel accommodation preferences
- Increases in recreational water exposure
- Increases in gardening and other activities
- **Exposure to systems with stagnant water**

Questions?

Chris Edens, PhD
Epidemiologist
iek4@cdc.gov

Resources

- **PreventLD Training:** https://www.cdc.gov/nceh/ehs/elearn/prevent-LD-training.html
- **Toolkit: Developing a Water Management Program to Reduce *Legionella* Growth and Spread in Buildings:** https://www.cdc.gov/legionella/wmp/toolkit/index.html
- **Toolkit for Controlling *Legionella* in Common Sources of Exposure:** https://www.cdc.gov/legionella/wmp/control-toolkit/index.html
- ***Legionella* Environmental Assessment Form:** https://www.cdc.gov/legionella/downloads/legionella-environmental-assessment.pdf
- ***Legionella* Environmental Assessment Form Marking Guide:** https://www.cdc.gov/legionella/downloads/legionella-environmental-assessment-marking-guide-508.pdf
- **Considerations for Hotel Owners and Managers:** https://www.cdc.gov/legionella/wmp/hotel-owners-managers.html
- **Considerations for Vacation Rental Owners and Managers:** https://www.cdc.gov/legionella/wmp/vacation-rental.html
- **Preventing Waterborne Germs at Home:** https://www.cdc.gov/healthywater/drinking/preventing-waterborne-germs-at-home.html
- **CDC Building Reopening Guidance:** www.cdc.gov/coronavirus/2019-ncov/php/building-water-system.html
- **EPA Guidance for Maintaining or Restoring Water Quality in Buildings with Low or No Use:** https://www.epa.gov/coronavirus/information-maintaining-or-restoring-water-quality-buildings-low-or-no-use
- **AWWA, IAPMO, Responding to Water Stagnation in Buildings with Reduced or No Water Use:** https://www.awwa.org/Portals/0/AWWA/Government/20201001FrameworkforBuildingManagersFINALDistCopy.pdf
- **ASHRAE Standard 188 & Guideline 12:** https://www.ashrae.org/technical-resources/standards-and-guidelines/guidance-on-reducing-the-risk-of-legionella

Technical Panel

Shawn McElmurry, Chris Owen, Vanessa Speight

15 Minute Break

12:30 – 12:45 pm ET

Segment 3: Existing Regulatory and Policy Context for Risk-Balancing Interdependencies

November 3, 2022

Richard Weisman, U.S. EPA OGWDW
Rob Greenwood, Ross Strategic

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Presentation Overview

- Monitoring requirements
- Treatment technique requirement for D/DBPRs
- Disinfection benchmark and profiling
- Consecutive systems including requirements for both microbials and DBPs
- Requirements for sanitary surveys for surface water systems
- Compliance analysis

Disinfectant Residual Monitoring Requirements in Distribution System (DS) under SWTR

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- Residuals in the distribution system must be measured at least at the same points and at the same time as Total Coliform (TC) are sampled (including routine or repeat samples, and additional samples for evaluations) (40 CFR 141.74; Analytical and monitoring requirements.)
  - The state may allow a public water system which uses both a surface water source, and a ground water source to take disinfectant residual samples at points other than the TC sampling points if the state determines that such points are more representative of treated (disinfected) water quality within the distribution system.
- Minimum number of monthly routine TC samples depends on the population served.
- All PWSs must collect TC samples according to a written sample siting plan, which is subject to state review and revision.
- This plan ensures samples are collected at locations representative of the entire distribution system.
- Systems must collect samples at regular time intervals throughout the month.

Minimum Number of Routine TC Samples per Month for PWSs under RTCR

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Public Water System ROUTINE Monitoring Frequencies					
Population	Minimum Samples/ Month	Population	Minimum Samples/ Month	Population	Minimum Samples/ Month
25-1,000*	1	21,501-25,000	25	450,001-600,000	210
1,001-2,500	2	25,001-33,000	30	600,001-780,000	240
2,501-3,300	3	33,001-41,000	40	780,001-970,000	270
3,301-4,100	4	41,001-50,000	50	970,001-1,230,000	300
4,101-4,900	5	50,001-59,000	60	1,230,001-1,520,000	330
4,901-5,800	6	59,001-70,000	70	1,520,001-1,850,000	360
5,801-6,700	7	70,001-83,000	80	1,850,001-2,270,000	390
6,701-7,600	8	83,001-96,000	90	2,270,001-3,020,000	420
7,601-8,500	9	96,001-130,000	100	3,020,001-3,960,000	450
8,501-12,900	10	130,001-220,000	120	≥ 3,960,001	480
12,901-17,200	15	220,001-320,000	150		
17,201-21,500	20	320,001-450,000	180		

*Includes PWSs which have at least 15 service connections, but serve <25 people.

Source: 40 CFR 141.21; Coliform sampling.

IDSE vs Routine Monitoring Requirements under Stage 2 D/DBPR for THM4 and HAA5

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Source Water	Population	Monitoring Requirements under IDSE (One Time)		Routine Monitoring Requirements		
		Number of Locations	Number of Samples	Frequency	Total DS Locations	Total number of Samples per Year
Subpart H	< 500	3	3	Per year[1]	2	2
	500 - 3,300	3	9	Per quarter	2	8
	3,301 – 9,999	6	36		2	8
	10,000 – 49,000	12	72		4	16
	50,000 – 249,999	24	144		8	32
	250,000 - 999,999	36	216		12	48
	1,000,000 - 4,999,999	48	288		16	64
	≥ 5,000,000	60	360		20	80
Ground Water	< 500	3	3	Per year[1]	2	2
	500 - 9,999	3	9		2	2
	10,000 – 99,999	12	48	Per quarter	4	16
	100,000 - 499,999	18	72		6	24
	≥ 500,000	24	96		8	32

1. Systems serving < 10,000 and Subpart H systems serving < 500 must increase monitoring to quarterly if an MCL is exceeded.

- One-time Monitoring Requirements under Initial DS Evaluation (IDSE):
  - To identify high THM4 and HAA5 occurrence sites throughout DS
  - Based on source water type and system size
  - Additional data sources used such as grandfathered data and models
- Routine Compliance Monitoring Requirements:
  - Based on source water type and system size
  - Selection of monitoring sites: combination of high DBP sites under IDSE and selected existing Stage 1 monitoring sites
- Compliance monitoring plans must be submitted to primacy agencies.

Treatment Technique Requirement – Stage 1 D/DBPR

	Source Water Alkalinity, mg/L as CaCO3		
Source Water TOC (mg/L)	0 - 60	> 60 to 120	> 120
> 2.0 to 4.0	35.0%	25.0%	15.0%
> 4.0 to 8.0	45.0%	35.0%	25.0%
> 8.0	50.0%	40.0%	30.0%

- Subpart H systems that use conventional coagulation treatment are required to remove specific percentages of organic matter, measured as total organic carbon (TOC), that may react with disinfectants to form DBPs.
- Removal must be achieved through a treatment technique (enhanced coagulation or enhanced softening) unless a system meets alternative criteria. Systems practicing softening must meet TOC removal requirements for source water alkalinity greater than 120 mg/L $CaCO_3$.
- TOC removal requirements using the 3x3 matrix were set with the intent that 90% of affected systems would be able to achieve them.
- Alternative performance criteria were included when it was technically infeasible for systems to meet the 3x3 matrix removal requirements.
- Alternative TOC removal percentage may be determined by performing jar tests on at least a quarterly basis for one year and the alternate percentage set at the point of diminishing return.
- It was assumed that utilities would design the treatment process to removal TOC with a 15% safety factor (e.g., 34.5% removal to reliably achieve a 30% removal).

Key Existing Requirements for Interdependencies

Today's Presentation

Drinking Water Value Chain	Contaminants of Concern		
	Microbials	Interdependencies	DBPs
Source Water			
Treatment			
Distribution			
Premise			

Key Existing Treatment Requirements for Interdependencies – Disinfection Benchmark and Profiling (IESWTR and LT1)

- Public water systems must evaluate impacts on microbial risk before changing disinfection practices to ensure adequate protection is maintained. Significant changes to disinfection practice include:
  - Changes to the point of disinfection.
  - Changes to the disinfectant(s) used in the treatment plant.
  - Changes to the disinfection process.
  - Any other modification identified by the state as a significant change to disinfection practice.
- Includes three major steps:
  - Determine if a public water system needs to profile based on TTHM and HAA5 levels (applicability monitoring) (annual average level TTHM > 0.064 mg/L or HAA5 > 0.048 mg/L);
  - Develop a disinfection profile that reflects daily *Giardia lamblia* inactivation for at least a year (systems using ozone or chloramines must also calculate inactivation of viruses); and
  - Calculate a disinfection benchmark (lowest monthly inactivation) based on the profile and consult with the state prior to making a significant change to disinfection practices.
- EPA provided a Disinfection Profiling and Benchmarking Guidance Manual to assist with making these calculations.

Key Existing Distribution System Requirements for Interdependencies – Consecutive Systems

- Consecutive systems meet the same requirements for D/DBPR MCLs and MRDLs, and SWTR disinfectant residuals in distribution systems, as non-consecutive systems.
- Consecutive and wholesale systems must determine their compliance schedules based on the population of the largest system in the combined distribution system.
- The provisions for consecutive systems under 40 CFR 141.29 allow the State to modify the monitoring requirements for combined distribution systems. When justified, the State may treat the combined distribution system as a single system for monitoring purposes. Such systems must follow a monitoring schedule specified by the State and concurred with by the Administrator of the EPA.

Key Existing Cross-Cutting Requirements for Interdependencies – Sanitary Surveys

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- Sanitary surveys are conducted at all PWSs in the United States to assess the PWS's capability to supply safe drinking water. These surveys are used to identify risks or deficiencies within water system infrastructure, operations, and management and are an important tool for primacy agencies to oversee and assist PWSs in complying with SDWA.
- States or other agencies with primacy are responsible for completing sanitary surveys and reporting information collected to USEPA.
- Sanitary surveys are conducted once every 3 years for community water systems (every 5 years for noncommunity water systems) for all surface water and GWUDI systems regardless of size.
- Deficiencies found during sanitary surveys may be classified as significant or minor.
    - They help to characterize the potential challenges faced by water systems in providing safe drinking water and assists systems and regulatory authorities prioritize risk management efforts and provide technical assistance.

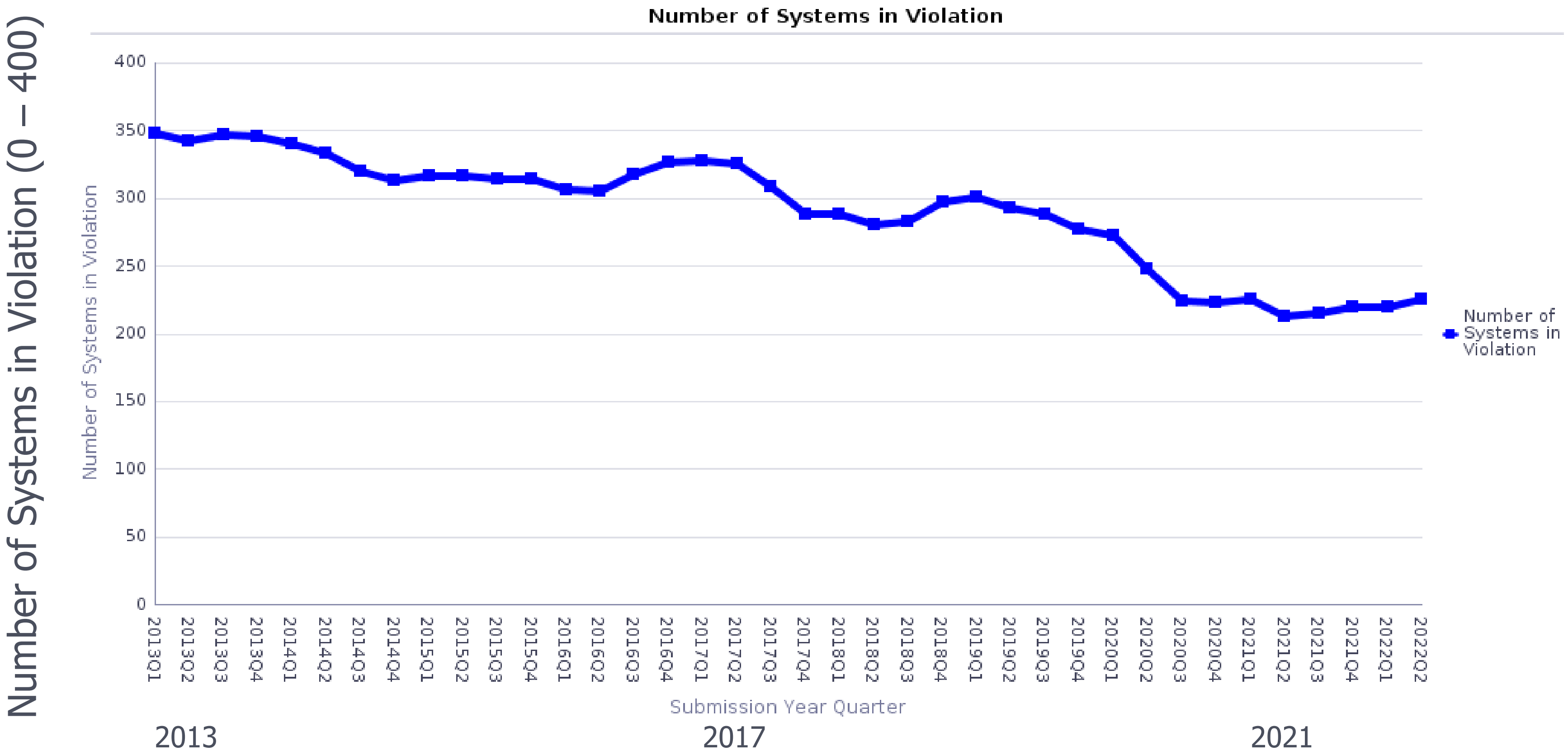
Compliance Analysis – Selected Results

- Previous meeting presented on violations for D/DBPRs including from In-Depth analysis about consecutive systems.
- Additional information relevant to D/DBPR non-compliance:
  - D/DBPRs (Stage 2) have the most health-based (HB) violations, however over the last five years the number of systems with D/DBPR violations has decreased by 41%.
  - Most D/DBPR violations (FY 21) occur at SW systems (64%).
  - Half (50%) of all HB violations at SW systems are D/DBPR (FY 21); for GW systems only 17% of HB violations are D/DBPR.

Examples of Violation Types under SWTR, IESWTR, and LT1

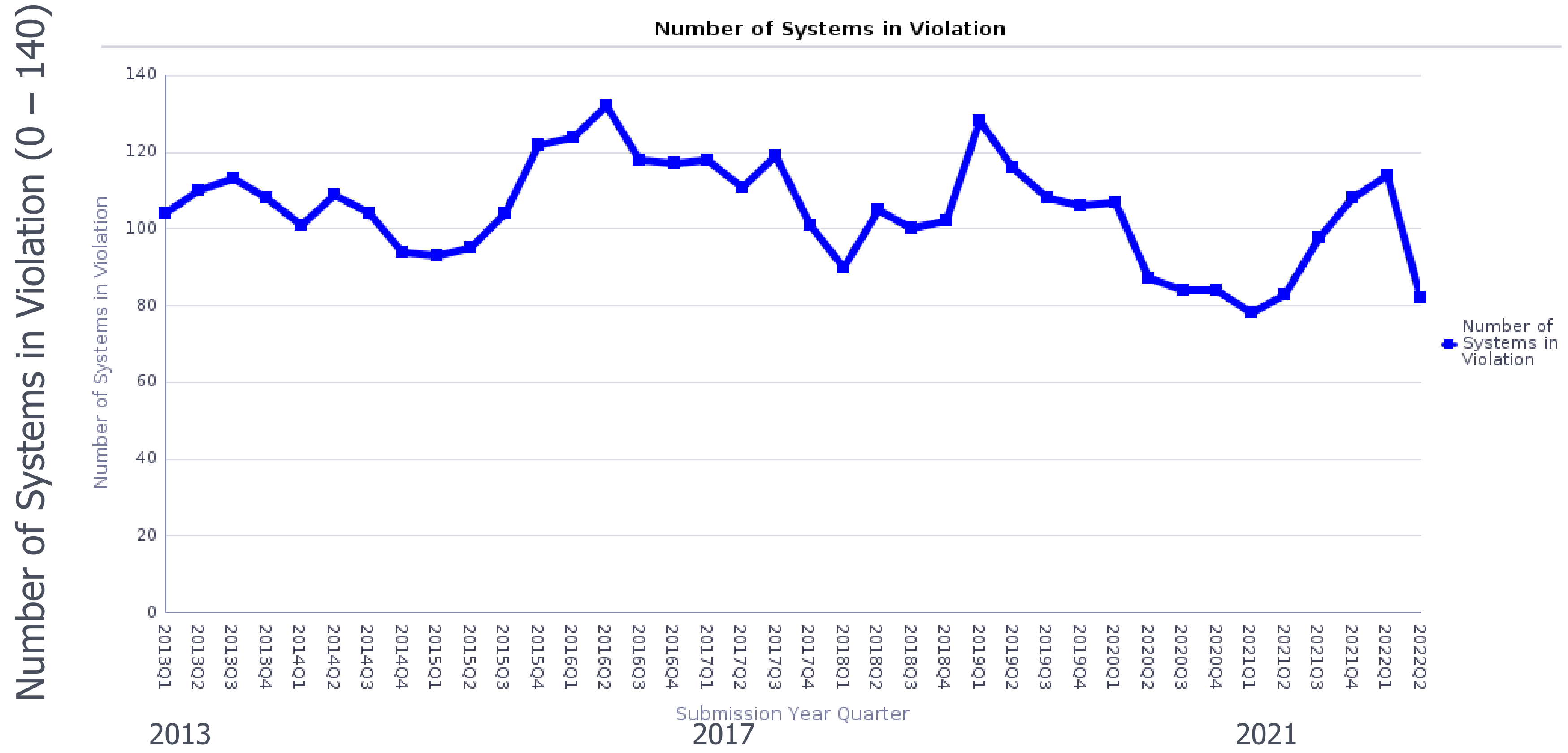
- Treatment Technique
  - Failure to ensure total treatment achieves 99.9% (3-log) inactivation and/or removal of *Giardia* and at least 99.99% (4-log) inactivation and/or removal viruses as determined by the State. (SWTR)
  - A PWS using a surface water source or a GWUDI lacking operation by qualified personnel who meet the requirements specified by the State. (SWTR)
  - A system that does not maintain the residual disinfectant concentration level (0.2 mg/L) entering the distribution system for more than 4 hours, or more than 5% undetectable residual samples (violation doesn't result for the system until the second month of having no detectable residual in 5% or more of the samples). (SWTR)
  - A system that fails to profile or consult with the state before making a significant change to a disinfection practice if required to develop a disinfection profile. (IESWTR and LT1)
  - A conventional or direct filtration system that fails to meet the turbidity requirements. (IESWTR and LT1)
- Monitoring and Reporting
  - Failure to collect and/or report required 1) turbidity samples; or 2) entry point disinfectant residual concentrations; or 3) distribution system disinfectant concentrations from a filtered water system.

