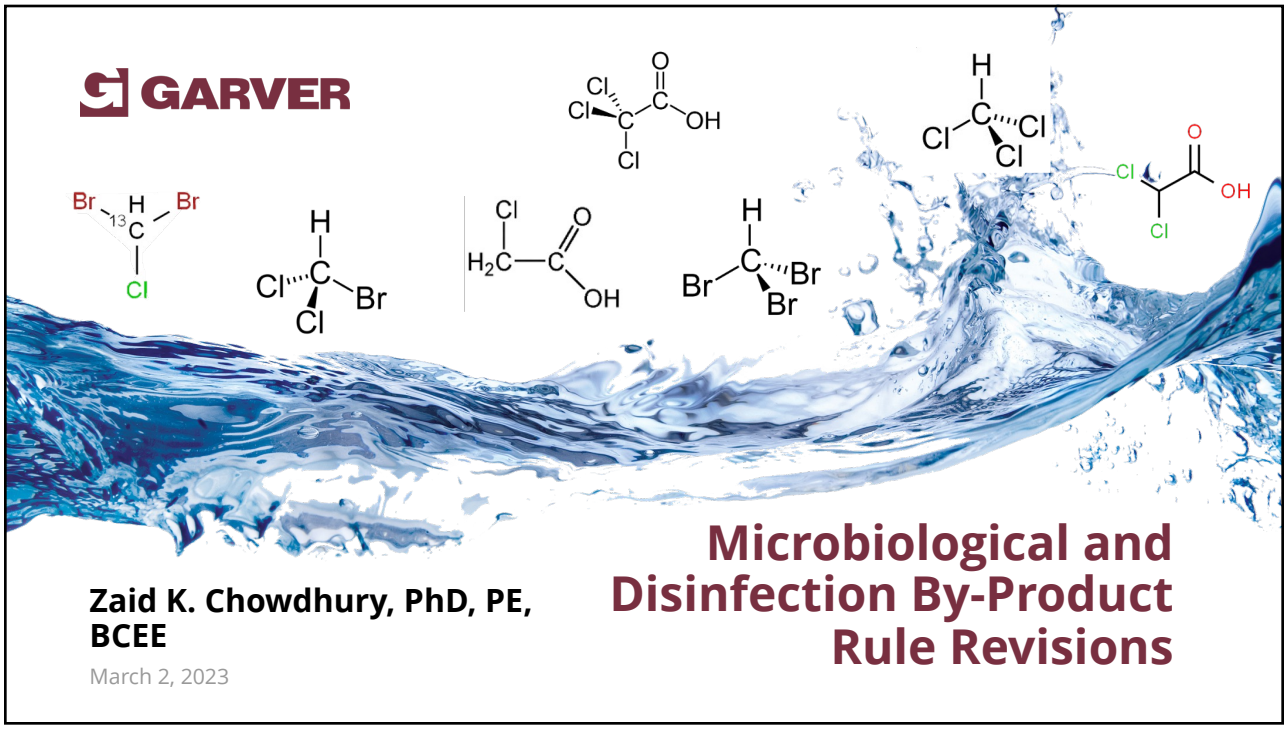
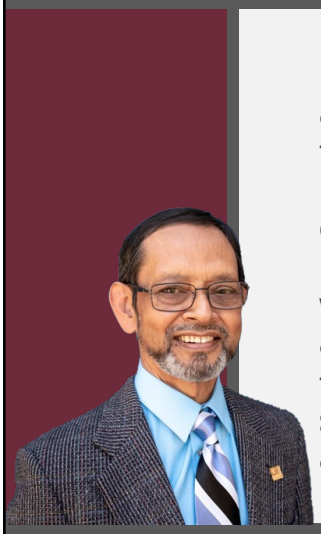


Microbiological and Disinfection By-Product Rule Revisions

Zaid K. Chowdhury, PhD, PE, BCEE

March 2, 2023

1



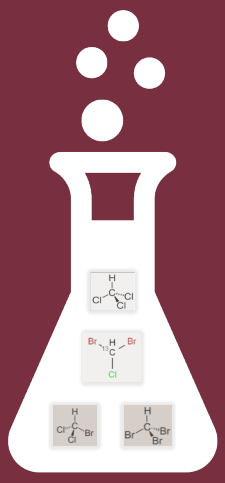
Dr. Chowdhury has 34 years of experience developing advanced methods and innovative solutions for water treatment. He is Garver's Water Treatment Practice Leader. Throughout his career, he has been actively engaged with EPA in various rule making process including disinfection by-products and arsenic rules as well as actively volunteering for AWWA regulatory affairs office. Dr. Chowdhury is currently a member of the Technical Analysts group assembled by the USEPA for supporting the deliberations of the workgroup assembled by NDWAC to guide the MDBP rule revisions.

