NDWAC MDBP Rule Revisions Working Group

National Drinking Water Advisory Council (NDWAC)

November 3, 2022 Meeting 4 Summary

Meeting Summary

Background on the MDBP Working Group

The United States Environmental Protection Agency (EPA) has sought public input and information to inform potential regulatory revisions of eight National Primary Drinking Water Regulations (NPDWRs) included in five Microbial and Disinfection Byproducts (MDBP) rules following the third Six-Year Review. EPA hosted an initial virtual public meeting in October 2020 to solicit input on further improving public health protection from MDBPs in drinking water. Throughout 2021, EPA sought input relevant to potential rule revisions through additional public meetings focusing on topics identified through public comments and information.

EPA has now charged the National Drinking Water Advisory Council (NDWAC or Council), a Federal Advisory Committee (FAC) established under the Safe Drinking Water Act (SDWA) of 1974 to provide the agency with advice and recommendations on potential revisions to the MDBP Rules. In addition, to support the work of the Council, EPA asked the NDWAC to form a working group to explore specific issues and identify potential MDBP rule revision options for the Council to consider in making recommendations to EPA. More information on the NDWAC MDBP Rule Revisions Working Group meeting schedules and other information are available at: https://www.epa.gov/ndwac/national-drinking-water-advisory-council-ndwac-microbial-and-disinfection-byproducts-mdbp. EPA is currently providing the public with an opportunity to send written input to EPA via the public docket at www.regulations.gov, Docket ID: EPA-HQ-OW-2020-0486.

Meeting summaries and background documents on each meeting topic are available in the MDBP Rule Revisions public docket at www.regulations.gov, Docket ID: EPA-HQ-OW-2020-0486. More information on the potential rule revisions is available at: https://www.epa.gov/dwsixyearreview/potential-revisions-microbial-and-disinfection-byproducts-rules.

Meeting Purpose

EPA held the fourth Working Group (WG) meeting to continue problem characterization discussions on opportunistic pathogens and disinfectant residuals; continue problem characterization discussions on disinfectant byproducts; and; begin problem characterization discussions on risk-balancing and interdependencies.

This document provides a summary of presentations and discussions from the meeting on November 3rd, 2022. EPA shared a document on Implementation Issue Considerations for MDBP Rules along with reference articles with the WG ahead of the meeting. In addition to WG members, approximately 125 observers attended the meeting.

Segment 1

Agenda Review and Meeting Procedures

Elizabeth Corr, MDBP Rule Revisions Working Group Designated Federal Officer, Office of Ground Water and Drinking Water (OGWDW), Office of Water, EPA

Ms. Corr welcomed all to the fourth meeting.

Crystal Rodgers-Jenkins, Deputy Director, Standards and Risk Management Division, OGWDW, Office of Water, EPA

Ms. Rodgers-Jenkins welcomed panelists and participants to this meeting. She extended thanks to panelists and all virtual participants for joining. She thanked members for their valuable input provided in the first three meetings. She also thanked the Technical Analysts who shared relevant information, perspectives, and interpretations for both opportunistic pathogens and DBPs through their presentations and discussions. Ms. Rodgers-Jenkins noted such efforts will aid in greater understanding of root causes and magnitudes of these public health concerns. EPA and other experts continue their work to address working group requests for additional information. Ms. Rodgers-Jenkins noted additionally that seeking opportunities to reduce risk from both pathogens and DBP's in the context of risk balancing is a critical step of the Working Group's process to better understand and characterize problems.

Lisa Daniels and Andy Kricun, NDWAC MDBP Rules Revision Working Group Co-chairs

Ms. Daniels thanked all panelists, technical analysts, and EPA. She recognized the important work and acknowledged efforts to provide in-depth background and additional technical information provided by all. Mr. Kricun echoed thanks to the team, and to EPA for providing information needed for participants in this group. Also, Mr. Greenwood and Ross Strategic acknowledged these efforts, along with those of volunteers serving on the panel.

Robert Greenwood, Principal, Ross Strategic

Mr. Greenwood reviewed controls for the Zoom platform and provided an overview of the agenda. He noted that WG panelists are providing their unique points of view and are not representing those from affiliated organizations. In particular, Mr. Greenwood noted how WG members have stressed the importance of creating a strong foundation of problem characterization before moving to interventions. Special attention will be provided to the magnitude of concerns and root causes, along with creating a platform to move into the next set of discussions relating to interventions that could help in response to what is found during the problem characterization phase.

See Appendix 1 for a roster of Working Group members and an indication of those in attendance.