EPA Compliance Monitoring Time Series Data – Health-based Violations of SWTR; Number of Systems in Violation



Source: SDWIS. Criteria: PWS_TYPE_CODE is equal to CWS; and RULE_CODE is not equal to / is not in 500; and NPM_CANDIDATE is equal to / is in Y; and VIOLATION_CATEGORY_DESCRIPTION is equal to Maximum Contaminant Level Violation, Treatment Technique Violation; and RULE_CODE_NAME is equal to SWTR.

EPA Compliance Monitoring Time Series Data – Health-based Violations of LT1



Source: SDWIS. Criteria: PWS_TYPE_CODE is equal to CWS; and RULE_CODE is not equal to / is not in 500; and NPM_CANDIDATE is equal to / is in Y; and VIOLATION_CATEGORY_DESCRIPTION is equal to Maximum Contaminant Level Violation, Treatment Technique Violation; and RULE_CODE_NAME is equal to Long-Term 1 ESWTR.

Segment 3: Regulatory and Policy Framework for D/DBPRs: Discussion Topics

- Clarifying Questions
- Based on your understanding, are there further features or aspects of the rules that you would like to highlight for WG consideration?
- Are there other aspects of the interdependencies of balancing risks while managing microbial pathogens and DBPs that you would like to learn more about to inform Working Group discussions, and why?

Lunch Break

Segment 4: Problem Characterization on Risk Balancing/Interdependencies

EPA & Technical Panel
Rob Greenwood, Ross Strategic

November 3, 2022

EPA

OFFICE OF GROUND WATER
AND DRINKING WATER

Disclaimer – Materials Not Developed or Provided by EPA

OFFICE OF GROUND WATER AND DRINKING WATER

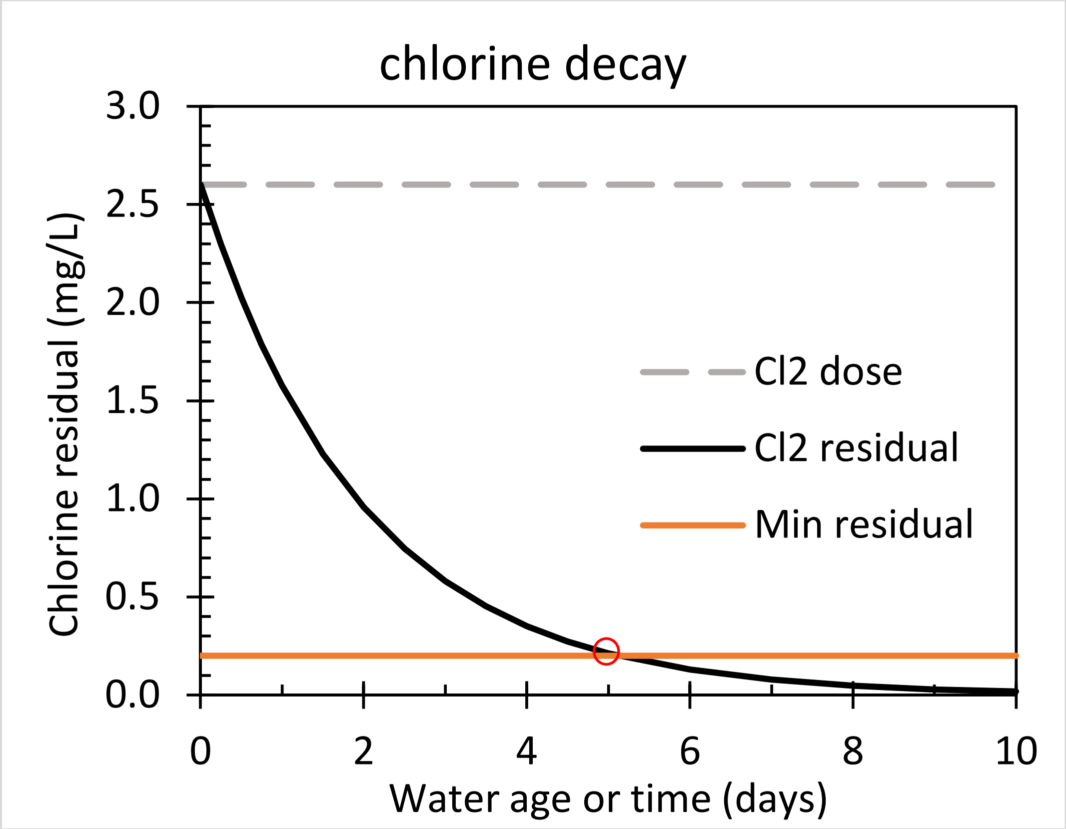
The following slides were developed by water industry experts, who are not employed by EPA. The content of these slides do not necessarily reflect EPA policies or positions.

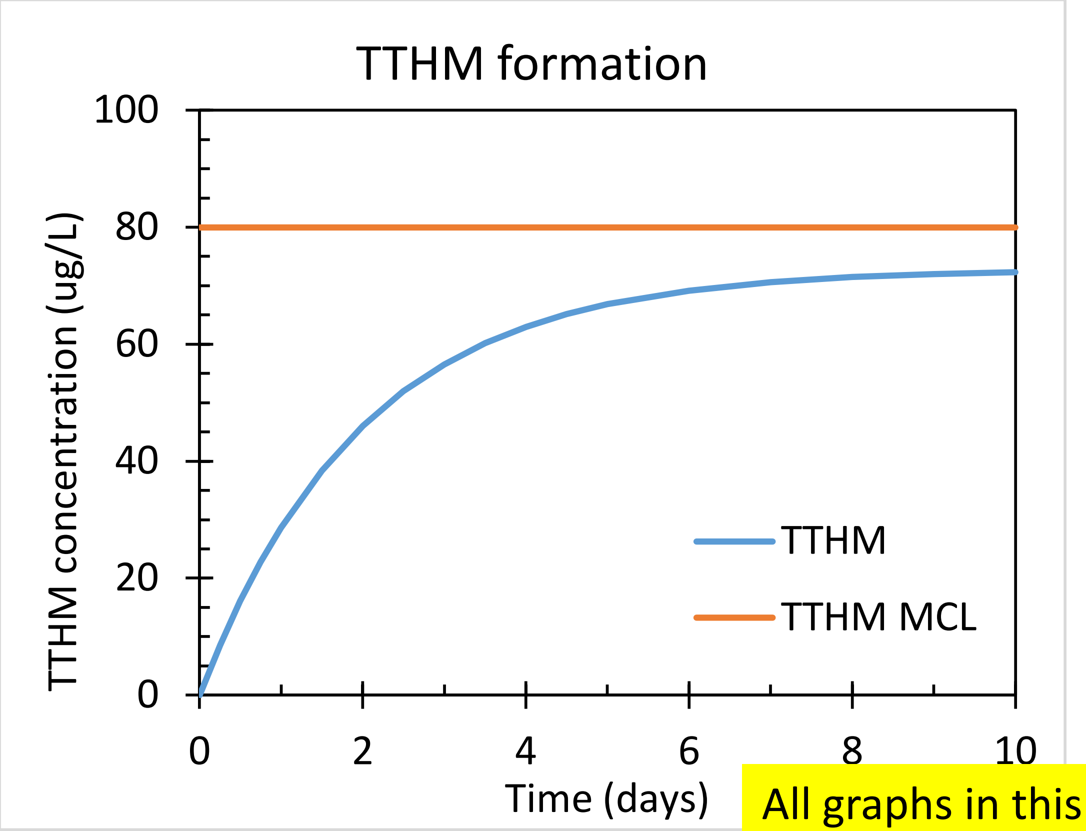
Impact of increasing disinfectant residuals on DBP levels in the distribution system

R. Scott Summers
University of Colorado – Boulder

11/01/2022

The Problem:
The need to meet a minimum chlorine residual without exceeding the disinfection byproduct MCL





All graphs in this presentation are meant to illustrate chlorine and DBP behavior

Three approaches for increasing disinfectant residual in the distribution system

A) Optimize distribution system (DS) management

B) Increase removal of compounds in the source water that react with chlorine

- Organic matter (OM) – natural organic matter (NOM) and wastewater effluent organic matter (EfOM) most often measured by total organic carbon (TOC)
- Inorganic compounds (e.g., Fe, Mn, NH_3)

C) Increase disinfectant dose

- We will focus on the use of chlorine as increasing the chloramine dose does not yield high levels of DBPs

All of theses can work and should be evaluated based on cost efficiency

Chlorine chemistry

Chlorine is a strong oxidant and very reactive

- Intended disinfection reaction

  Chlorine + pathogenic microbes → inactivated pathogens

- Byproduct reactions

  Chlorine

  + inorganic compounds (Fe, Mn, NH_3) → oxidized inorganics

  + organic matter (NOM + EfOM) → oxidized OM

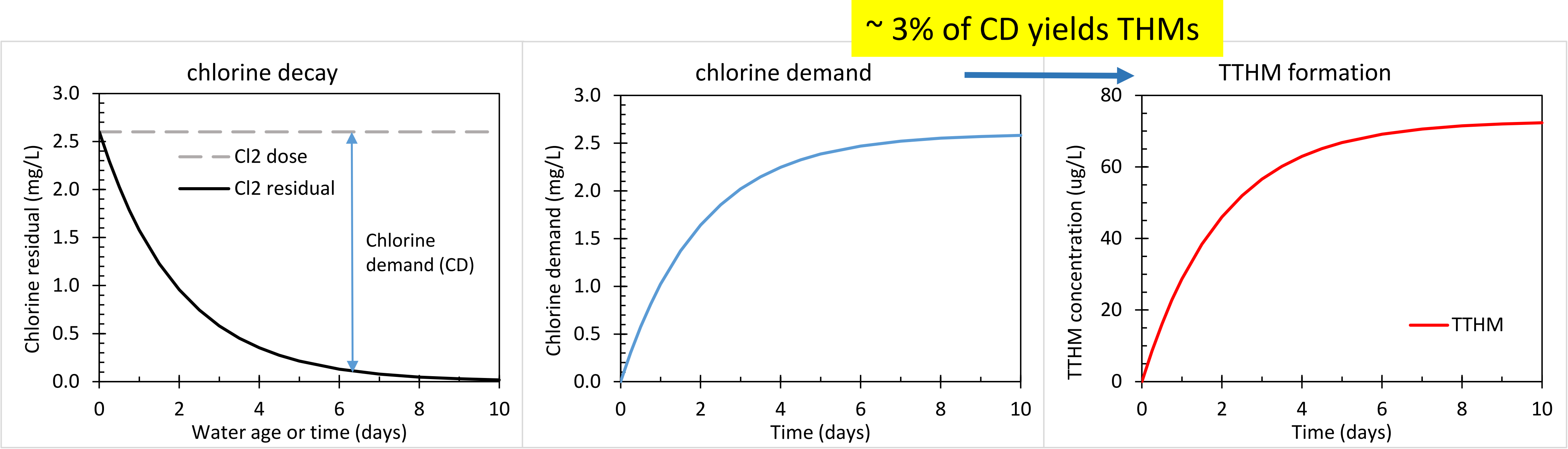
  → substituted OM

  organic DBPs, e.g., THMs

  + bromide → brominated DBPs

- ~90% of the reacted chlorine yields chloride (Cl^-) and ~10% yields DBPs

Relationship of chlorine dose to
a) chlorine residual,
b) chlorine demand and
c) DBP formation



Chlorine chemistry

- Inorganic compounds occur in the plant influent and in the distribution system as sediment and pipe walls

  controlling inorganic compounds <u>decreases</u> chlorine demand

- Organic matter occurs in the plant influent

  controlling OM <u>decreases</u> chlorine demand and most DBPs

- Both chlorine decay and DBP formation kinetics are impacted by temperature

  higher temperature yields <u>faster</u> chlorine decay and <u>more</u> rapid DBP formation

Waters with high levels of inorganic compounds and OM create high chlorine demand, especially at high temperatures

Distribution system best management practice (BMP) yields positive impacts on chlorine demand and DBPs

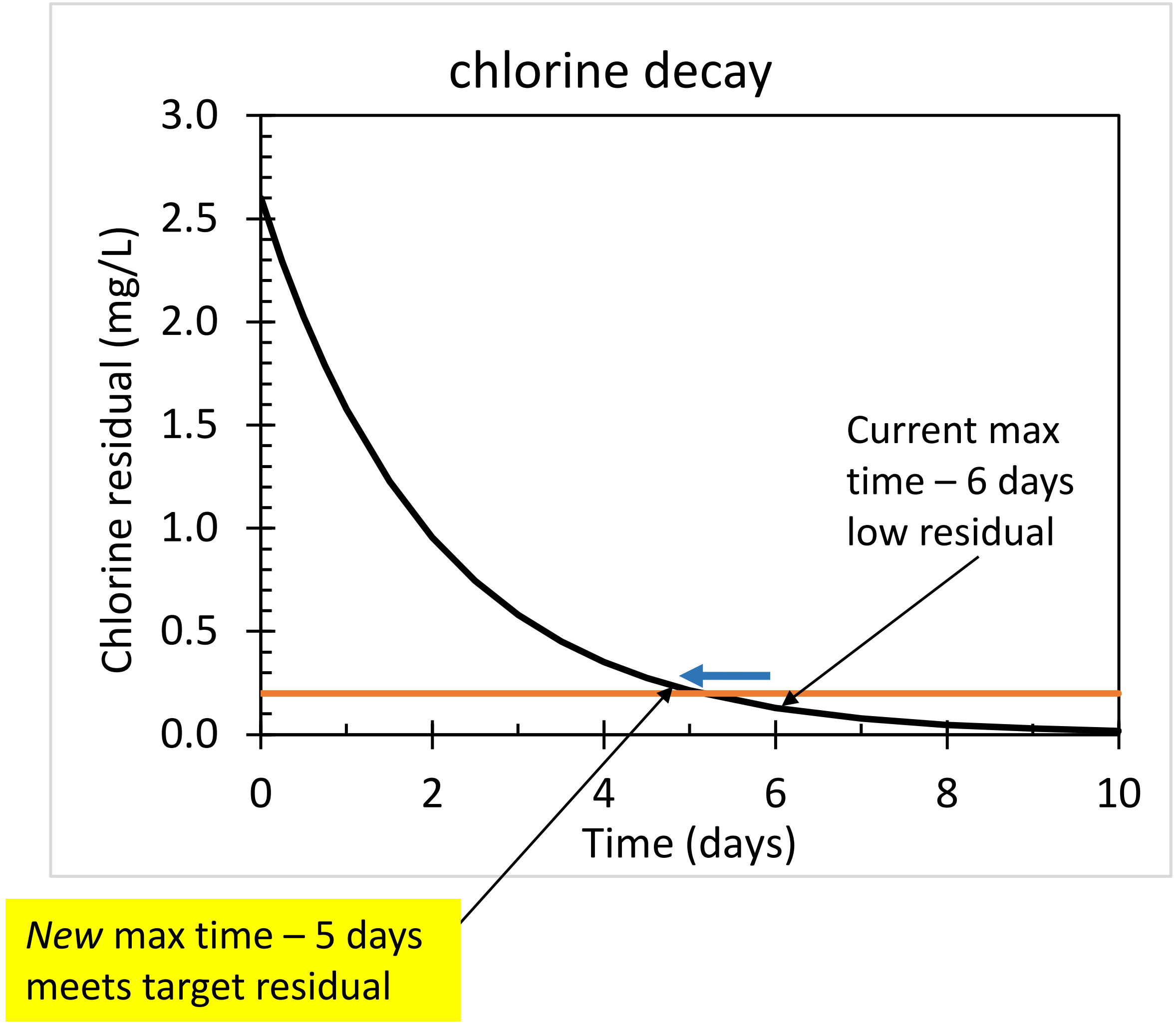
Successful distribution system best management practice has many facets
The following highlight the impact on chlorine demand and DBPs

- Flush sediments from pipe lines, corrosion control and old pipe replacement
  decreases inorganic compounds and chlorine demand
- Clean storage tanks
  decreases inorganic compounds and chlorine demand
- Optimize flow through storage tanks
  decreases water age, chlorine demand and DBP formation
  - a minimum water age is required for fire-fighting and lower insurance rates

Distribution system BMP reduces the chlorine dose needed to carry a residual to a target time in the distribution system

Distribution system hydraulic management

- Decrease the water age to the furthest point in the distribution system
  - re-route water path
  - minimize dead-ends
- Not always possible, as distribution system hydraulics may already be optimized