2

OUR AGENDA

1. DBP and DBP Control: Fundamental Concepts
2. DBP Rule: History
3. DBP Rule: Revision Process
4. Considerations for Revisions

3



DBP and DBP Control:
Some fundamental Concepts

4

Precursors and disinfectants together produce DBPs

Precursors (NOM Bromide and Iodide)

- **Organic:**
  - NOM
  - DMA
- **Inorganic:**
  - Bromide
  - Iodide

+

Disinfectant

- Chlorine
- Ozone
- Chlorine dioxide
- UV
- Chloramines

=

DBP

- **Chlorine**
  - THM, HAA, HAN, HAL, etc.
- **Ozone**
  - Bromate
- **Chlorine Dioxide**
  - Chlorite
- **UV**
  - None
- **Chloramines**
  - NDMA

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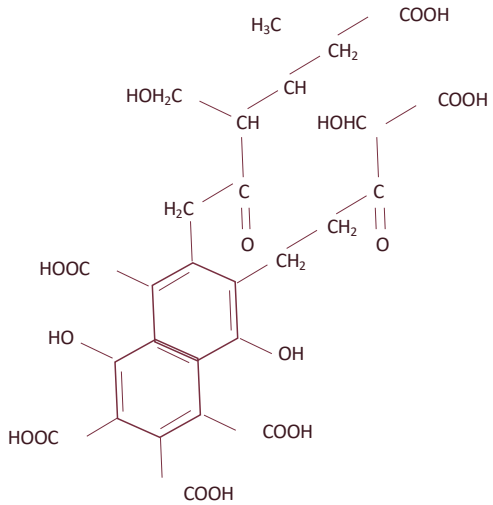
Properties of NOM need to be understood to better control DBPs



- Molecular Weight
- Hydrophobicity
- Reactivity
- Biodegradability

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6

Several technologies are available for the removal of organic DBP precursors

Technology	Expected Removal
Enhanced coagulation	Low to moderate removal
Powdered activated carbon	Removal constrained by dose
Granular activated carbon adsorption	Removal is a function of media replacement frequency
Biological filtration	Only removes biodegradable fraction
Ozone-assisted biological filtration	Removal increases due to increase of biodegradable fraction

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Removal of inorganic DBP precursors are often not practiced in water plants

- Much smaller molecules
- Hydrophilic
- Needs more expensive treatment processes
- Some small groundwater systems have inorganic contaminant removal experience

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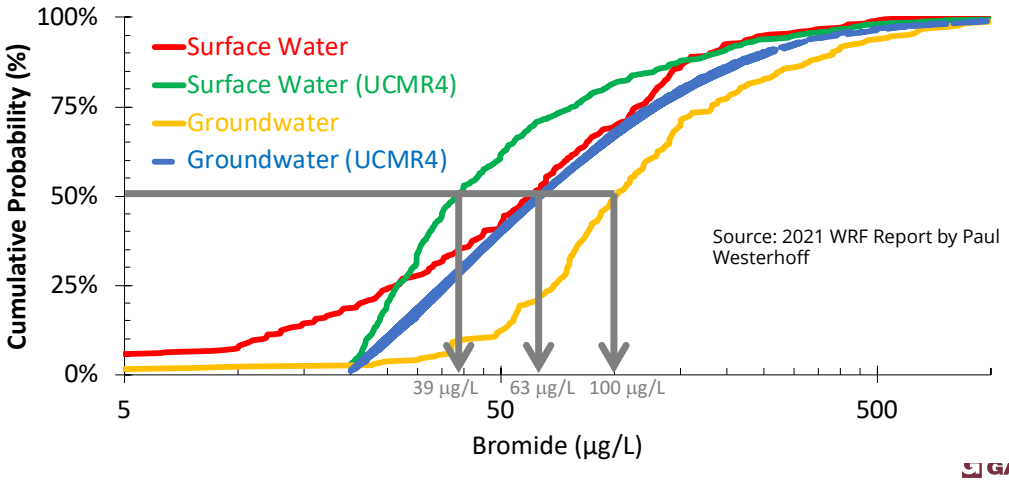
Significant level of bromide is present in US source waters



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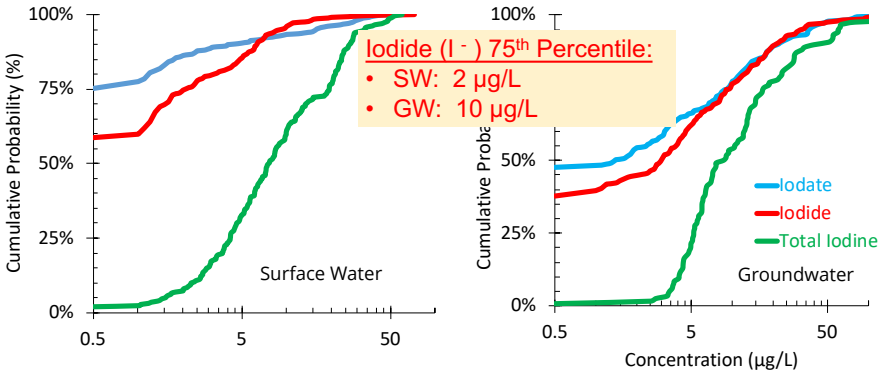
Significant iodide levels were also found in the survey



Source: 2021 WRF Report by Paul Westerhoff

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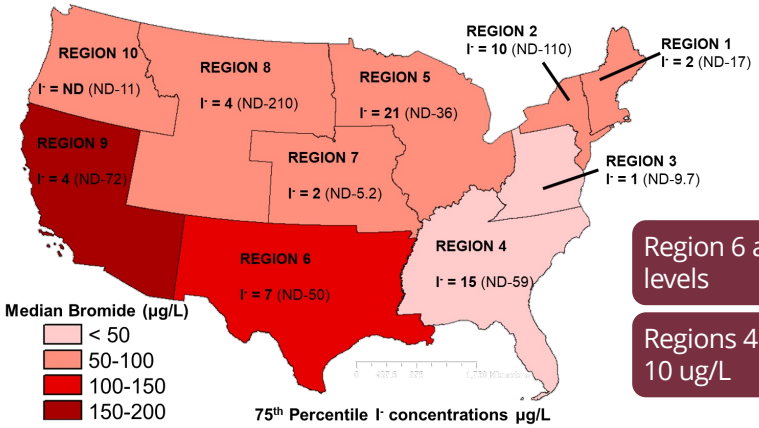
The survey also identified distinct geographical trends in bromide and iodide