Segment 2

Follow-up on Problem Characterization Discussions on Opportunistic Pathogens and Disinfectant Residuals; Follow-up on Problem Characterization Discussion on Disinfectants/Disinfection Byproducts

Ken Rotert, OGWDW, EPA thanked the WG, analysts, and all virtual participants for attending and providing their time to the WG, as well as supporting answers to many questions. Mr. Rotert presented slides with questions from WG members raised during prior meetings, and answers provided by the technical analysts. The technical analysts include Mark LeChevallier (Dr. Water Consulting, LLC, formerly with American Water), Nancy Love (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), and Chris Owen (Hazen and Sawyer).

'How do sampling designs affect the occurrence of opportunistic pathogens?': Technical analysts noted this is often situation dependent. One suggested approach is to place focus on perceived risks. Technical analysts provided an example of monitoring biofilm growth if there is a perceived risk for it. This could differ from the current rules and guidelines for a specific contaminant. Guidelines and regulatory requirements catch similar data from all systems and do not go into perceived risks on a system-by-system basis.

'What leads to simultaneous compliance issues?': Technical analysts noted several factors here including lowering pH, which can reduce presence of some trihalomethanes but increase some haloacetic acids, and lower pH Can cause corrosion control problems to worsen. Lowering pH could also improve Total Organic Carbon (TOC) removal in conventional treatment. Another area includes biofilms where some analysts felt there were larger contributions with excess biofilms on DBP formation. They pointed out how biofilm can biochemically exist in systems and be subject to direct influence by available nutrients and various types of surface materials. Additional simultaneous compliance issues can arise with regards to disinfection practices, with an example noted for control of nitrification, or impacts of bulk-pipe wall conditions such as material of construction or workmanship. Related items could impact system water quality dynamics, and whether feasibility of control approaches may or may not exist can lead to simultaneous compliance issues. Switching disinfection methods may help achieve adequate disinfection but cause compliance issues with other rules such as the Lead and Copper Rule (LCR) or the Revised Total Coliform Rule (RTCR).

'What are the root causes for D/DBP Rule non-compliance?': Technical analysts noted that the lack of precursor removal and high water age are probably the two areas of root causes that are most impactful. Also, if not properly operated or managed, there can be issues with unregulated DBPs in chloraminated systems, especially in cases where a system may not provide adequate free chlorine contact time before chloramine formation.

'How useful are the existing Initial Distribution System Evaluations (IDSEs)?': Technical analysts recognized that IDSEs were implemented years ago under the Stage 2 rule. As conditions have changed in systems since, consideration for IDSE may not be necessarily useful for a lot of systems today. However, if the IDSEs are updated they may still prove to be valuable.

'What are the impacts of high chlorine doses close to plants?': Technical analysts noted that unacceptability of chlorinous tastes and odors for consumers and utilities were to be avoided by water systems. The rate of DBP formation will significantly increase at higher chlorine residual conditions.

'To what extent do reduced monitoring provisions result in missing DBP problems? How frequently are monitoring plans reviewed?': Technical analysts did not have additional insights to provide at this time.

'How much are users responsible for water quality?': Technical analysts indicated that owners and operators of large buildings should have building water management plans in accordance with ASHRAE Standard 188. This is a best practice but not required other than in New York and in Veteran Administration hospitals. Owners that oversize plumbing for future expansion create the potential for water quality degradation and subsequent water quality issues. Technical analysts suggested to considering delineations between the utility-owned component and the property/building owner component.

Presentation

Dr. Chris Edens is an epidemiologist with the Center for Disease Control and Prevention (CDC), within the Respiratory Disease Branch of the National Center for Immunization and Respiratory Disease. Dr. Edens presented on Legionnaires Disease (LD) in the U.S.. Dr. Edens shared an overview of three primary ways to diagnose Legionnaires Disease; the urinary antigen test (94% of tests), PCR, and culture. He noted that going back prior to LD being a reportable disease, the rates were pretty static, and started rising in the last 20 years (especially the last 10 years). He presented results from a study by Barskey et al. (2022) showing *Legionella* incidence rates by age group and race. People of age 85 and older had the highest incidence, but most cases occurred in the 45-74 years age range. Dr. Edens noted age and demographic differences in cases of LD in the U.S. with causes of racial disparities likely to be multifactorial and worsening. Presented data showed certain comorbidities associated with an increased risk for Legionnaires Disease are more common among Black or African American persons. While explanations behind this trend are not defined, Dr. Edens noted a hypothesis suggesting a number of comorbidities increase the likelihood of individuals to contract LD if exposed to *Legionella* bacteria in water. Comorbidities include a number of factors commonly known to be immunosuppressive, including diabetes, renal disease, and some cancers. In addition to this hypothesis, numerous social determinants of health may play a role. This includes cases being higher in census tracts with higher poverty and lower education levels. Cases are higher in areas within proximity to a high number of cooling towers, construction sites, and certain types of industry. Additionally, renter occupied homes built more than four years ago have been previously identified to be at-risk. More cases of disease are reported among people working and have hazardous or service industries such as transportation repair, protective services, cleaning and construction.