Optimized or additional treatment to remove chlorine demand and DBP precursors

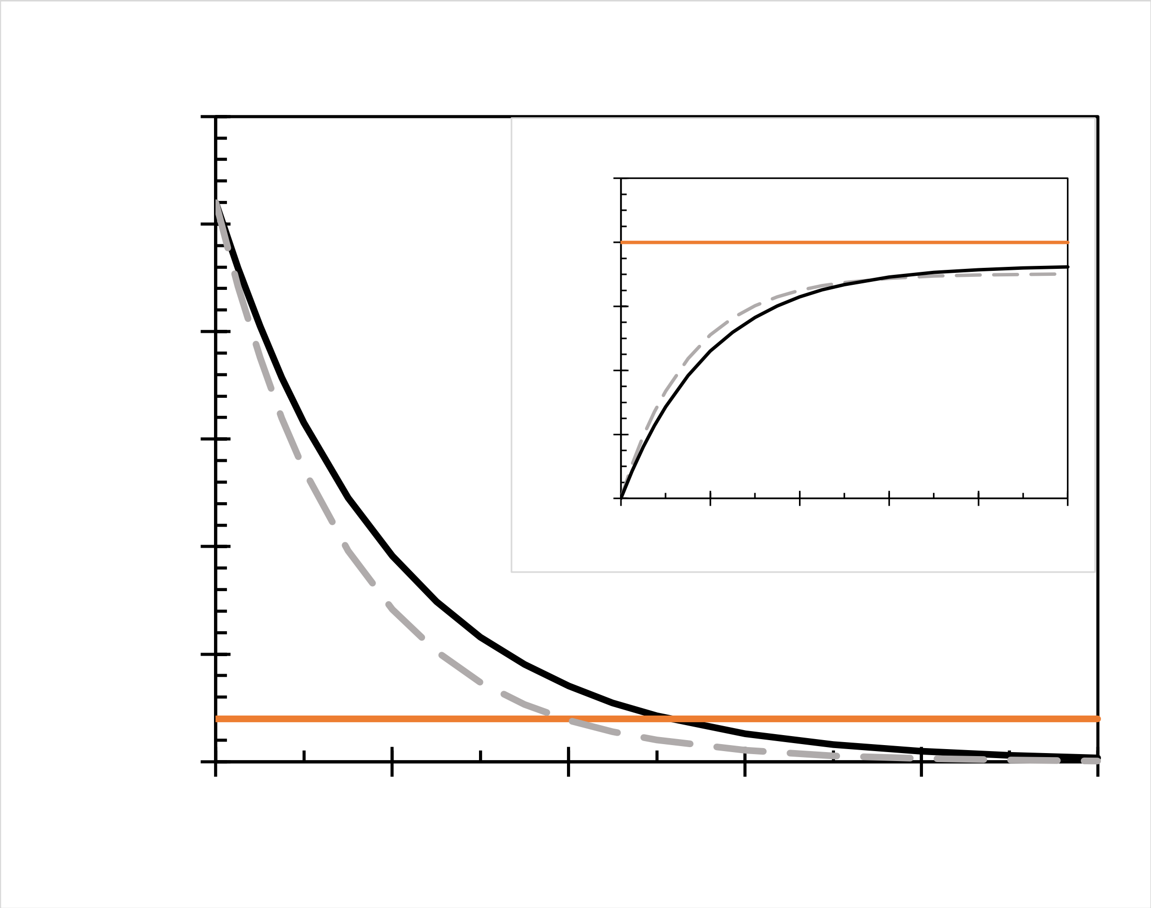
- Inorganic compounds (Fe, Mn, NH_3) and organic matter (NOM + EfOM) react with chlorine to increase the chlorine demand
- Organic matter (NOM + EfOM) reacts with chlorine to form DBPs

- These compounds are removed to some extent by "conventional" surface water treatment – try to optimize
- Advanced treatment, e.g., ozone, biotreatment and activated carbon adsorption, can removal more, but at a cost

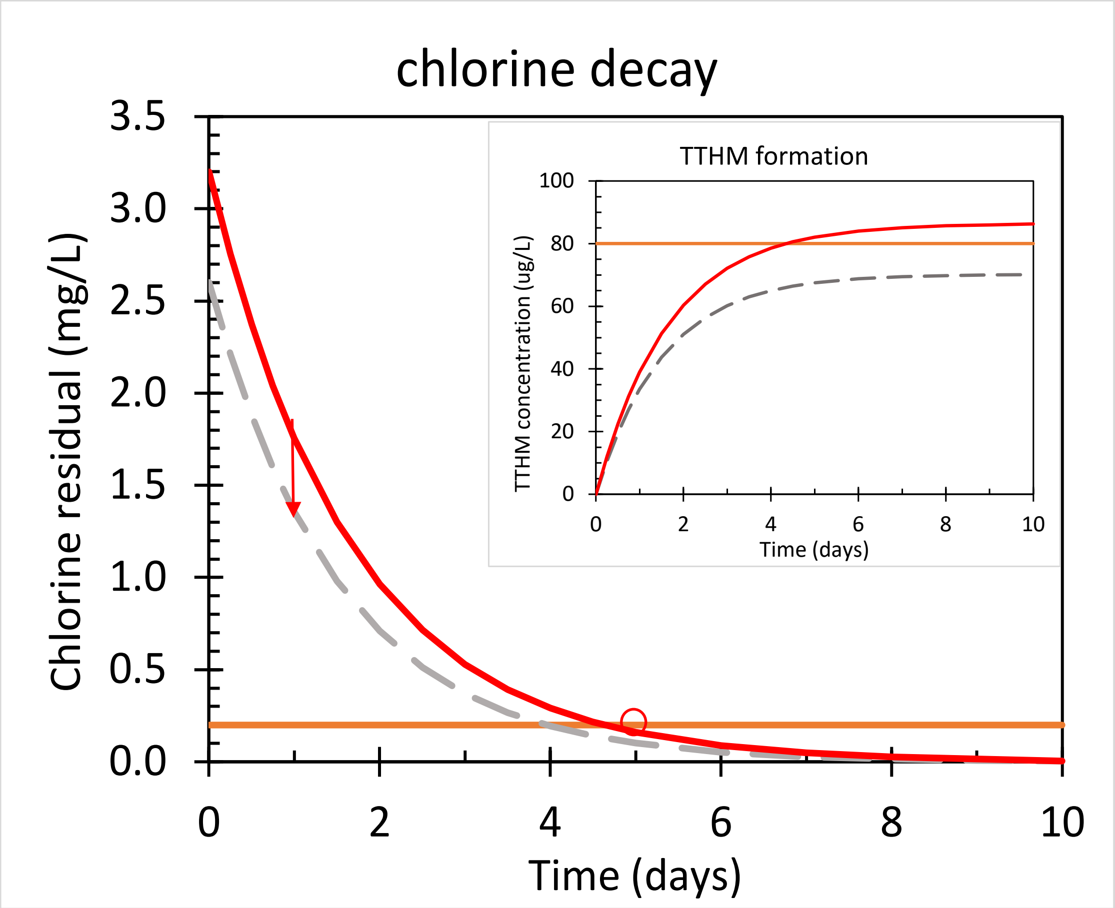
Additional treatment reduces the chlorine dose needed to carry a residual to a target time in the distribution system and lowers DBP formation

To meet a target residual at 5 days

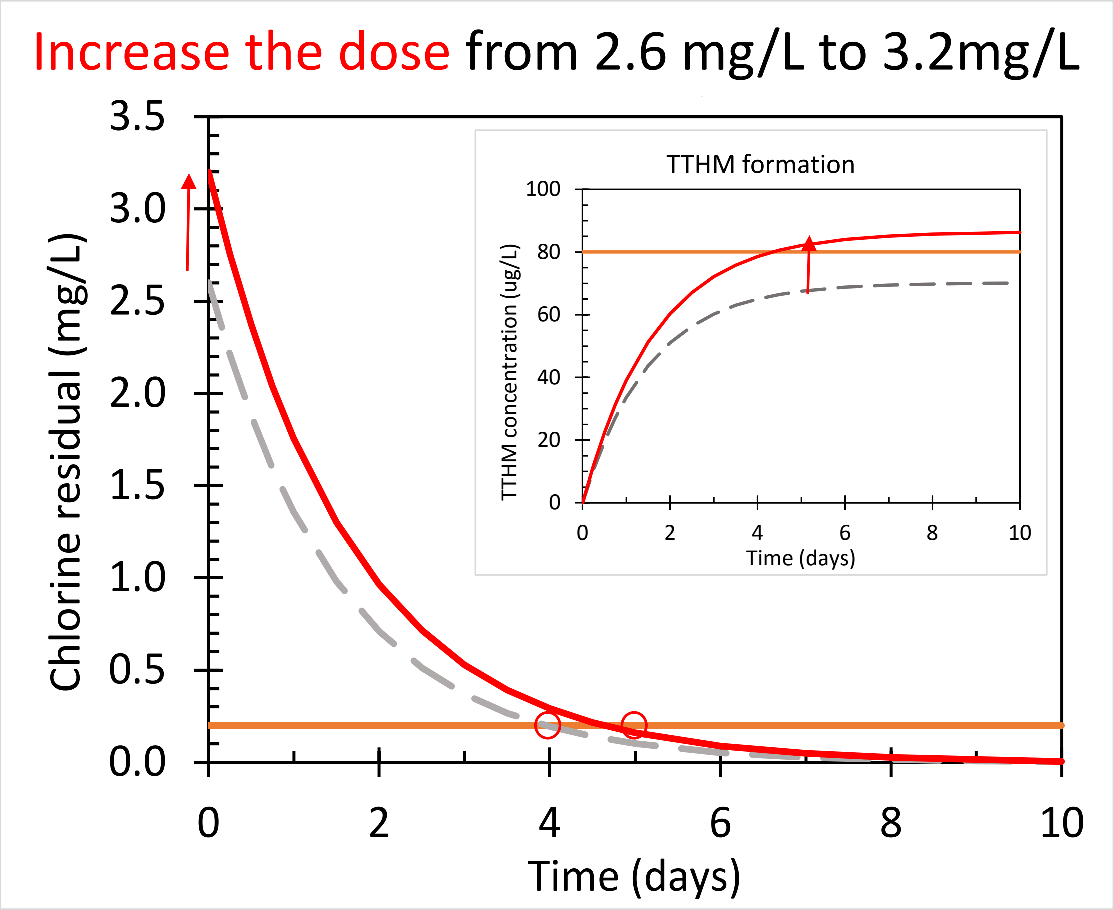
a) DS best management practice



b) additional treatment decreases the demand, the dose from 3.2 to 2.6 mg/L, and DBPs



Impact of increasing chlorine dose on chlorine residual to meet a target residual at 5 days

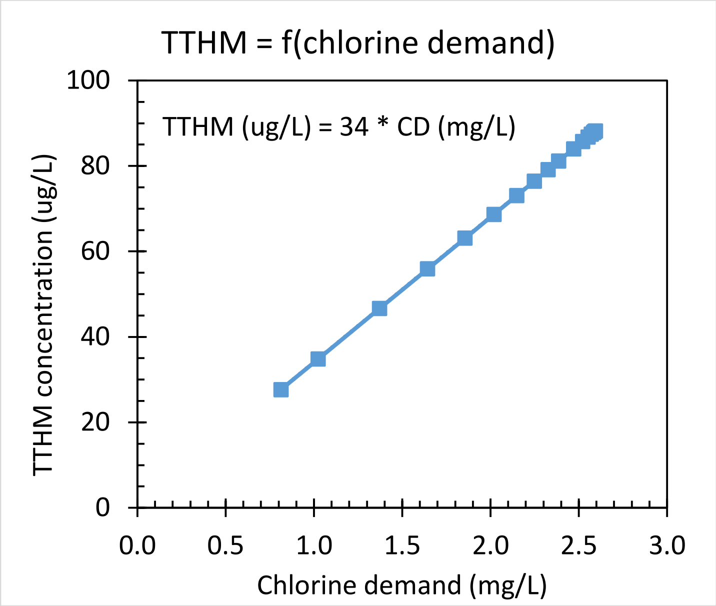


- After distribution system optimization - best management practice
- Evaluate the increase in DBPs caused by higher chlorine doses needed to increase the chlorine residual

Downside
Could increase
DBPs above MCL

Strong relationship between chlorine demand and TTHM formation

- From the chlorine DBP chemistry, we know that some of the chlorine consumed (or demanded) in water produces DBPs, e.g., TTHMs.



34 μg TTHM/ mg CD

Source	Waters	type	TTHM/CD ug/mg
Gallard and von Gunten, 2002	5	mixed	38
Gang et al., 2002	4	raw	40
	4	coag	30
Boccelli et al., 2003	4	finished	42
Valenti et al., 2007	8	finished	38
Roth et al., 2018	17	finished	25
Kennedy et al., 2020	3	mixed	53
	n= 45	**weighted mean =**	**34**

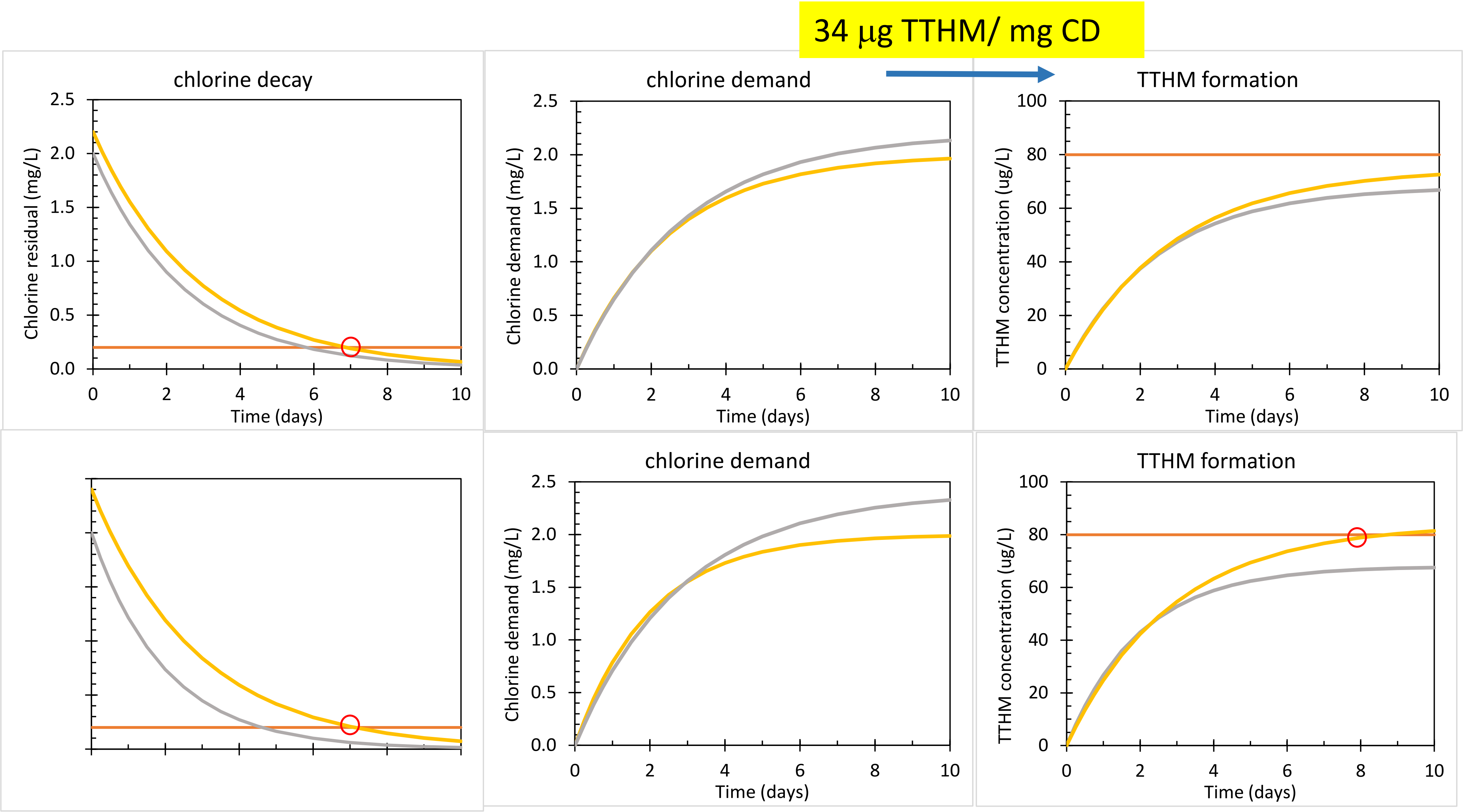
2.5 to 5.2 % yield

Only three studies looked at HAA5 – relationship not very clear

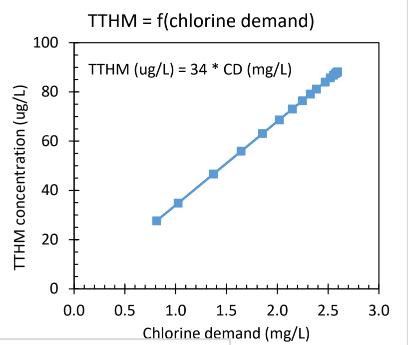
How can we use this TTHM/CD relationship to project the impact of a higher chlorine dose on the increase in TTHM?