Region 6 and 9 had the highest bromide levels

Regions 4 and 5 had iodide levels above 10 ug/L

Source: 2021 WRF Report by Paul Westerhoff

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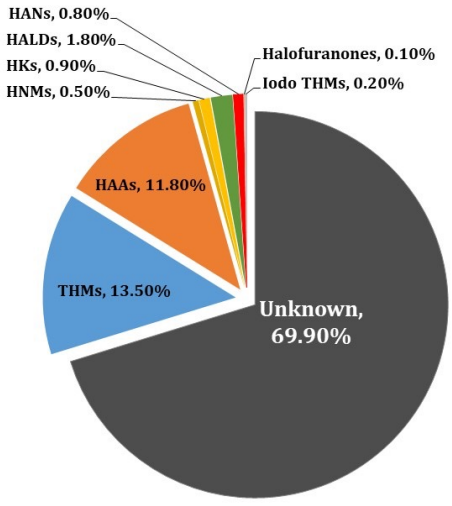
11

Many disinfection by products still remain unknown

We are only able to identify 30 percent of DBPs



Source: 2009 Book by Bill Mitch

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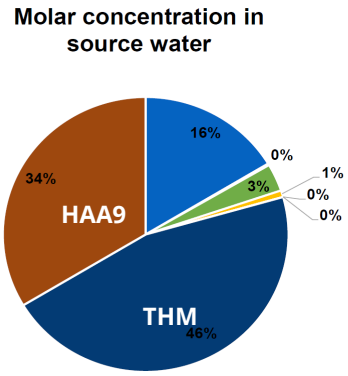
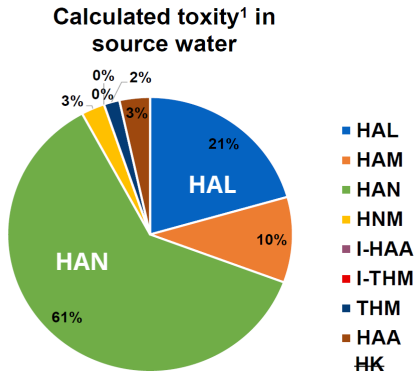
Cyto-toxicity of known DBPs vary widely





- Sum toxicity of individual DBPs
- Acute toxicity (LC50) of Chinese hamster ovarian cells

Calculated Toxicity = C_A / $LC50_A$

[1]Chuang and Mitch, ES&T, 2017, 51(4) p.2329
LC50 work from Plewa and Richardson

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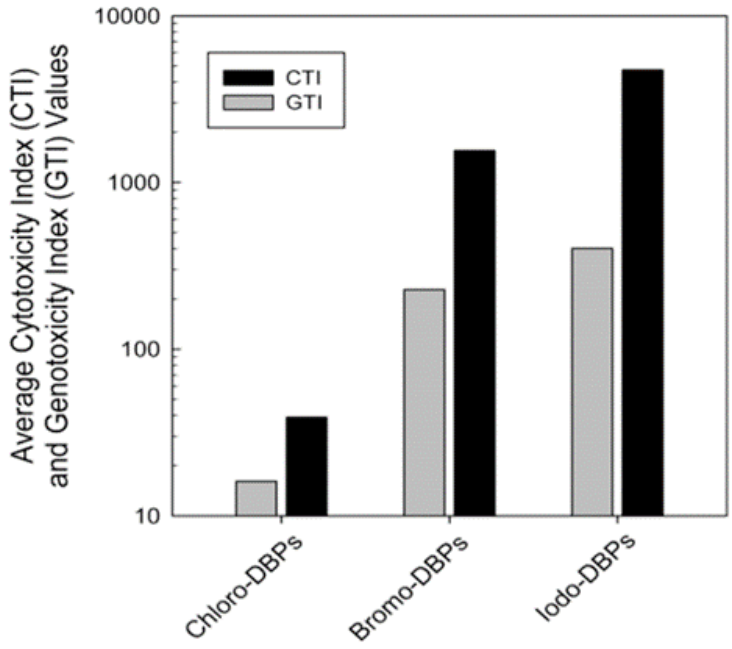
Cyto-toxicity of brominated and iodinated DBPs are higher compared to chlorinated DBPs



Source: 2017 article by Michael Plewa's group published in Journal of Environmental Science

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Removal of inorganic DBP precursors are rarely practiced due to the absence of regulatory drivers

Bromide and iodide can be removed using **ion exchange process**

- MIEX type application in basins
- IX columns as in small groundwater systems

Research is on-going on these technologies
WRF 5122 (Garver led)

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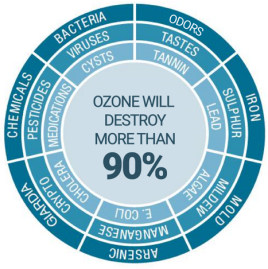
Properly choosing primary and residual disinfectants could minimize the formation of DBPs