Dr. Edens added that LD is more common in the northeastern U.S., centered primarily around Pennsylvania, New York, Ohio, and Michigan. There is large variability in the percent of identified outbreaks states report to CDC. In terms of case load, numbers were lower in 2020 compared to 2018 and 2019 however, a rebound was noted in 2021. Few cases were associated with known outbreaks and most cases do not include reported exposures. Cases are believed to be under-reported. An example is when the State of Georgia changed their case reporting questionnaire, they noted an increase in outbreak reported cases.

Factors associated with the COVID-19 pandemic may have impacted LD incidence rates and associated reporting. Anecdotal data showed increases in recreational water exposure, as purchasing of hot tubs and pools increased dramatically during the COVID-19 timeframe. Water use in large buildings decreased in 2020. Dr. Edens reviewed factors that had the potential to reduce LD incidence and those with the potential to increase LD incidence in year 2020.

Technical Panel

Mr. Greenwood introduced Shawn McElmurry (Wayne State University), Chris Owen (Hazen and Sawyer), and Vanessa Speight (University of Sheffield) for the technical panel portion of this segment. Dr. McElmurry co-led a large multidisciplinary team that evaluated complex interactions between chemicals and pathogens in Flint, Michigan. Ms. Owen is the Director of the Water and Reuse Innovations office with Hazen and Sawyer and is active in regulatory issues at the state and federal levels. Dr. Speight is a professor of Integrated Water Systems at the University of Sheffield, within the Department of Civil and Structural Engineering.

Dr. McElmurry presented slides showing outcomes of work performed with researchers in Flint, Michigan, with the Health Environment Partnership. Prompted by a change in water supply, an uptick of LD cases showed 87 occurring from 2014 to 2015. Field sampling was undertaken when use of the original water supply resumed. One factor researchers looked at was chlorine residual, which showed variation in amounts of chlorine in the distribution system. Across eight monitoring locations, some held very little to no chlorine for long periods and others held high residuals all the time. Odds of cases present from that neighborhood increased by a factor of at least three when the chlorine levels were lower. Researchers compared occurrence of *Legionella* with neighboring areas. The take home message was a much higher rate of *Legionella* in drinking water following 2014 and 2015 and occurrence of *Legionella* was further verified with 'at the tap' sampling, where samples were collected in homes across Flint. The counts went down after residual disinfectant levels were stabilized, and as free chlorine increased in a census tract, the probability of having an LD case decreased. A species shift was also observed, and Dr. McElmurry noted that some other strains are as virulent and the urine antigen test doesn't detect these. This work was used to assess incidence of LD cases relative to differences in water quality. Dr. McElmurry suggested incentivizing water systems to go beyond normal routine monitoring and to investigate anomalies further and that current disinfectant residual levels may be insufficient.

Ms. Owen noted that in order to better understand the occurrence of *Legionella* and impacts on public health, better surveillance and understanding of organism life cycles and the association with amoeba is needed. Biofilms are an ecosystem in which Opportunistic Pathogens (OP) thrive, and they are present in all systems. There is a need to recognize that protection of public health from *Legionella* is a shared responsibility between water providers, water utilities and households, premise plumbing, and building owners. Water utility personnel face challenges with entering buildings.

Dr. Speight echoed points from Dr. McElmurry and Ms. Owen. Further, she encouraged consideration of the hydraulic component, and mentioned a need to go beyond disinfectant residuals alone. This would entail managing water in a more deliberate manner, noting some systems do not have simple flow monitors to gauge water age within their distribution piping but would benefit from having them available. Dr. Speight described ongoing research with the United Kingdom, linking hydraulics and physics with biofilm growth, to assess increasing maximum peak flow to affect biofilm strength and longevity in water systems. She suggested that systems should manage the supply for water quality, rather than for future fires. Dr. Speight described regulations in the U.K. that require systems to evaluate hydraulics; such regulations were driven in part by concerns about iron and manganese. Flow has to be considered in concert with water chemistry.