Case 1- Increasing the dose from 2.0 to 2.2 mg/L meets the 7 day residual and MCL

Case 2- Increasing the dose from 2.0 to 2.4 mg/L meets the 7 day residual, but exceeds the MCL



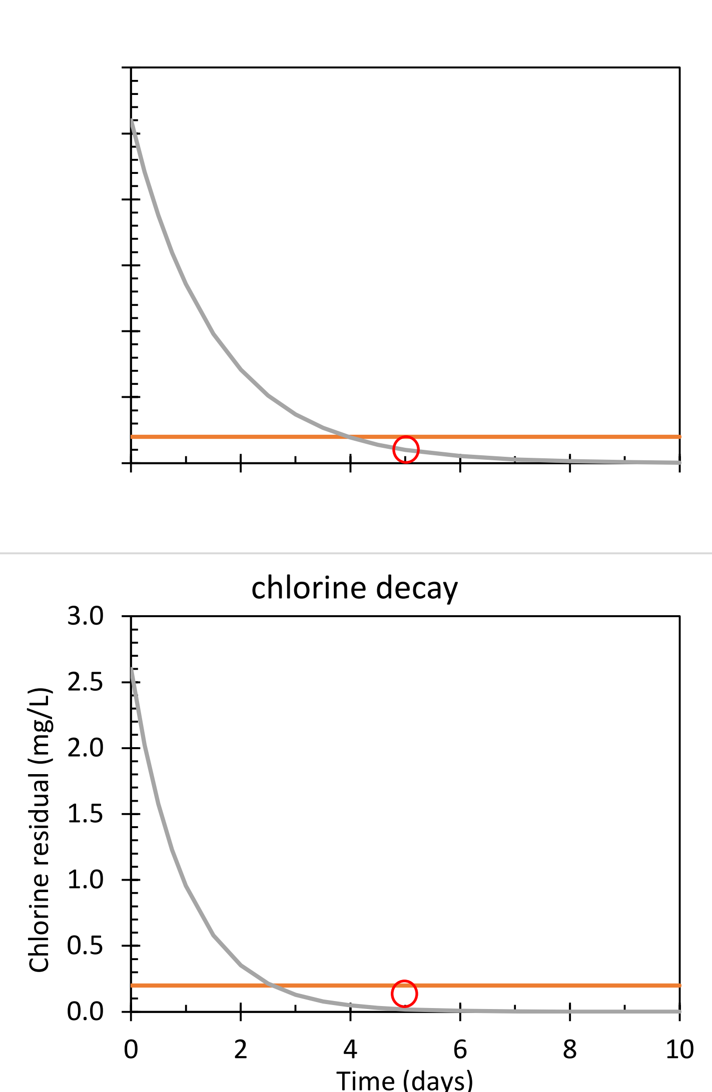
Projecting the increase in TTHMs caused by an increase in chlorine dose (demand)



If a trace residual in the distribution system is detected, then expect the following

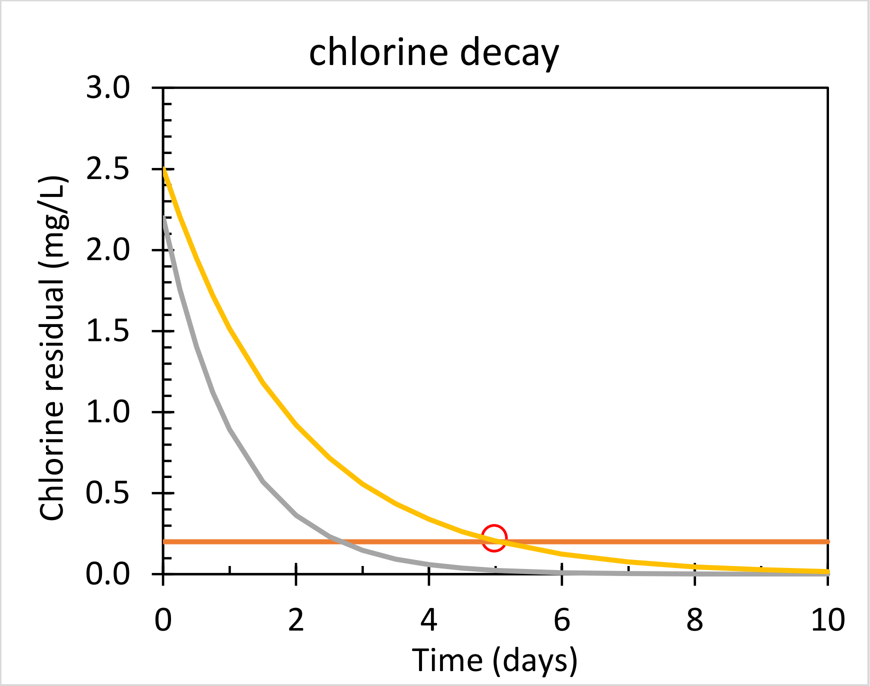
delta residual (mg/L)	delta TTHM (ug/L)			
	Median	-1 SD	+1 SD	highest
0.1	**3.4**	2.6	4.2	5.3
0.2	**6.8**	5.2	8.4	10.6
0.3	**10.2**	7.8	12.6	15.9

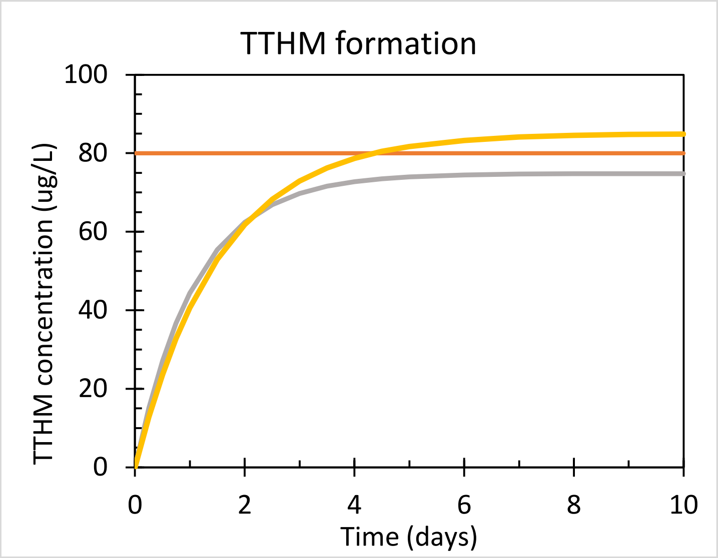
If a trace residual is **not** detected then you can't easily project the impact as all of the chlorine demand is not yet met at the time of interest



What happens when there is no trace chlorine residual?

- For example, increasing the dose from 2.2 to 2.5 mg/L and TTHM increases from 75 to 85 μg/L





Very difficult to predict because you may not know the water age at the point of minimum residual

Disinfectant residual in the distribution system can be increased without exceeding DBP MCLs

A) Optimize distribution system (DS) management

B) Increase disinfectant <u>dose</u>

- Check on DBP levels

C) Increase removal of compounds in the source water that react with chlorine

- Organic matter
- Inorganic compounds

All of theses can work and should be evaluated based on cost efficiency

Critical question

- What fraction of systems with TTHMs greater than ~ 65-70 μg/L, do not have chlorine residuals above an acceptable level?

or

What fraction of systems that do not have chlorine residuals above an acceptable level, have TTHMs greater than ~ 65-70 μg/L?

Formation of Emerging DBPs

Stuart Krasner

Formation of Emerging DBPs

- **Chlorination of drinking water forms regulated THMs and HAAs**
  - **In addition, forms unregulated HAAs and emerging DBPs**
    - **Emerging DBPs include nitrogen-containing DBPs (e.g., haloacetonitriles [HANs]), some of which are more toxic than regulated DBPs**
  - **In general, control of regulated DBPs controls the formation of many of the emerging DBPs**
    - **However, have more HAN formation in algal or wastewater-impacted drinking water**
- **Chloramination of drinking water forms less regulated THMs and HAAs**
  - **However, forms other DBPs (e.g., iodine-containing DBPs, nitrosamines [e.g., NDMA)**

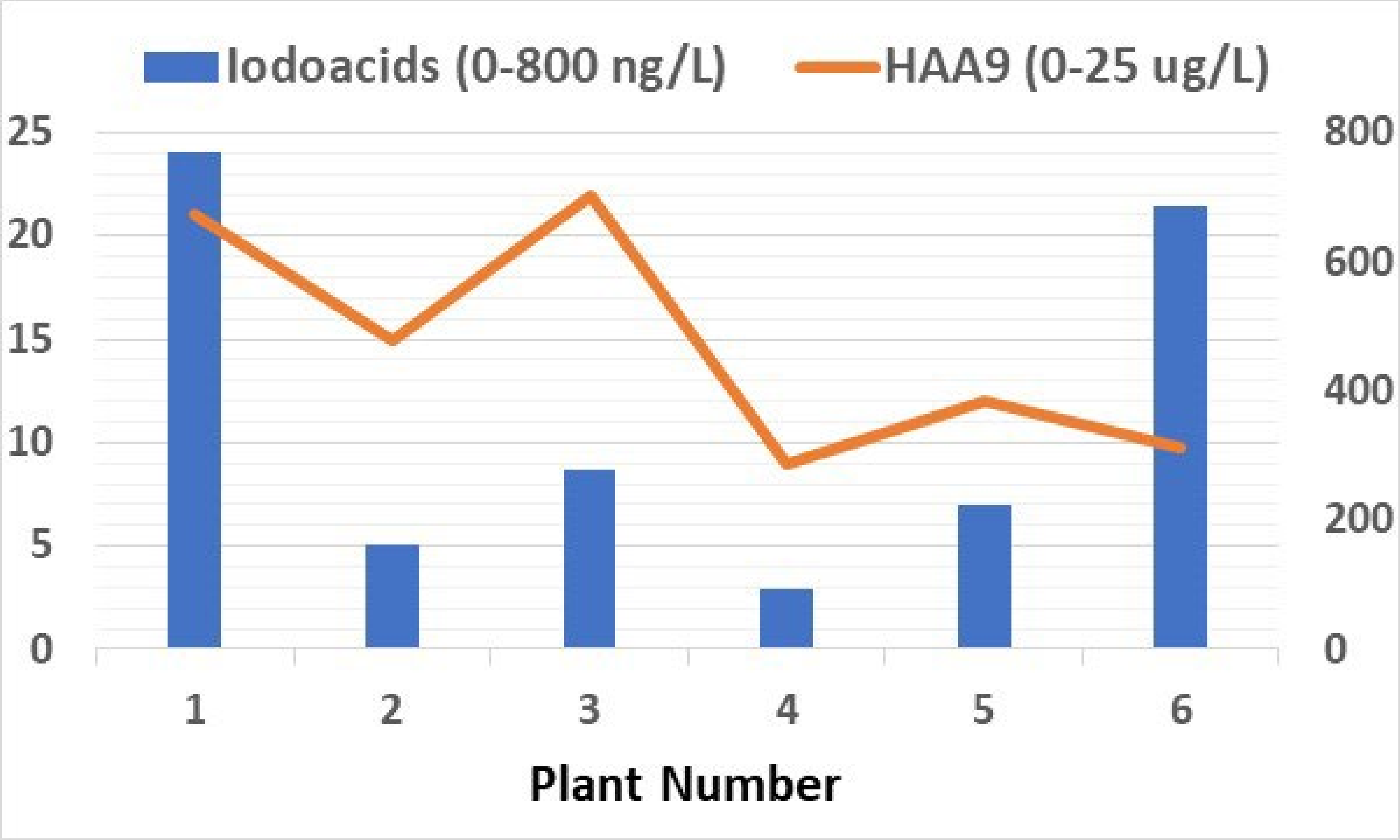
Occurrence of Emerging DBPs of Health Concern (Krasner et al., 2016, 2022)

DBP Class	Bromine-Containing Species	Nitrogen-Containing Species
Haloacetonitriles	X	X
Haloacetamides	X	X
Halonitromethanes	X	X
Haloacetaldehydes	X	
Haloketones	X	
Iodinated THMs	X	
Iodoacids	X	
Nitrosamines		X

Nitrogen-containing DBPs more toxic than regulated carbon-containing DBPs

Bromine-containing DBPs more toxic than chlorine-containing DBPs

Occurrence of Iodoacids and HAA9 in U.S. Study (Weinberg et al., 2011)



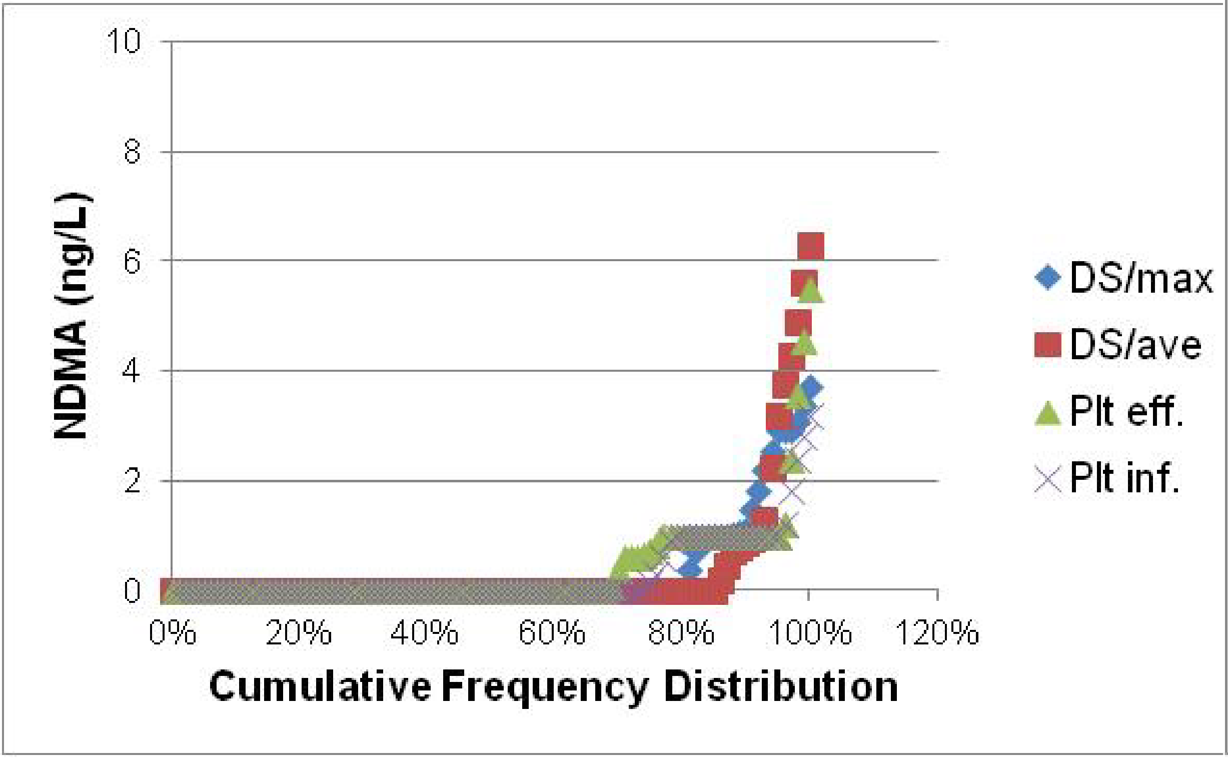
Formation of Iodinated DBPs (Weinberg et al., 2011)

- **Some waters have iodide in addition to bromide**
  - **Iodinated DBPs preferentially formed in chloraminated waters**
    - **However, with waters with chlorine or ozone as the primary disinfectant and chloramines as the secondary disinfectant, form less iodinated DBPs**
      - **e.g., 2 plants (chlorine/chloramines) in EPA Region 6**

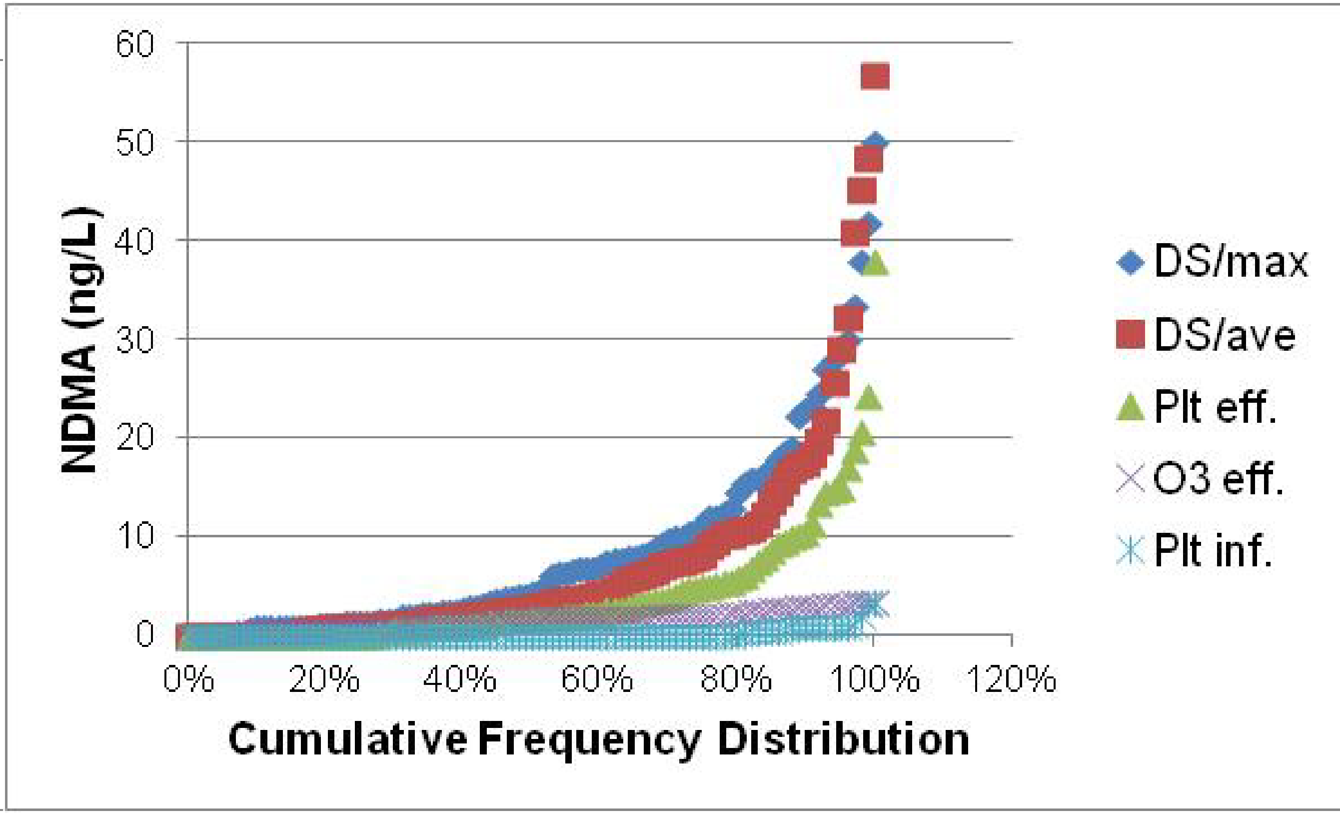
Plant	Free Chlorine Contact Time	Iodine (µgL)	Iodoacids (ng/L)
1	2.2 minutes	30	769
2	1.3 hours	53	161