DISINFECTANTS

Primary Disinfectants:
- Chlorine
- Chlorine Dioxide
- Ozone
- UV

Residual Disinfectants:
- Chlorine
- Chloramines



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DBPs can also be removed after they are formed by some technologies

Technology	Expected Removal
Aeration/air stripping	Only volatile DBPs can be removed e.g., some THMs
Biodegradation	Only biodegradable DBPs can be removed e.g., HAAs, and HALs
Adsorption	Limited removal efficiency

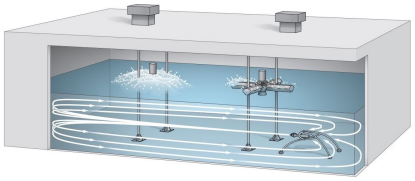

Image Source: PSI Water Technologies

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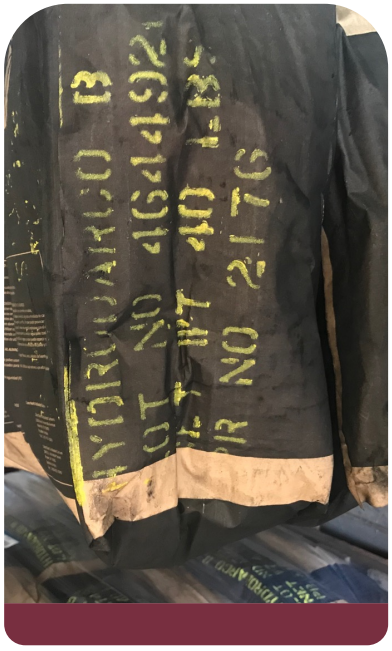

Properly designed and operated Powdered Activated Carbon (PAC) system can be effective for the removal of organic precursors

- Requires dosing as a chemical
- Keeping PAC mixed in water is challenging
- Often remains severely underutilized due to lack of mixing
- Finer PAC (SPAC) may be better but difficult to use

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GAC Adsorption

Effective processes for the removal of organic DBP precursors

Adsorption is a dynamic process – requires frequent replacement/renewal of adsorbing media

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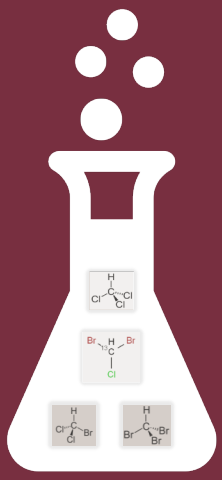
Biological filtration

Biodegradation is a steady-state process – does not require replacement/renewal of media

Biodegradation benefits can be achieved with any fixed media, however, a porous media (e.g. GAC) is a better host of microbes responsible for biodegradation

20



DBP Rule:
History

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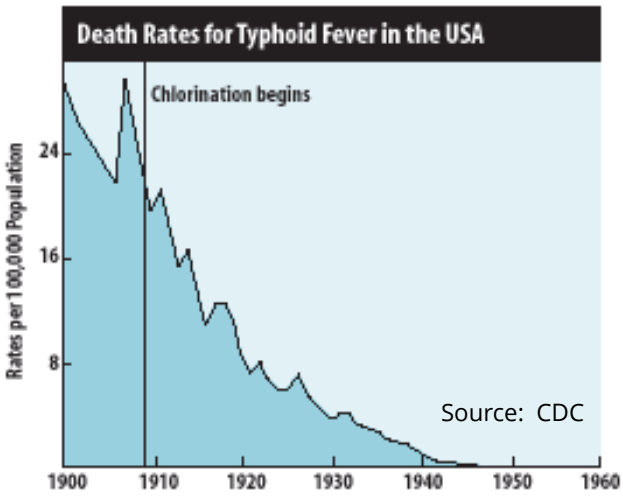
Drinking water disinfection is by far the most impactful contribution of our profession



But we form harmful disinfection by products

We still have some water-borne illnesses despite our best efforts

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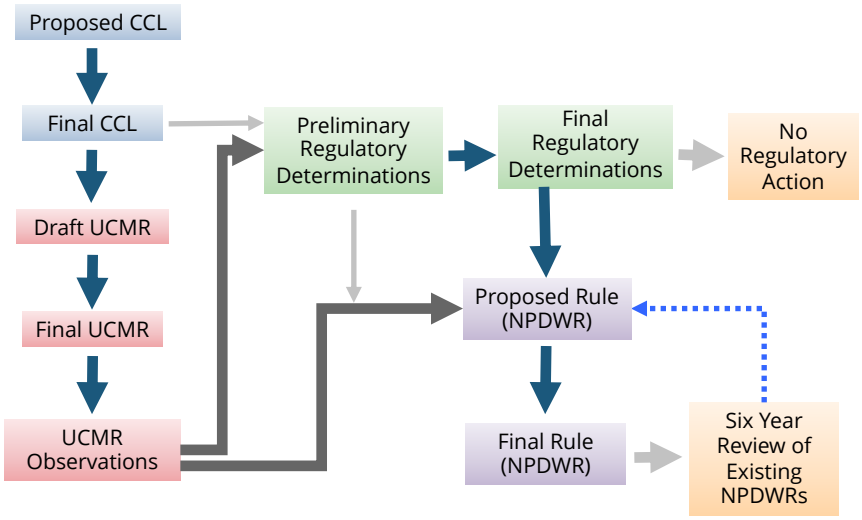
EPA is required to use a risk-based process for drinking water rule making