Occurrence of N-Nitrosodimethylamine (NDMA) in North American Study (Krasner et al., 2020)

Chlorine Plants



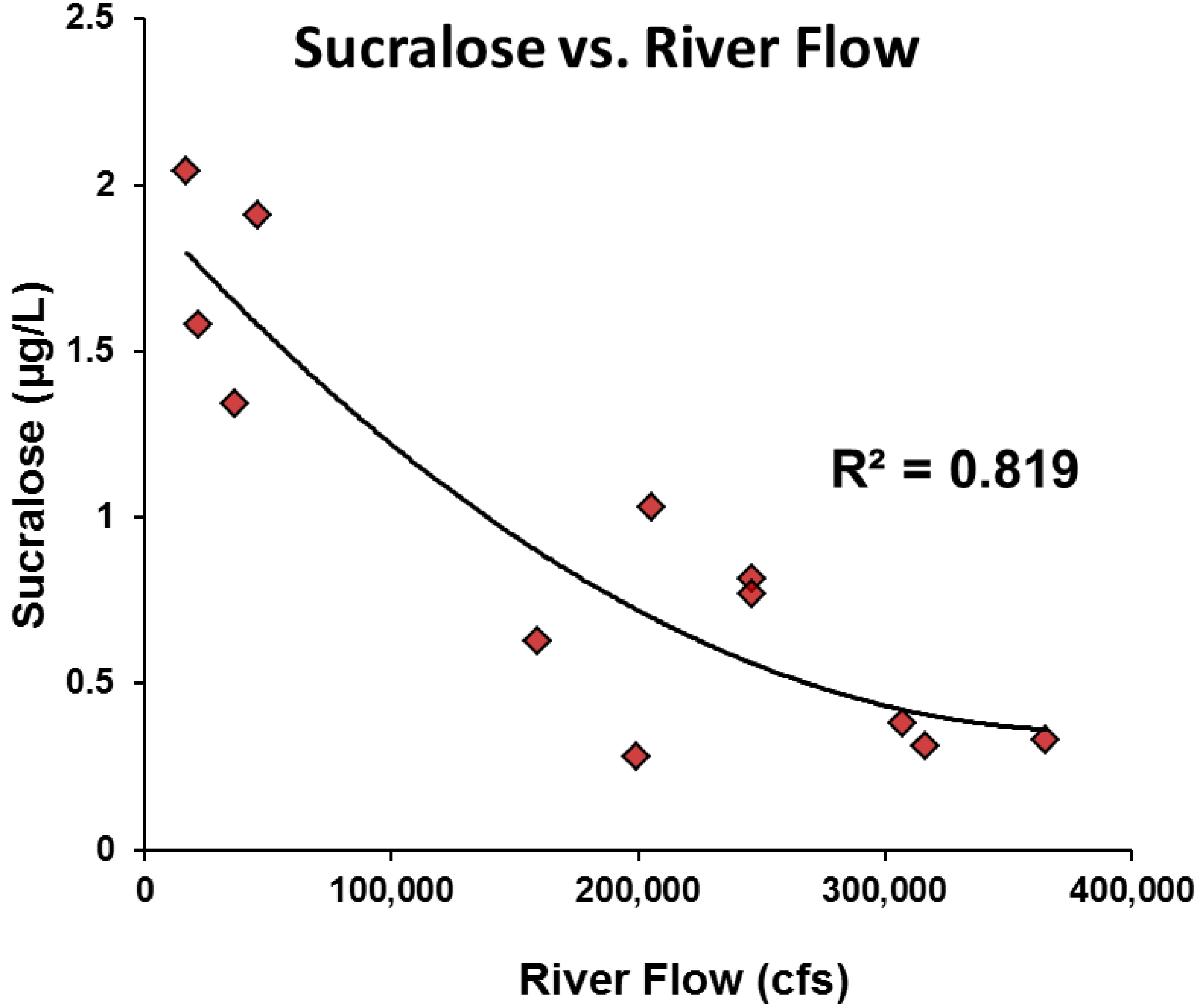
Chloramine Plants

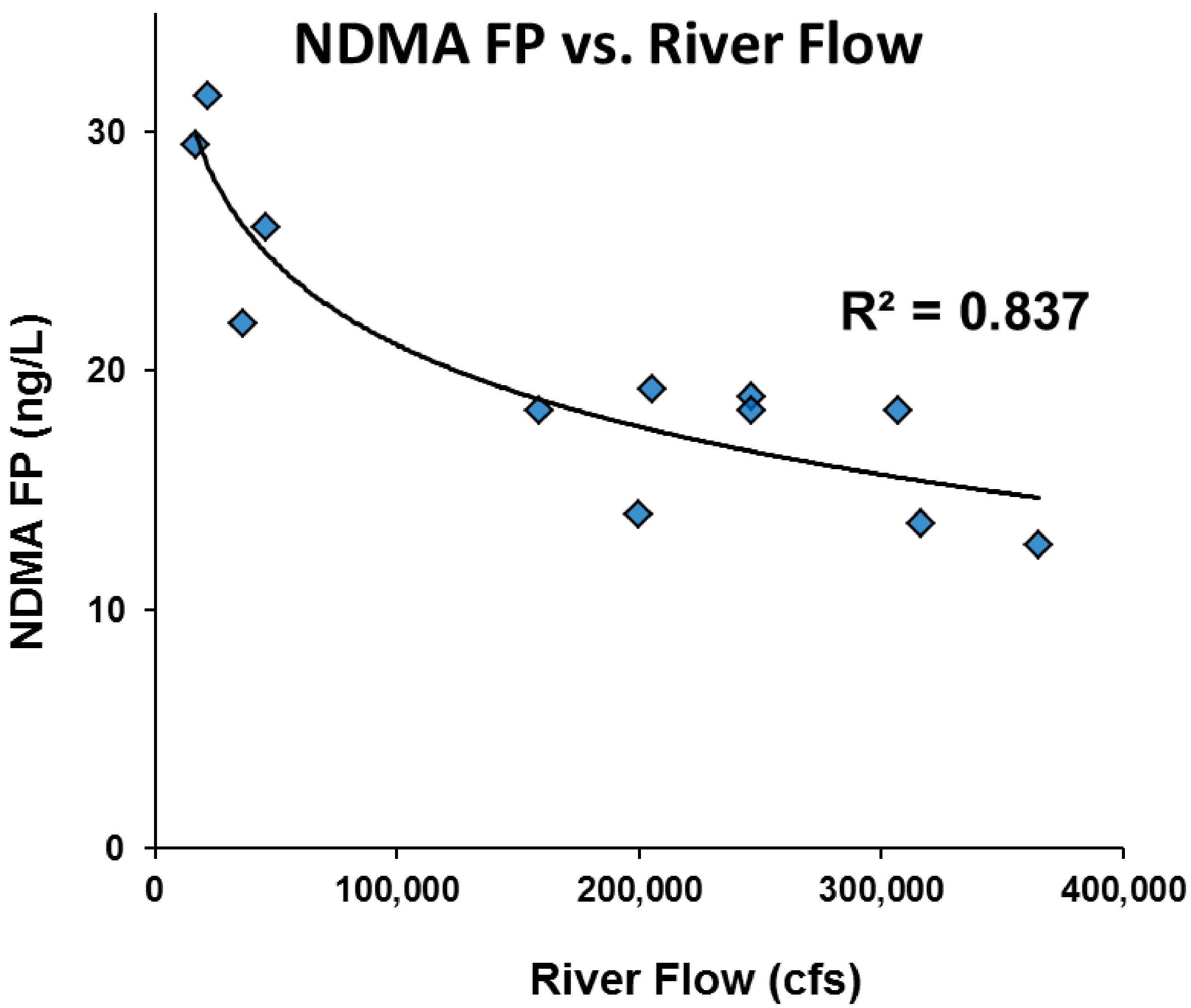


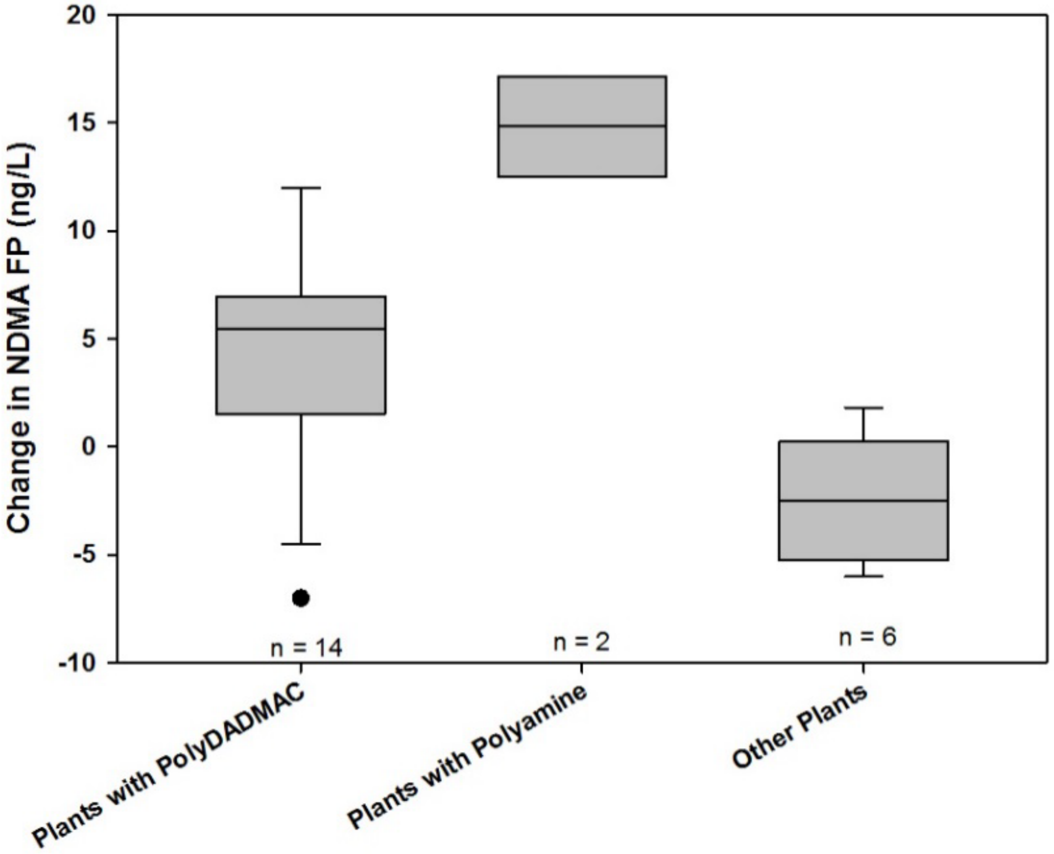
Formation of NDMA (Krasner et al., 2020)

- **NDMA precursors include**
  - Treated wastewater effluent organic matter
  - Certain pharmaceuticals
  - Certain coagulation polymers (e.g., polyDADMAC)
  - Certain anion resins (e.g., used for removal or nitrate)
- **Indicators of NDMA precursors**
  - The artificial sweetener sucralose is an indicator of wastewater presence in a watershed
  - NDMA formation potential (FP) test (high chloramine dose applied to water sample) is a measure of NDMA precursor level

Relationship of Sucralose and NDMA FP to River Flow (Prescott et al., 2017)

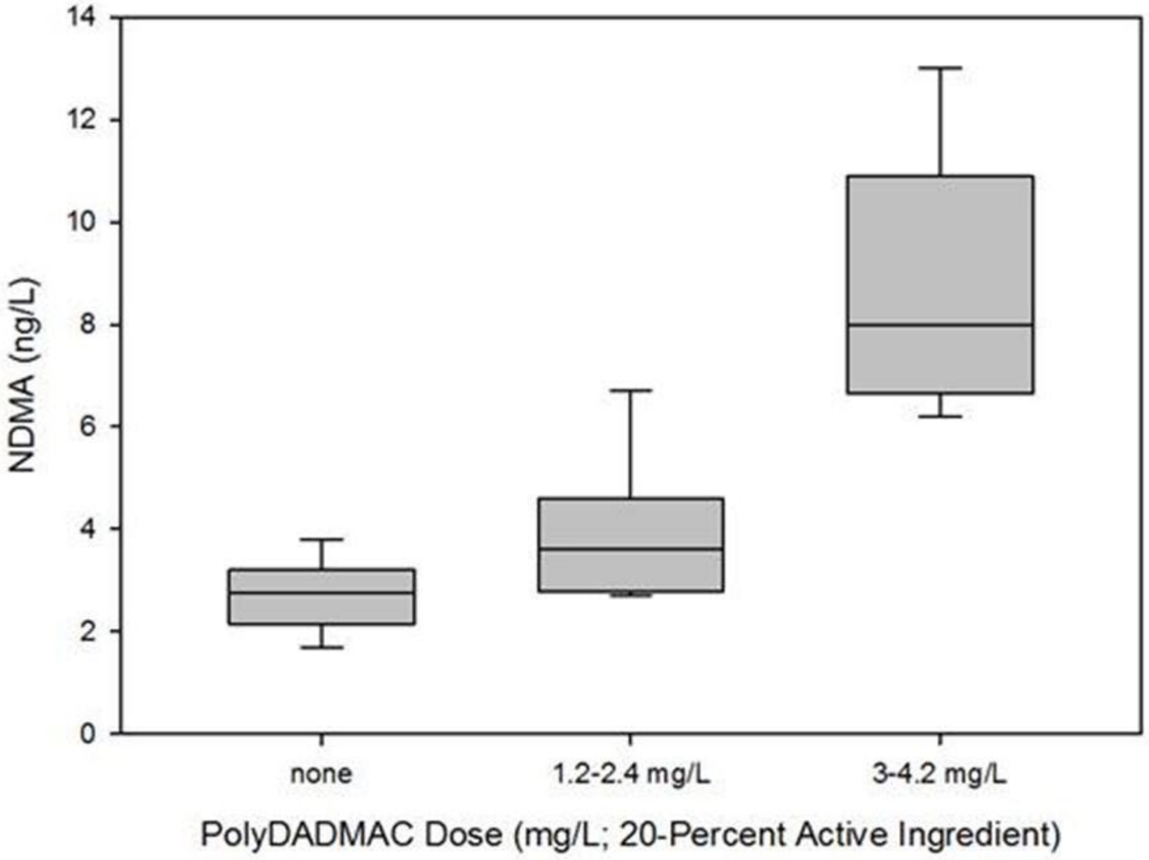






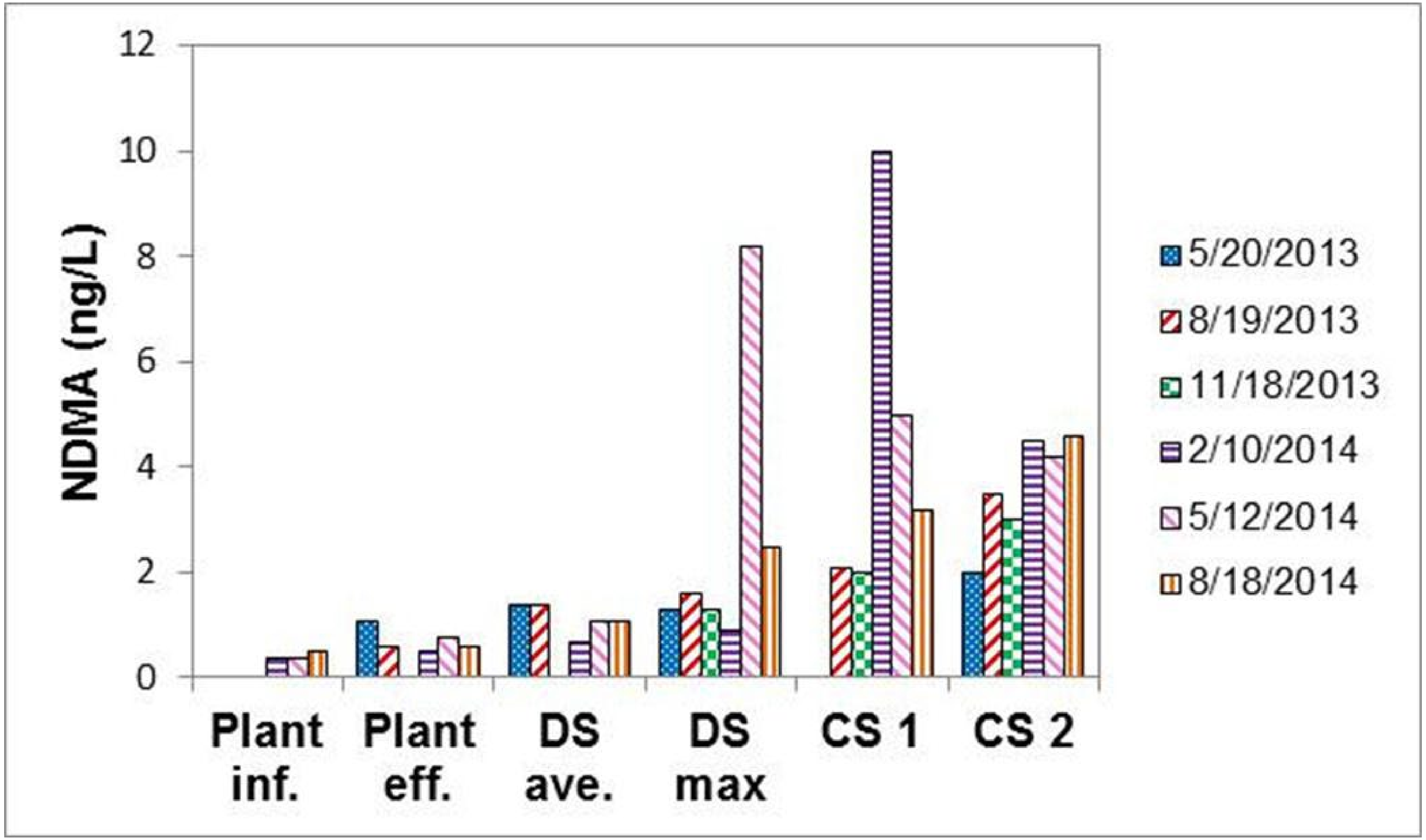
Impact of settling on NDMA FP as a function of type of polymer (other plants with no polymer or polyacrylamide) (Krasner et al., 2018)

Impact of polymer dose on occurrence of NDMA at plant 7 (in distribution system) (Krasner et al., 2016)



Occurrence of NDMA at Plant 10 and in its Consecutive Systems (CSs) (Krasner et al., 2016)

Detention times in distribution system (DS) (ave. and max. were 2-6 hr and 24-48 hr, respectively. Detention times in the CSs (CS1 and CS2) were 4-5 days and 24-48 hr, respectively.



Formation of Emerging DBPs: Key Take Aways

- **Chlorination of drinking water forms**
  - **brominated DBPs beyond those in THM4 and HAA9**
  - **forms nitrogenous DBPs in addition to carbonaceous DBPs**
- **Chloramination of drinking water forms less THMs and HAAs, but forms iodine-containing DBPs and nitrosamines**
  - **primary disinfection with chlorine or ozone forms less iodinated DBPs during post-chloramination**
  - **NDMA occurs at more than 50% of chloramine plants, but rarely found at chlorine plants (and, if so, at very low levels)**
- **NDMA occurrence can increase in**
  - **wastewater-impacted drinking water**
  - **drinking water treated with certain coagulation polymers or anion exchange resins**
  - **consecutive systems with higher water age**

Clarifying questions?

Sanitary Survey: A Review

Gary A. Burlingame
Retired Laboratory Director for Philadelphia Water Department
Senior Scientist for Environmental Science, Policy and Research Institute

General Purpose for Sanitary Survey (EPA 815-R-99-016 April 1999)

As stated in the December *1995 EPA/State Joint Guidance on Sanitary Surveys*, the primary purpose of a sanitary survey is: "to evaluate and document the capabilities of the water system's sources, treatment, storage, distribution network, operation and maintenance, and overall management to continually provide safe drinking water and to identify any deficiencies that may adversely impact a public water system's ability to provide a safe, reliable water supply." In addition, the joint guidance notes that sanitary surveys provide an opportunity for state drinking water officials or approved third party inspectors to establish a field presence at the water system and educate the operators about proper monitoring and sampling procedures, provide technical assistance, and inform them of any upcoming changes in regulations. Sanitary surveys also aid in the process of evaluating a public water system's progress in complying with federal and state regulations which require the improvement of the capabilities of the system to provide safe drinking water. Sanitary surveys provide the water system with technical and management information regarding the operation of the system from the water source, through the treatment facilities and the distribution system.

SDWA System Applicability

State to State differences exist in definitions, system application, frequency requirements, violation definitions, response requirements, and responsibilities.

Rule	40 CFR Reference	Applicability
Basic Primacy	142.10(b)(2)	All PWS
IESWTR 1998	142.16(b)(3)	Subpart H systems SW and GWUDI
GWR 2006	142.16(o)(2)	GW systems
RTCR 2013	141.21(d) (Initially laid out in Total Coliform Rule, 1989)	PWS <4,100

Frequency Requirements

- **Community Water System (CWS)** - Every 3 Years
- **Non-Community Water System (NCWS)** - Every 5 Years
- **CWS with outstanding performance based on prior sanitary surveys** - Every 5 Years

- Also in existence are various guidance documents and manuals:
  - For States from the EPA and by States
  - For water systems, to be prepared for compliance

United States
Environmental Protection
Agency

Office of Water
(4607)

EPA 815-R-99-016
April 1999

EPA

Guidance Manual for Conducting Sanitary Surveys of Public Water Systems; Surface Water and Ground Water Under the Direct Influence (GWUDI) of Surface Water

Eight Elements of a Sanitary Survey

www.epa.gov/dwreginfo/sanitary-survey

Area	Description
Source	Reviews a raw water source's features for the purposes of preventing potential contamination or water quality degradation.
Treatment	Identifies existing or potential sanitary risks by evaluating the design, operation, maintenance and management of water treatment plants.
Distribution System	Reviews the design, operation, maintenance and management of distribution systems to prevent contamination of the drinking water as it is delivered to customers.
Finished Water Storage	Reviews the design and major components of finished water storage facilities in order to prevent water quality problems from arising during storage.
Pumps	Reviews the design and use of water supply pumping facilities in order to determine overall reliability and identify potential sanitary risks.
Monitoring & Reporting	Determines water system conformance with regulatory requirements through the review of water quality monitoring plans and system records; verifies data reported to the regulatory agency are consistent with system records.
Management & Operation	Evaluates water system performance in terms of management and operation, including its long-term viability in meeting water quality goals.
Operator Compliance	Ensures water systems have qualified professionals that meet all applicable operator certification requirements.

Two Types of Sanitary Surveys

A **Class I** sanitary survey is **required by rule** as a periodic comprehensive on-site evaluation of all water system components and operation and maintenance procedures.

A **Class II** sanitary survey is a limited on-site survey, **conducted on an as-needed basis** such as for investigatory (complaint-related) inspections, Class I follow-up inspections, or inspections conducted as a result of a compliance problem and/or enforcement related action.

Example of a Checklist

WATER SUPPLY SANITARY SURVEY REPORT CHECKLIST

COMPLETION REPORT

PWS ID #	PWS NAME	INSPECTION ID #	Date of Completion

Name Person(s) Interviewed Title		Modules	Completion Time *(total)*
______________________	______________________	______________________	*File review:* ______ *hours*
______________________	______________________	______________________	*On-site:* ______ *hours*
______________________	______________________	______________________	*Travel:* ______ *hours*
			Report: ______ *hours*

INSTRUCTIONS: Indicate the number of checklists and check the compliance status for each Module

How many Checklists?	8 elements of a complete Sanitary Survey	Not Applicable	No Deficiency	Minor Deficiency	Violation (C,D,E)	Significant Deficiency (A,B)

Example of a Checklist

				PIPE MATERIALS
☒	☐	☐	☐	3-6. Does the distribution system contain Asbestos-Cement pipe?
				If Yes, is monitoring required or waived? *How many sites?*
☒	☐	☐	☐	3-7. Does the distribution system contain lead pipes, lead service lines, or lead goosenecks?
☐	☒	☐	☐	3-8. If Yes, does the PWS have a lead service line replacement plan?
☐	☒	☐	☐	3-9. Are all new materials used in the distribution system ANSI / NSF Standard 61 certified?
				PRESSURE ZONES
				(Pressure below 20 psig allows backflow or contaminants to enter through leaking mains)
☐	☒	☐	☐	3-10. If there is any point in the main where pressure drops below 20 psi or above 150 psi, is pressure managed? *(e.g. booster pumps or pressure reducing valves at services)*
☐	☒	☐	☐	3-11. Is distribution main pressure monitored?
☐	☒	☐	☐	3-12. Does the CWS maintain an updated list of critical customers *(reduced pressure severely affects)?*
				VALVES
☐	☒	☐	☐	3-13. Is there a valve inspection and exercising program, and are records maintained?
☐	☒	☐	☐	3-14. Are there written procedures for isolating portions of the system and repairing mains?
☐	☒	☐	☐	3-15. Can the PWS locate valves during response to leaks and other emergencies?
				PLANNED SERVICE INTERRUPTIONS AND MAIN BREAKS
☐	☒	☐	☐	3-16. Is reasonable notice given to affected customers prior to planned service interruptions?
☐	☒	☐	☐	3-17. Is DEP notified whenever service is interrupted to 15 or more services, or greater than 8 hours?
☐	☒	☐	☐	3-18. Are main breaks tracked? *(written records)*
☐	☒	☐	☐	3-19. Does the PWS follow AWWA Standard C-651?
☐	☒	☐	☐	3-20. Is a certified operator *(Class E)* on-site of all main breaks, or is he/she contacted from the site

2N-Chloramine Disinfection | 2O-Ultraviolet Disinfection | **3-Distribution System** | 4-Water Storage | 5-Pumps & (...

What a Sanitary Survey ends up with:

Adopted from: A. Heinrich, D.V. Renwick, R.J. Weisman, A. Greene, S. Regli, K. Roland, and K. Rotert. 2022. **Using sanitary survey findings to identify risk management challenges**. *JAWWA* 114(5)35-45

- **Significant deficiencies** are ones that could cause or have the potential to cause or allow water contamination, and thereby are a public health risk.
- **Minor deficiencies** are ones that could contribute to or indirectly affect a public health risk. The two can cross over and interchange depending on the water system and its individual conditions.
- **Recommendations** from the primacy agency as helpful advice.
- Finally, a Sanitary Survey can find a **violation** of a drinking water regulation.
- These result in **Corrective Action requirements** and timelines.

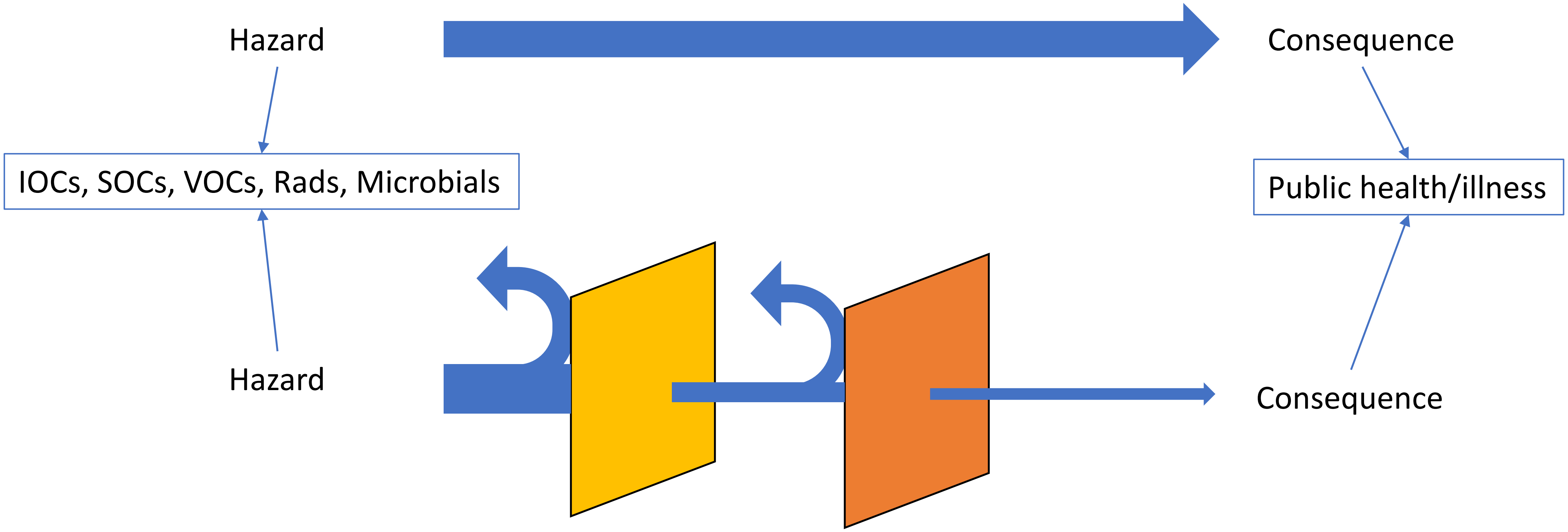
Examples of what a Sanitary Survey might find:

- **Discrete issues such as**:
  - An operator is past due on updating training and certification
  - A storage tank had not been cleaned in 5 years
  - Sampling locations do not represent all areas of the distribution system
  - A filter inspection was not done properly
  - The system forgot to perform annual SOC monitoring during the assigned quarter
  - The surface water intake is prone to flooding
  - Proper corrosion resistant piping is not being used in a chemical feed system
  - The water system failed to report a water main break which caused a loss of adequate water pressure for 3 hours
  - A storage tank’s vents have defective or missing screens

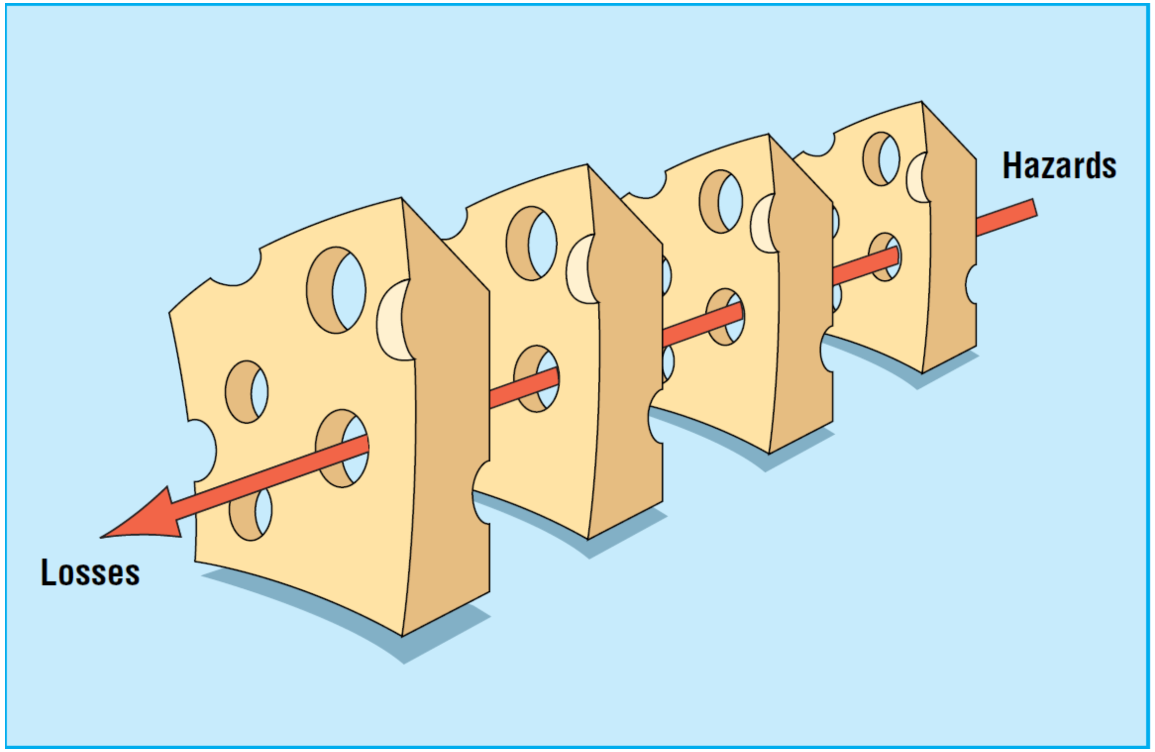
In Parallel with Sanitary Surveys

- **SDWA Compliance Reporting: monthly, quarterly, annually, etc.**
- **Engineering Review of construction plans, changes in source water, changes in treatment, operating permits**
- **Operator Training and Certification**
- **AWOP and Technical Assistance provided by the States**

Sanitary Surveys can look at the Multiple Barriers that should be in place:



Swiss Cheese Model – How controls integrate to reduce risks



Reason's Swiss Cheese model shows how a certain event trajectory may result in controls, barriers and safeguards being penetrated (Reason, 2000).

Recent Published Review

A. Heinrich, D.V. Renwick, R.J. Weisman, A. Greene, S. Regli, K. Roland, and K. Rotert. 2022. **Using sanitary survey findings to identify risk management challenges**. *JAWWA* 114(5)35-45

- SDWIS national compliance database for years 2010-2017

- The study found surveys with:
  - Minor deficiencies – 28%
  - Recommendations – 24%
  - **Significant deficiencies** – 11% (5,249 systems)
  - Most common significant deficiencies were:
    - **Finished water storage** (increased in occurrence with larger systems)
    - **Monitoring and reporting** (increased in occurrence with smaller systems)
    - **Treatment** (similar occurrence across all systems)

Shortcomings of Sanitary Surveys:

- An identification of risk-based priorities would be largely dependent on the knowledge and experience of the Sanitary Survey inspectors which would not reveal itself in a national database.

- The results of Sanitary Surveys more directly indicate where water systems have difficulty in being able to maintain their water systems as reliable systems but any associations between deficiencies and public health risks have to be assumed. Hazards are not readily linked to the assumed risks.

- The data do not identify public health risk severity (likelihood and consequence) nor risk priorities for water systems.

Elements and Controls tend to be siloed

- It is not uncommon for the elements of risk management to be siloed within water utilities, such as the water quality group, laboratory, water treatment, and distribution system operations all operate independently with their own SOPs and data systems.

- The Sanitary Survey does not break down these siloes but can keep them intact, addressing them within the siloes of the water system.

Stressors that Exist Today

- A generation or two of knowledgeable State and water system employees have retired or will retire soon, leaving a knowledge gap and taking with them valuable experience.
- Recently, it has become even more difficult to hire new staff. Turnover can be significant.
- At the same time, regulatory requirements that States must carry out continue to increase while resources and funding do not provide adequate support to fully do what is needed.
- And water systems are themselves becoming more stressed with resource limitations and funding and staffing shortages.

Questions for improvement????

- Do States have what they need for training and knowledge retention?
- Is the 3/5-year frequency for surveys optimum or is there a better frequency, considering the capacity of States.
- Do smaller systems need more support than States can provide?
- Can we better define what inspectors find as issues being SDWA requirements for corrective action vs professional dialogue and technical support to kick over to programs such as AWOP?
- Can Sanitary Surveys be optimized and focused for risk prioritization and a more direct linkage to hazards?

Thank You

DPBR Compliance Challenges DBPs and Disinfectant Residuals

It's Complicated

J. Alan Roberson, P.E. – ASDWA Executive Director

asdwa
Association of State
Drinking Water Administrators

WHY IS IT COMPLICATED?