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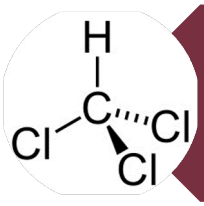
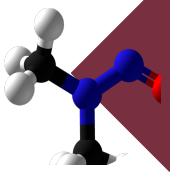
More than 600 DBPs have been reported, but only 4 groups are regulated



Regulated DBPs include:

- Total THMs
- HAA5
- Bromate
- Chlorite



Unregulated DBPs include:

- Nitrogenous DBPs (haloacetonitriles and nitrosamines)
- Iodinated DBPs
- ***Brominated DBPs***
- Many more

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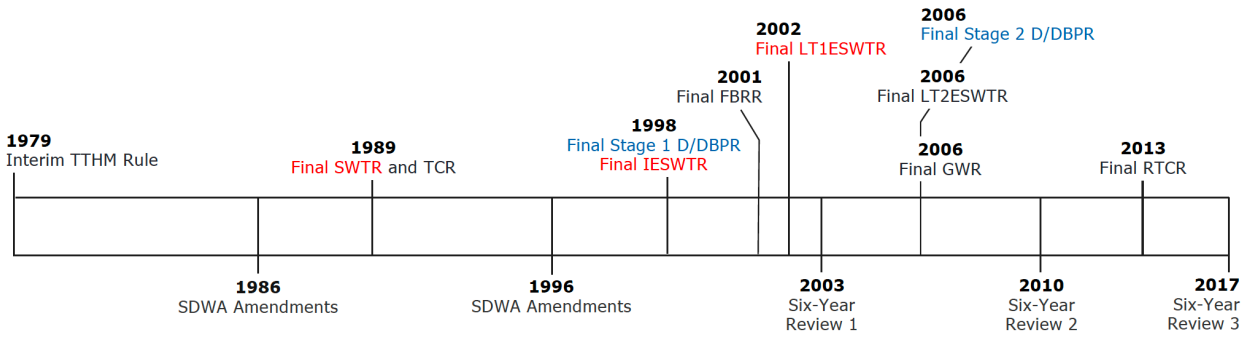
First regulation of DBPs was developed almost half a century ago and it continues to evolve



DBP rules under consideration
Microbial rules under consideration

Source: EPA October 2020

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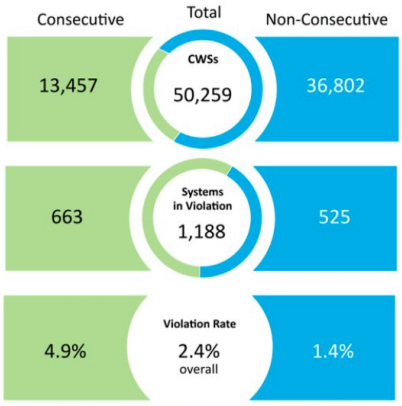
There is room for improvements for DBP Rule compliance in consecutive systems



Rates of Stage 2 DBPR health-based violations at consecutive CWSs and non-consecutive CWSs (Fiscal Year 2017).

- Consecutive systems are 3.5 times more likely to have MCL violations
- Only a quarter of the consecutive systems require monitoring at the point of purchase
- Highest violations are observed in Oklahoma and Texas

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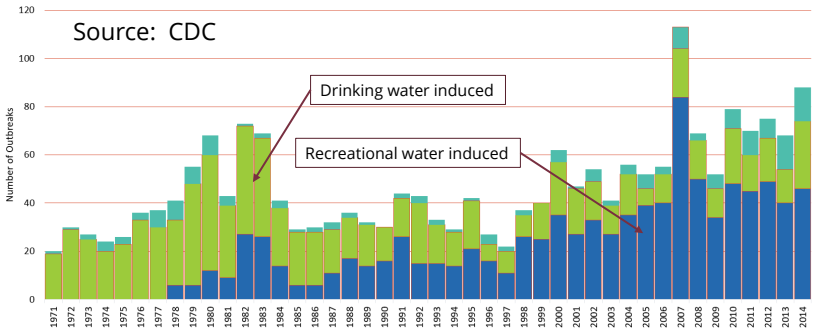
Despite the advances in disinfection, waterborne disease outbreaks continue to cause death in the US



Water-borne disease outbreaks = ~20/year

Recreational water disease outbreaks = ~50/year

"Every year waterborne pathogens cause 7,000 deaths, 120,000 hospitalizations, 7 million illnesses, and $3 billion in healthcare costs" - CDC

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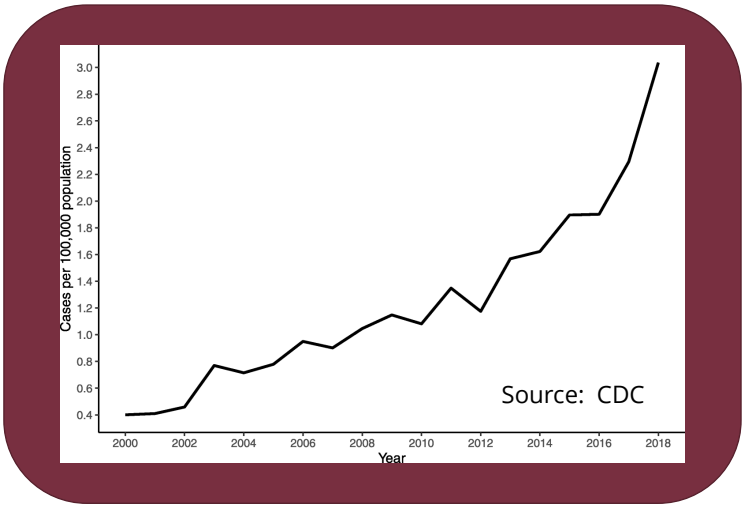
Legionella cases are sky-rocketing in the US in recent years