- The linkages between DBPs and disinfectant residuals and the Revised Total Coliform Rule (RTCR) and other regulations (such as the Lead and Copper Rule [LCR]) are complicated
  - Simultaneous compliance with all regulations isn't simple
  - One change to comply with one rule likely will create unintended consequences
- More systems switched (or are switching) to chloramines to comply with Stages 1 and 2 DBPR
  - Nitrification -> loss of disinfectant residual
    - Nitrification isn't regulated at this time (until it's too late)
- Installing additional treatment in a distribution system isn't simple
- Consecutive systems have their own special challenges with Stage 2 DBP compliance

SIMULTANEOUS COMPLIANCE

- Simultaneous compliance with all regulations is critical to protecting public health
- Water chemistry is complicated
- When you change treatment (or add additional treatment) to comply with one regulation, water chemistry likely changes
  - Could impact decay rate of disinfectant residual
    - Could compromise microbial protection
  - Could impact corrosion control treatment
  - Could impact nutrients and biofilm
  - Could impact metals on the scales of distribution system pipes

CHLOROAMINES

- More systems switched (or are switching) to chloramines to comply with Stage 1 and Stage 2 DBPR
  - Chloramines are more stable in the distribution system
- Challenges with chloramines
  - Getting the optimal chlorine:ammonia ratio
    - Can be challenging for small systems
  - Chloraminated consecutive systems need some "TLC" from the wholesaler
  - Nitrification
    - Growth of nitrifying bacteria leads to loss of disinfectant residual
      - Chlorine conversion for a period of time is a common practice
    - Nitrification isn't regulated at this time (until it's too late)
      - Ongoing ASDWA study on the effectiveness of nitrification action/management plans

TREATMENT IN DISTRIBUTION SYSTEMS

- Booster chlorination/chloramination is challenging
  - Water chemistry issues
  - Typically limited land for additional treatment in the distribution system
    - Possible exceptions at storage tank sites, but some of those are tight
    - Meter vault for consecutive systems doesn’t have room for additional treatment
- Not a common practice
  - A small percentage of systems currently use booster chlorination/chloramination
- Small system operation & maintenance challenges
  - Could lead to compliance challenges

WHAT IS A CONSECUTIVE SYSTEM?

- A consecutive system buys treated water from a "nearby" system and distributes the treated water to its customers
  - Suburban systems, i.e., Fairfax Water sells water to Loudoun Water and Prince William County Service Authority
    - Typically have adjacent service areas
  - Rural systems – smaller systems that have consolidated
    - Longer runs of pipe to connect the systems, i.e., can be miles apart
- Contracts between wholesalers and retailers
  - Typically focuses on the price per gallon of water sold
    - Sometimes include funding for a portion of the water supply & treatment
  - Water quality clauses vary – sometimes "complies with SDWA regulations at point of entry (POE)", i.e., at the meter vault between the systems

THE MAJOR ISSUES

- More consecutive systems due to increased interest & pressure for system consolidation -> longer distribution systems and increased water age
- How water quality can vary between wholesalers and retailers is systems-specific
- Many consecutive systems don’t have the space (or technical capacity) to add additional treatment at point of entry
- More violations with consecutive systems
  - EPA’s Stage 2 DBPR In-Depth Analysis
- Relationships between wholesalers and retailers vary

MORE CONSECUTIVE SYSTEMS

- More consecutive systems due to increased interest & pressure for system consolidation
  - Over 50,000 community water systems
    - 410 systems serve greater than 100,000 people
      - Typically well-run systems with solid finances and well-trained staff
    - Approximately 82% serve less than 3,300 people
    - Approximately 55% serve less than 500 people
      - Do not have a full-time operator
- Longer distribution systems in rural areas
  - Increased water age

WATER QUALITY IN CONSECUTIVE SYSTEMS

- Consecutive system has minimal control over water quality coming from wholesaler
  - Have to work closely with wholesaler to understand any changes in water quality coming into its distribution system
- Distribution system in consecutive system increases water age
  - Decay of disinfectant residual can be a problem
- Many consecutive system contracts only address the cost
  - Some have compliance with SDWA regulations at point-of-entry (POE)
    - An ideal water quality clause would be for 80%-90% of DBP MCLs at POE to allow some flexibility in its distribution system

MORE VIOLATIONS IN CONSECUTIVE SYSTEMS

	Total	Consecutive	Non-Consecutive
Community Water Systems (CWSs)	50,259	13,457	36,802
Violations	3,508	968	2,540
Violation Rate	7.0%	7.2%	6.9%
Stage 2 DBPR Violations	1,188	663	525
DBPR Violation Rate	2.4%	4.9%	1.4%

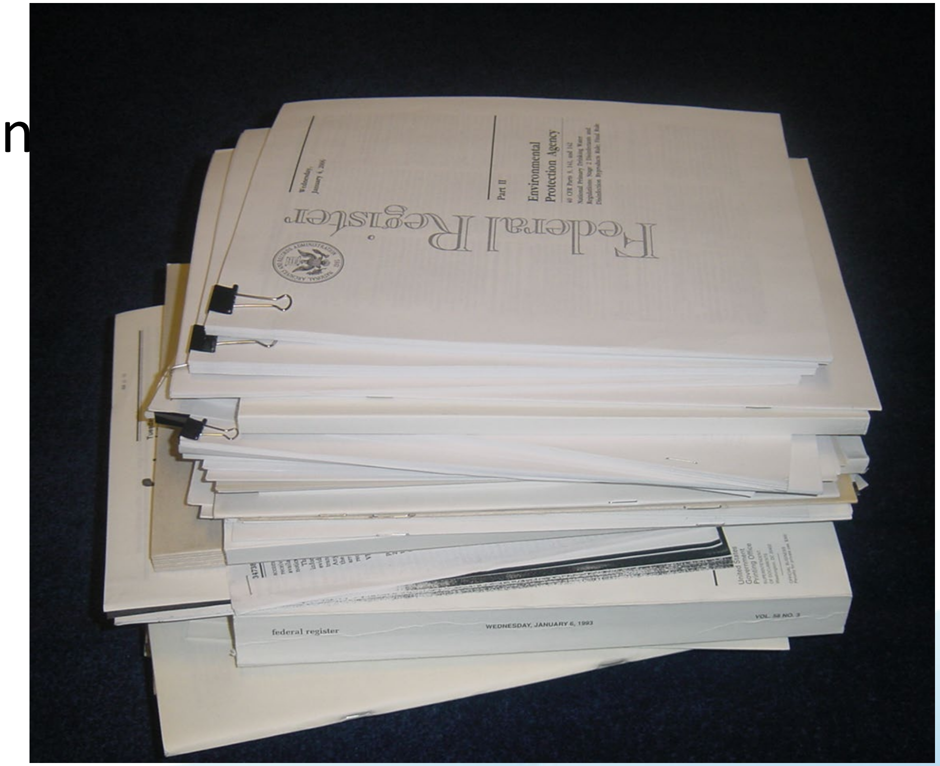
EPA's Stage 2 DBPR In-Depth Analysis

RELATIONSHIPS BETWEEN SYSTEMS

- Relationships between water systems can be complicated
  - Beyond the legal contract
  - Social, cultural, & other issues
- Contract between wholesaler and retailer typically focuses on financial issues
  - How water quality is addressed at point of entry (POE) to consecutive system can vary considerably in each contract

A FINAL REQUEST

- Please do not make complex recommendations
  - KISS -> Keep it Super Simple
  - Stay away from “states analyze” or “states assess” such as the Stage 1 DBPR benchmarkin and profiling, RTCR assessments, and LCRR “find-and-fix”
    - A more complex regulation leads to significant increases in states’ workload
- Small system compliance challenges
- States are stretched to the breaking point with current workload
  - BIL Funding, Lead, PFAS have added to an already significant workload



QUESTIONS?

Contact information

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Association of State
Drinking Water Administrators

Overview of Drinking Water Storage Issues

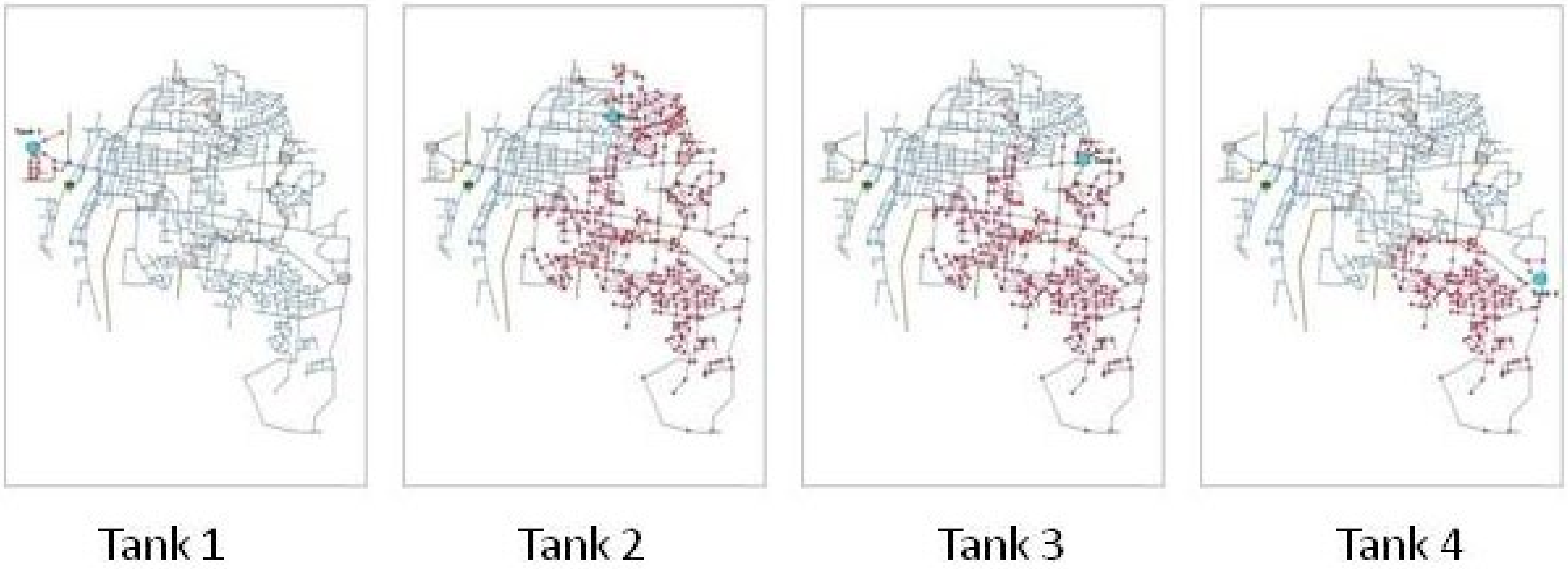
Prof Vanessa Speight, PhD, PE

Dept of Civil and Structural Engineering, University of Sheffield

The University Of Sheffield.

Storage Tanks are Critical Distribution System Facilities

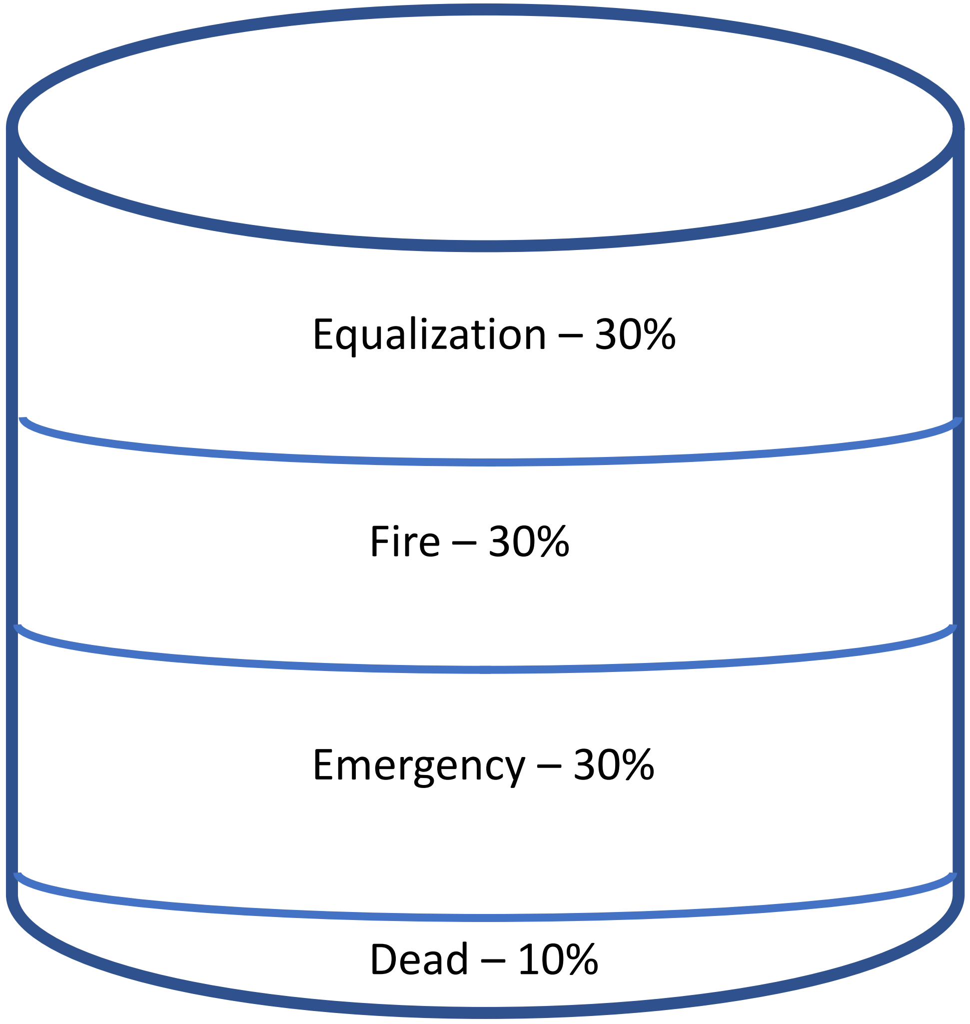
on



Speight et al., 2010. An Exposure Assessment Methodology for Water Distribution Storage Facility Contamination Events, Proceedings of IWA World Water Congress, Montreal.

Storage Tank Design

- Equalization to meet peak demands
- Fire storage depending on local requirements
- Emergency storage depending on local requirements
- Dead, unusable volume

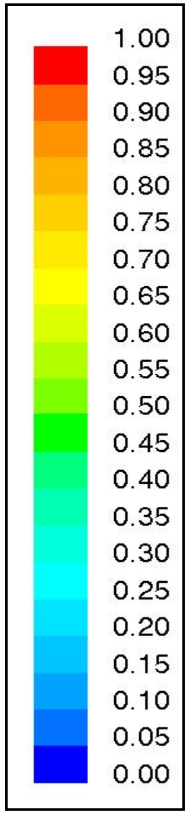


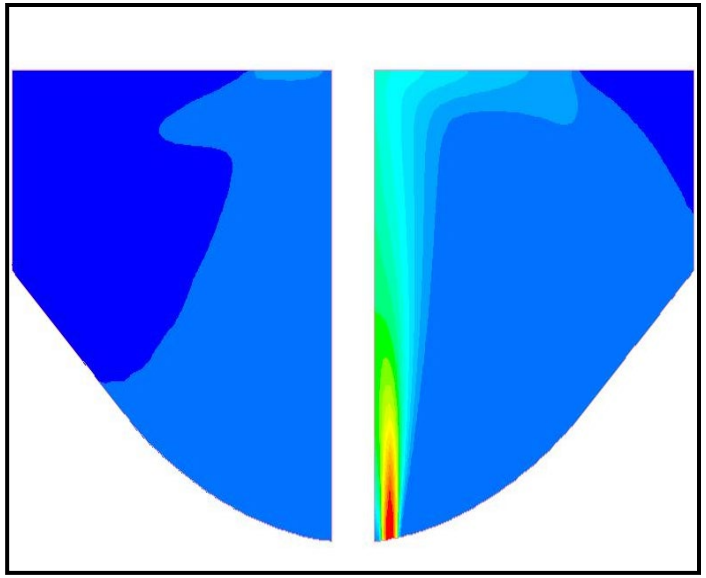
Minimum capacity for systems not providing fire storage is an average day demand (Ten State Standards, 2018)

Key Contributor to Water Age

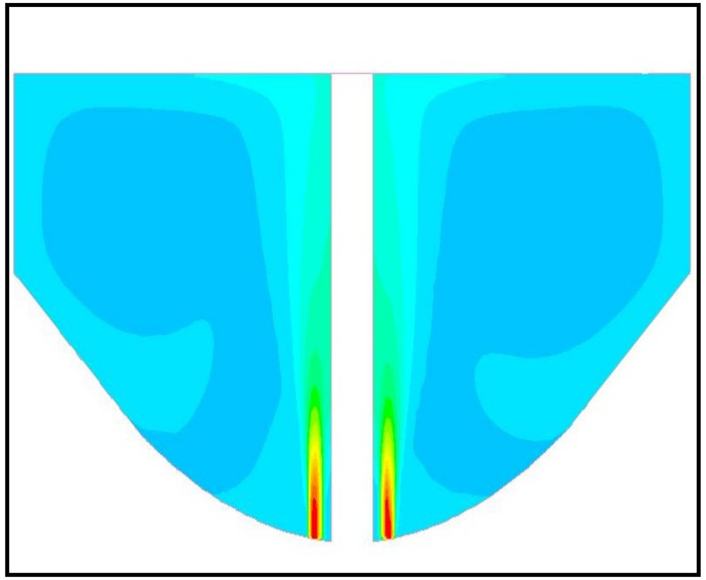
- Depending on volume, operation, design, and mixing conditions (flows, temperature, water quality)

Concentration (disinfectant)