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Drivers for the current revisions of the M/DBP Rules

1. Significant fraction of the DBP Rule violations are in Consecutive Systems
2. Water-borne disease are still the cause of many deaths
3. Changes in source waters are altering the DBP precursor matrix
4. Additional DBP health effects are discovered

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EPA's settlement of a lawsuit with Water Keeper's Alliance obligates them for a regulatory timeline

Three organizations sued EPA in 2019 to maintain compliance schedule

CALIFORNIA COASTKEEPER ALLIANCE

WATERKEEPERS CHESAPEAKE

A lawsuit was settled with the following agreement:

- M/DBP Rule Revisions will be published by 7/31/2024 (subject to 12-month extension for FACA process)
- CCL5 by 7/18/2022 and CCL6 by 11/17/2026
- M/DBP Final Rule by 9/30/2027 (subject to 12-month extension for FACA process)
- Cr(VI) decision must be made within 3-years of toxicity assessment

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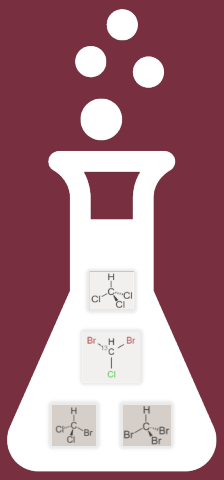

DBP Rule:
Revision Process

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M/DBP Rule Revisions – recent and upcoming activities

2021

Stakeholder engagement
- Series of meetings
- EPA provided information and obtained feedback
- Asked for NDWAC Committee (FACA)

2022

NDWAC Committee Deliberations
- Committee formed
- Technical analyst group formed
- Six meetings completed (more to go)

2025

Rule proposal by 7/31/2025

2028

Final Rule by 9/30/2028

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NDWAC formed an 18-member committee with representation from multiple interest groups and expertise

NDWAC: MDBP Rule Revisions Working Group		Regulatory	Utility	Consultant	University	Association	Engineer	Doctor	Other
Lisa D. Daniels* – Working Group Co-chair	Director, Bureau of Safe Drinking Water Pennsylvania Department of Environmental Protection Harrisburg, Pennsylvania	x							x
Elin W. Betanzo, PE*	Founder and Principal, Safe Water Engineering LLC Detroit, Michigan			x			x		
D. Scott Borman*	General Manager, Benton/Washington Regional Public Water Authority Rogers, Arkansas		x						
Nancy A. Quirk, PE*	General Manager, Green Bay Water Utility Green Bay, Wisconsin		x				x		
Alex Rodriguez*	President & CEO, Diversity Consulting Group Santa Barbara, California			x					x
Andy Kricun, PE** – **Working Group Co-chair**	Senior Fellow, US Water Alliance Managing Director, Moonshot Missions Camden, New Jersey					x	x		
Benjamin J. Pauli, PhD**	Associate Professor of Social Science, Kettering University Flint, Michigan				x				x
John Choate	General Manager, Tri County Regional Water Distribution District Russellville, Arkansas		x						x
Kay Coffey, PhD, PE	Engineering Manager and Public Water Supply Group Project Adviser, Water Quality Division Oklahoma Department of Environmental Quality Oklahoma City, Oklahoma	x					x		
Jeffrey K. Griffiths, MD, MPH&TM	Professor of Public Health and Community Medicine, and of Medicine Tufts University School of Medicine Boston, Massachusetts				x			x	
Michael Hotaling, MBA, PE	Facilities Manager (Retired), Newport News Waterworks Department Yorktown, Virginia		x				x		
Jolyn Leslie, PE	Regional Engineer, Office of Drinking Water, Northwest Regional Office Washington State Department of Health Kent, Washington	x					x		
Rosemary Menard	Water Director, City of Santa Cruz Santa Cruz, California		x						x
William F. Moody, PE, BCEE	Director, Bureau of Public Water Supply Mississippi State Department of Health Jackson, Mississippi	x					x		
Erik D. Olson	Senior Strategic Director, Health & Food, Healthy People & Thriving Communities Program Natural Resources Defense Council Washington, D.C.					x			x
Lisa J. Ragain	Principal Water Resources Planner, Metropolitan Washington Council of Governments Washington, D.C.					x			x
Lynn W. Thorp	National Campaigns Director, Clean Water Action Clean Water Action/Clean Water Fund Washington, DC					x			x
Gary Williams	Executive Director, Florida Rural Water Association Tallahassee, Florida					x			x

*Member of U.S. EPA's National Drinking Water Advisory Council.
**Member of U.S. EPA's National Environmental Justice Advisory Council.