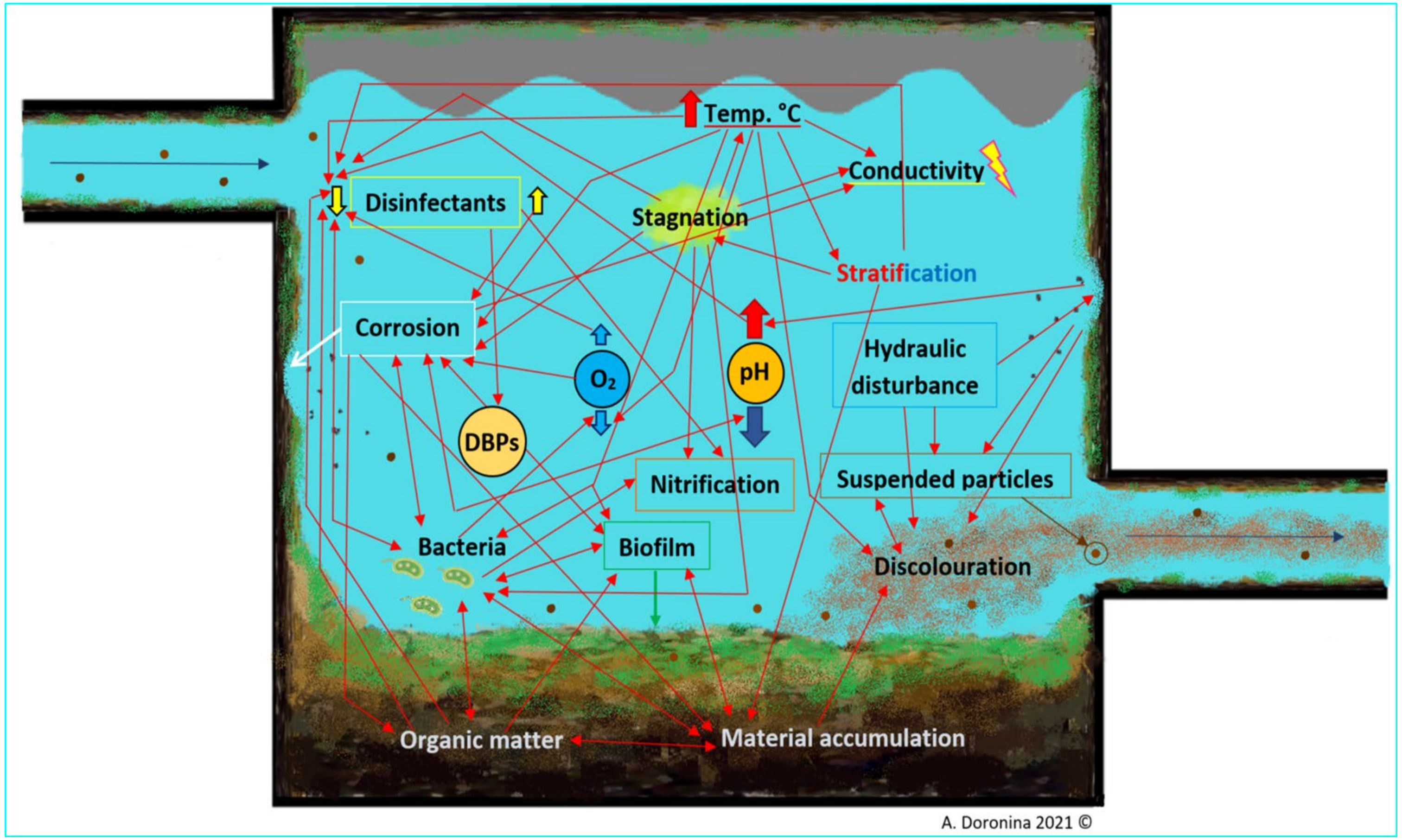
Original Configuration:
single 16-inch
inlet/outlet, 600 gpm,
7 hour fill cycle



Modified Configuration:
dual 8-inch
inlet/outlet, 600 gpm,
7 hour fill cycle

Water Quality Deterioration in Storage Tanks

- Accumulation of material, organic + inorganic
- Decay of disinfectant residual
- Formation of disinfection by-products
- Biofilm formation and microorganism regrowth



Research on Accumulated Material

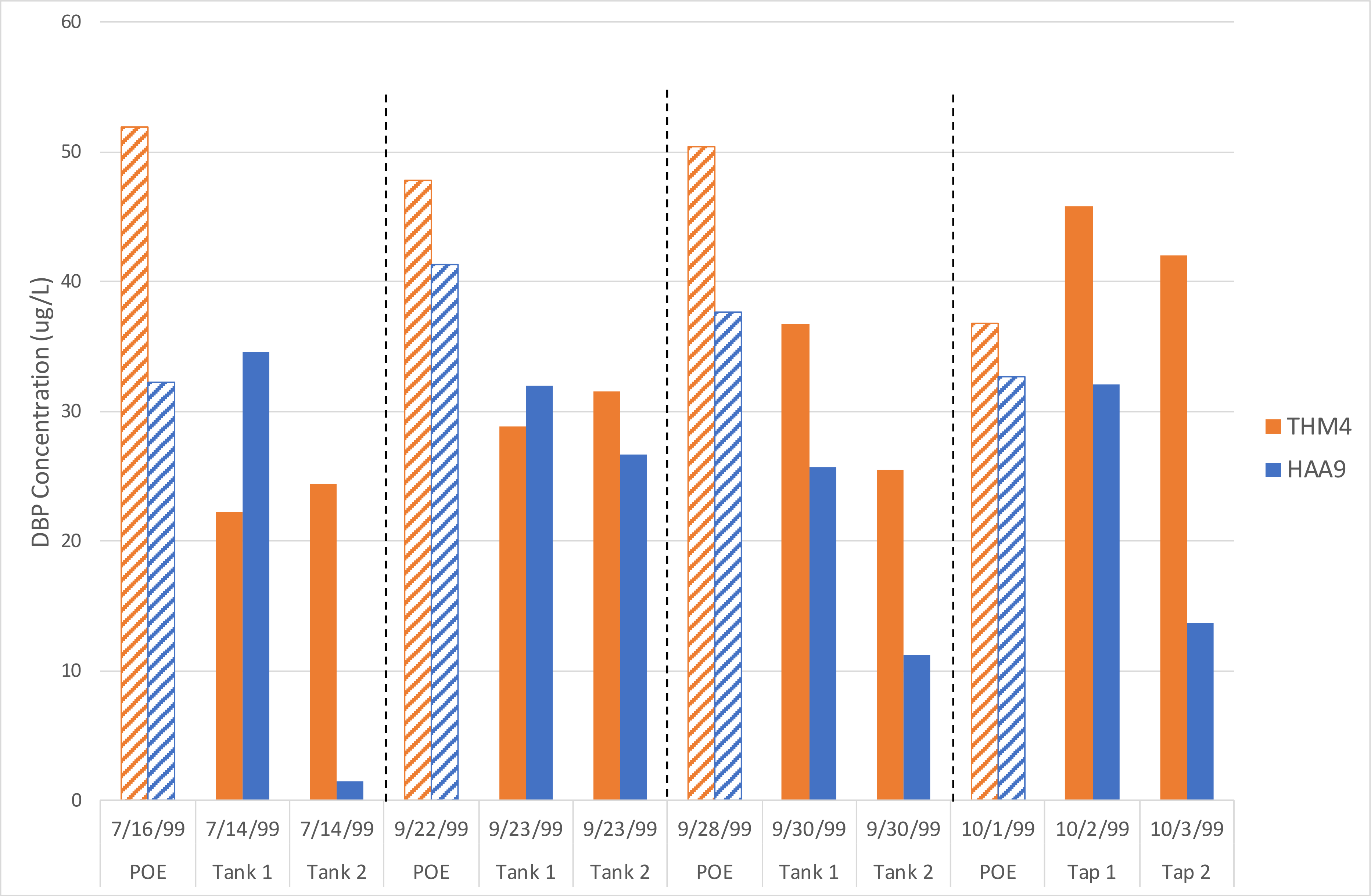
- Analysis of tank sediments from multiple studies shows presence of DNA for microorganisms
  - Predominantly organisms associated with biofilms including *Mycobacterium* spp., *Legionella* spp., and *Acanthamoeba* spp.
  - Little or no detection of bacterial pathogens
- Common elements in water systems also found to varying degrees
  - Iron, manganese, aluminum, etc.
- Accumulated material likely acts as a barrier to disinfection
- Very little sampling/monitoring of this material

Storage Tank Related Outbreaks

- Documented source for outbreaks
  - Often associated with a physical breach but not always

Current Regulatory Coverage – Water Quality

- Rarely sampled directly
  - Many states prohibit sampling from tanks as they are not ‘free flowing tap’ locations
  - Difficult to know whether tank is draining or filling when sampling
- When sampled, often only for TCR not DBP
  - DBP sampling locations should reflect the influence of the tanks



DBP levels in tanks are highly variable

- Changes over time due to POE levels, flows, etc.
- Decay can also take place

Adapted from Speight VL & Singer PC. 2005. Association between residual chlorine loss and HAA reduction in distribution systems, *JAWWA* 97:2:82-91.

Table 5.

The number of tests performed and the number of tests not meeting the standard

Parameter	Current standard	Total number of tests	Test not meeting the standard	Additional information
Water leaving water treatment works				
E. coli	0/100ml	173,514	3	NES (1), SWB (1), WSX (1)
Coliform bacteria	0/100ml	173,514	52	AFW (2), ANH (4), ISC (2), SST (1), SVT (9), SWB (2), WSX (4), YSK (3), TMS (6), SEW (4), UUT (1), SRN (8), NES (4), BRL (2)
Clostridium perfringens	0/100ml	24,684	4	AFW (1), NES (2), SWB (1)
Turbidity[1]	1NTU	173,481	18	AFW (1), ANH (3), SVT (3), SWB (1), SEW (3), SRN (1), TMS (2), UUT (1), WSX (2), YSK (1),
Water leaving service reservoirs				
E. coli	0/100ml	188,360	4	AFW(1), ANH (2), SRN(1)
Coliform bacteria	0/100ml in 95% of tests at each reservoir	188,360	108	AFW (3), ANH (13), BRL (9), DWR (1), ISC (2), NES (13), SEW (5), SRN (3), SVT (13), SWB (10), TMS (13), UUT (6), WSX (11), YSK (6), All 3,791 reservoirs in the region met the 95% compliance rule
Water sampled at consumers' taps				
E. coli	0/100ml	134,730	11	AFW (2), NES (4), SEW (1), SVT (1), TMS (1), YSK (2),
Enterococci	0/100ml	14,757	4	ANH (2), NES (1), SRN (1),

England Compliance in 2020: E. Coli and Total Coliform

- 3700 service reservoirs (storage tanks) sampled
- E. Coli 4 failures, 3 traced to integrity problems
- Total coliform 108 failures
  - Many related to integrity problems
  - Also sample line and tap issues
  - 1 enforcement related to chronic low residual, poor turnover, multiple failures

England Compliance in 2020: Iron, Manganese

- Unusually high sampling rate at service reservoirs due to covid restrictions on sampling at customer's taps
- Noticeable reduction in iron failures compared to tap samples in previous years
- National level of manganese failures similar to previous years but with localized increases

Source: Drinking Water 2020, the Drinking Water Inspector's Report for Drinking Water in England

Current Regulatory Coverage – Physical Integrity

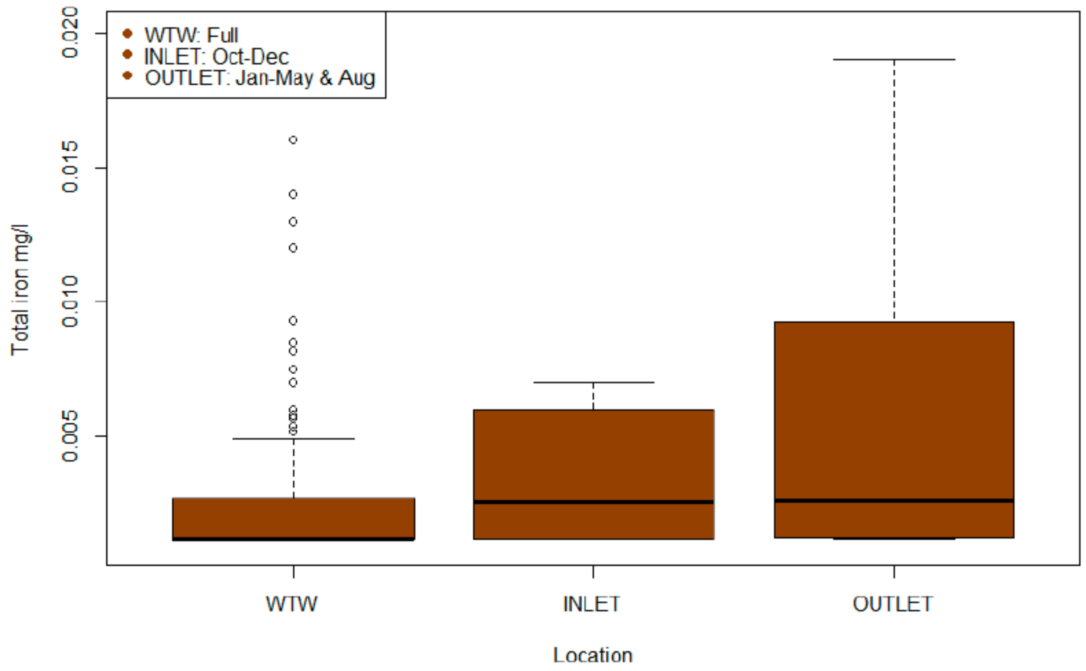
- Inspected during sanitary survey (typically 5 years)
  - Detailed integrity inspection generally not included
- Visual inspections take effort
  - Confined space entry requirements
  - Climbing safety requirements
- Some additional state initiatives, e.g. Colorado Storage Tank Rule
- Many opportunities for contaminants to get in
- Advances in drone/remote operated inspection technologies allow for more in service inspections

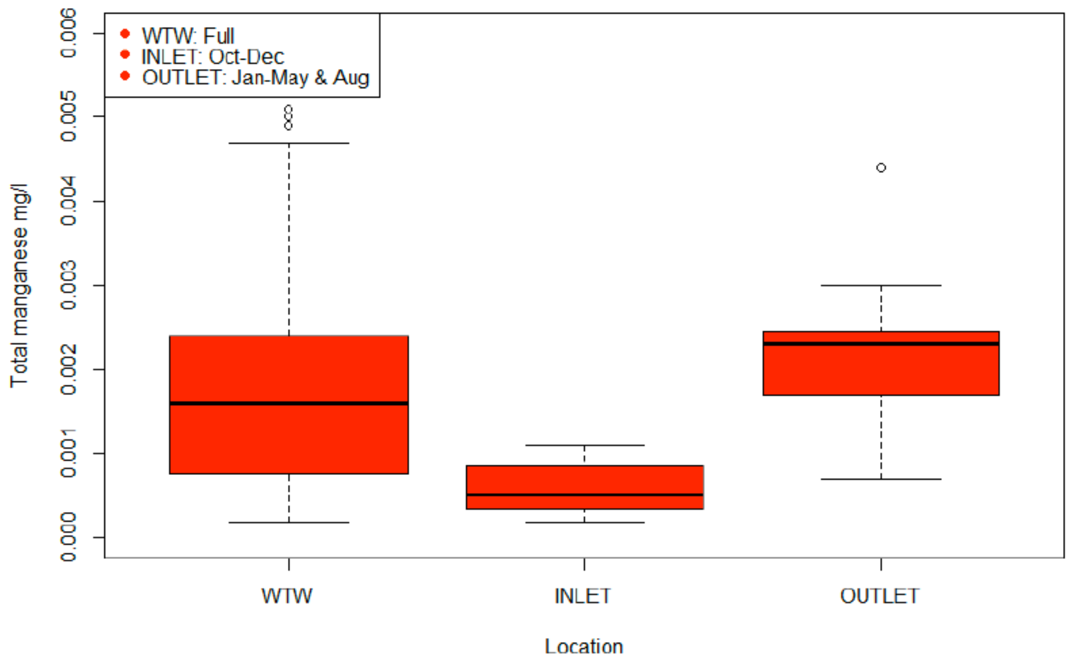
https://aquatalk-colorado.blogspot.com/2022/09/another-storage-tank-article-heres-why.html

Source: Panton McLeod

Value of Inlet and Outlet Monitoring

- To fully understand what is happening with storage tanks, need to monitor at the inlet and outlet





Doronina AV, Husband SP, Boxall JB, Speight VL. 2020. The Operational Value of Inlet Monitoring at Service Reservoirs, *Urban Water*, 17:8:735-744.

Summary of Storage Tank Issues

- Much general information already exists on how to inspect, operate, maintain, and monitor storage facilities
- Key parameters include: flows and design (influencing water age and turnover), disinfectant residual, water temperature, incoming water quality
- Water Quality Issues: material accumulation and resuspension, biological regrowth, nitrification, etc.
- Physical Integrity Issues: cracks, holes, access points, coatings, structural
- EPA requires storage facilities be covered and addressed during sanitary surveys
  - States vary significantly in additional requirements
  - Safety issues and accessibility are impediments to inspection

OFFICE OF GROUND WATER AND DRINKING WATER

15 Minute Break

Technical Panel

Chad Seidel, Scott Summers, Kerry Howe

Segment 4: Problem Characterization on Risk Balancing/Interdependencies: Discussion Topics

- Do you have additions or refinements to characterization of risk balancing/interdependency problems?
- What additional information will be helpful to further understand risk balancing/interdependency?
- Within the drinking water value chain, what do you believe are the most prominent root causes of risk balancing/interdependency problems?
- Given the information you have in front of you today, how do you perceive the magnitude of the public health concern and why?

Segment 5: Meeting 5 Agenda & Next Steps

Co-Chairs Andy Kricun & Lisa Daniels

Rob Greenwood, Ross Strategic

OFFICE OF GROUND WATER
AND DRINKING WATER

Presentation Overview – Teeing Up Meeting 5 (Preliminary)

- CDC on water system characteristics and outbreaks
- National Academies Study on Legionella in Distribution Systems
- D/DBP Problem Characterization, cont.
- Environmental Justice Issues
- MDBP Rule Related Implementation and Compliance Challenges

Discussion Topics

- 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 5 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

Lisa Daniels & Andy Kricun, WG Co-Chairs

MEETING CLOSURE

ELIZABETH CORR, U.S.EPA, DFO