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EPA formed a Technical analysis committee to support the NDWAC deliberations

NDWAC: MDBP Rule Revisions Technical Analysis Group		Utility	Consultant	University
Shawn Mcelmurry	Wayne State University			X
Nancy Love	University of Michigan			X
Mark LeChevallier	Private Consultant	X		
Anne Camper	Montana State University			X
R. Scott Summers	University of Colorado			X
Steven Duranceau	University of Central Florida			X
Chad Seidel	Corona Environmental		X	
Christine Owen	Hazen and Sawyer		X	
Susan Teefy	East Bay Municipal Utilities District	X		
Zaid Chowdhury	Garver		X	
Andrew Jack	Water Quality Investigations		X	
Vanessa Speight	University of Sheffield		X	X
Rob Greenwood	Ross Strategic			

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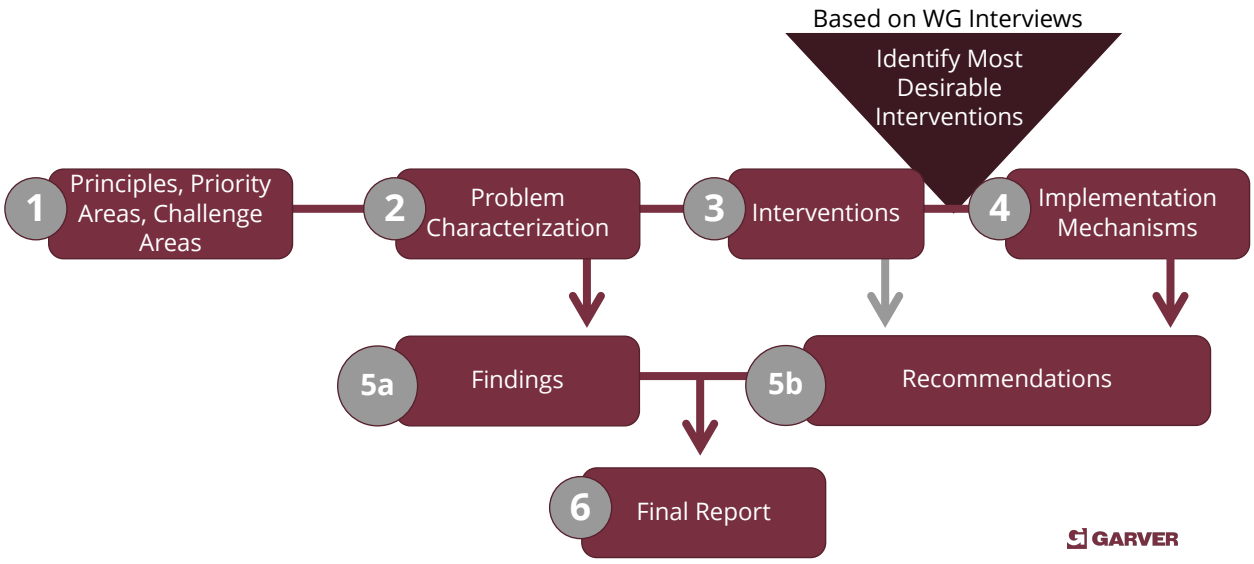
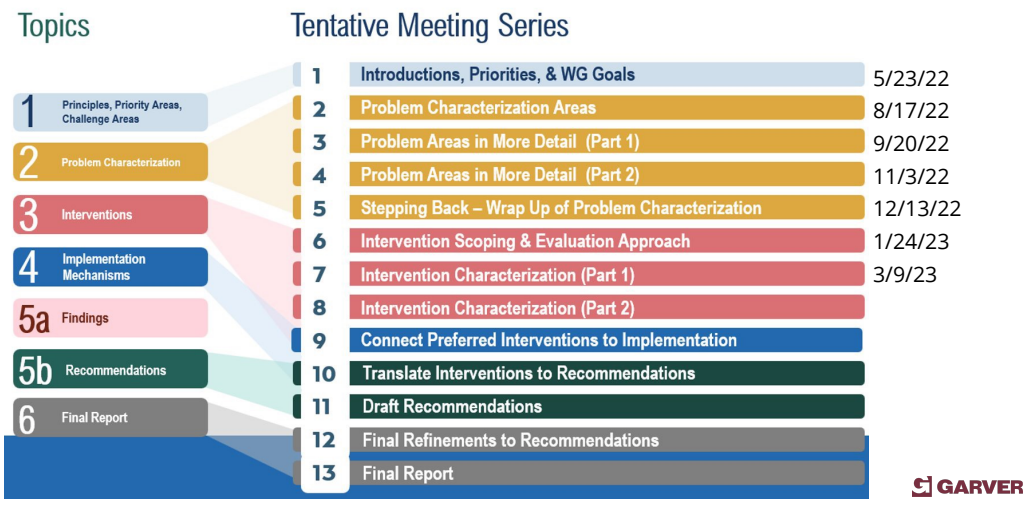
EPA envisions a 6-step process for the NDWAC Committee



35

NDWAC Committee is now meeting periodically to deliberate on recommendations



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Various factors need to be considered for developing regulatory framework for waterborne pathogens

Type

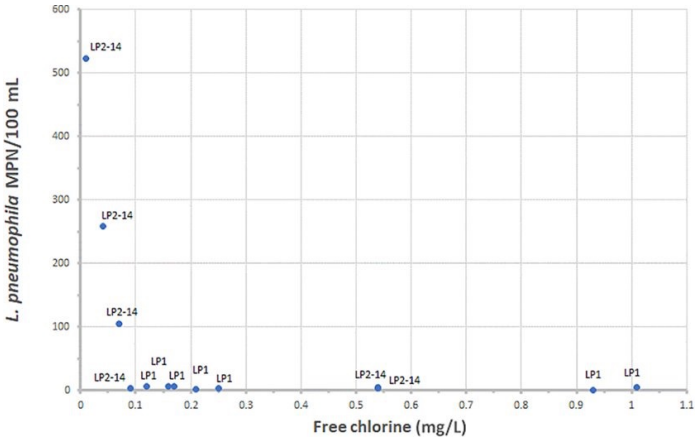
- Legionella pneumophila
- Nontuberculous Mycobacteria
- Pseudomonas aeruginosa

Origin

- Distribution Infrastructures
- Sediments
- Source waters

Occurrence frequency

- Biofilms
- Locations with no or low residuals
- Chloraminated systems (for legionella the trend is opposite)



Source: 2020 AWWA Journal Paper by Mark LeChevallier

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Considerations for Revisions

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The inputs/comments received from the workgroup members are being compiled now

EPA has identified recommendations

Microbiological interventions	DBP control interventions	Common Intervensions

Many options for regulatory improvements

These recommendations will be discussed, prioritized, and narrowed down to a manageable list of recommendations from the workgroup

AWWA and other groups are working on preparing to identify regulatory improvements they can live with

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Higher priority regulatory changes

Quantitative disinfectant residual

More disinfectant = less opportunistic pathogens

Consecutive Systems

Emphasis on compliance at the point of transfer

Additional DBP Control

Possible revisions to EC removal matrix

Include brominated HAAs

DBP monitoring during chlorine burn

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Additional expected changes

Revisions to TOC removal requirements

Possible revision to the 3x3 matrix or the exception criteria

Finished water TOC targets are discussed but not very likely to be a top recommendation

Tank inspections

Periodic inspection to avoid water quality deterioration

Reduce precursors to biofilm formation in distribution systems

Monitor and reduce biodegradable organic matter

Maintain disinfecting conditions throughout the system

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TAKEAWAYS

- **The revisions to the D/DBP Rule will impact some systems and we need to be preparing for it**
- **Major expected changes in the DBP Rule include provisions to reduce legionella and brominated DBPs**
- **Traditional technologies as well some innovative technologies may be employed for minimizing regulated and unregulated DBPs**
- **Strategically employed process upgrades is expected to pay long-term dividends**

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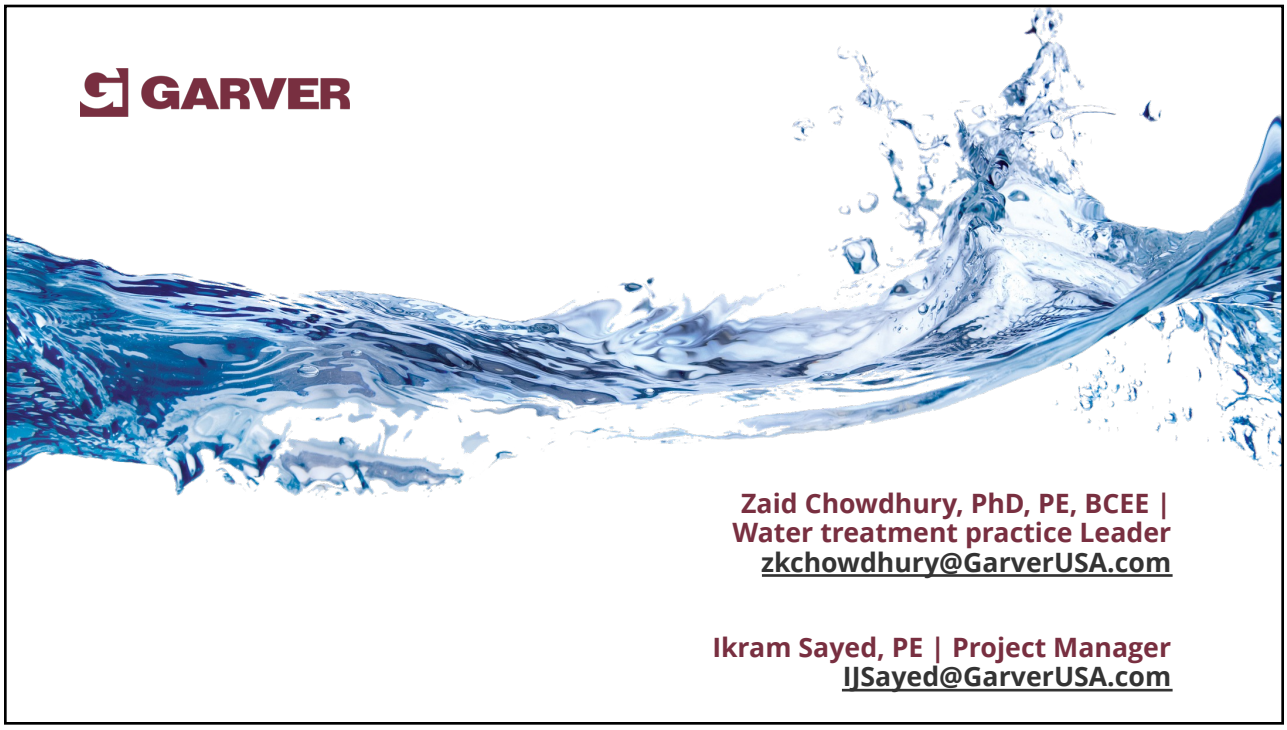

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Ikram Sayed, PE | Project Manager
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