Facilitated Discussion

Mr. Greenwood opened the floor for discussion. A WG member asked about what is known about biofilms in systems that use reverse osmosis (i.e., have very little nutrients) (relative to *Legionella* growth or disease incidence); what can be understood about *Legionella* occurrence through study of sewage sludge (including trends); and what the UK is doing to recognize importance of flow management. Dr. Speight noted the UK has changed a lot of their behavior with regards to biofilms. Companies have grasped links between biofilms and actively promote biofilm management. She

noted that iron, manganese, and turbidity are regulated parameters in UK distribution systems, and utilities are using increased flow to meet these requirements, although flow is not a regulated parameter. Failures to manage them yield a financial penalty and private utilities are keen to avoid such an outcome. Apart from this, flow management and sampling were both looked at. Excess flushing is not necessarily needed but she suggested the benefit of flushing at a rate of just a bit more than peak flow as beneficial in stripping off portions of biofilm-related organisms. Separately, Dr. Speight noted being involved in sewage sampling work but *Legionella* has not been sought for in that. In regard to biofilms in systems using reverse osmosis, Dr. Speight explained that even a glass of distilled water, left out overnight will have biofilm.

Ms. Owen noted that microbes are facultative and remarkably adaptable, they are found anywhere and everywhere and will find anything to consume. Managing associated microbes is a question of understanding what those biofilm ecosystems are. Ms. Owen suggested that systems using reverse osmosis would still have biofilm concerns since they are putting that water into a network of "old pipes".

A WG member asked whether the increases in prevalence and incidence of *Legionella* was due to enhanced reporting or a true and real increase. Dr. Edens responded that reporting has not fundamentally changed over time. Electronic data reporting has been the case for more than 20 years across most of the US. However, underdiagnosis of this disease is probably at the diagnostic level. He indicated that, if diagnosed, the data will make its way to CDC, and that the CDC has concluded that the data indicate a true increase in disease rather than an artifact of reporting.

A WG member asked about the pathogenicity of the *Legionella* serotype 6s found in Flint's drinking water system and recalled that similar organisms may have been found in NY and Germany. The member asked if different serotypes or species of *Legionella* might vary per distribution system. Dr. McElmurry responded that the Flint serotypes were just as pathogenic as SG1 and that all forms of *Legionella* should be assumed to be pathogenic unless shown otherwise.

A WG member noted that the prevalent use of urine antigen test (UAT) (which responds only to SG1) leads to the presumption among infectious disease physicians that cases caused by other serotypes are not prevalent. In few instances are sputum samples used. Further, that there could be co-pathogens present but unidentified given testing for SG1 and that use of antibiotics also could lead to changes in occurrence of specific serotypes. Dr. McElmurry responded that culture testing tends to focus on those things that are tested for, so if serotype 1 is found in a culture that is what is noted.

A WG member asked if stay-at-home orders during the COVID-19 pandemic affected the decrease in reported cases and suggested a hypothesis that this inferred less of a *Legionella* problem in homes than in larger buildings and properties. Dr. Edens noted that an analysis of the factors related to the 2020 decrease in cases is still evolving. For example, he discussed the reduction in amount of stagnant water for consumers who were working at home all day and suggested the causes were likely multifactorial. In addition, as hospitals were overwhelmed with COVID-related patients, testing rates did differ during the peak of the pandemic.

Further discussion revolved around the idea of implicit risk for Legionnaire's disease where biofilm growth could be lower in a small household water system compared to a large building water system. WG members encouraged not to draw conclusions on this specific hypothesis but encouraged understanding if a household system is inherently less risky due to a decrease in localized system complexity.

A WG member asked if hierarchies might be needed to address the issue of simultaneous compliance for drinking water systems and indicated that some issues with acute public health concerns might be more important than those

with chronic public health repercussions like DBPs. Mr. Rotert reminded the Working Group of the provision in the Safe Drinking Water Act that stipulates that any revision of a national primary drinking water regulation must maintain, or provide for greater, protection of public health. Further, he noted there are opportunities for helping with implementation and compliance related issues within rule revisions. Mr. Greenwood suggested additional input on this topic could be relevant to future WG meetings.

Working Group members raised questions regarding the graphic for chlorine residuals at Flint (as presented by Dr. McElmurry), specifically if low residuals stemmed from plant effluent, or if they were measured at the distribution system's end. Also, when sampling, was turbidity or total suspended solids (TSS) looked at, as those could affect chlorine residual readings. Dr. McElmurry noted how Flint had high water age problems and the water treatment plant kept high chlorine levels to compensate. Residual samples were taken at 8 DS locations, with some areas already experiencing issues (including with iron); he also noted complex mixing in the DS, including that residuals are unequally distributed. In addition, issues stemmed from the water source going from a low organic content to a source with a high organic content (high in ionic strength). He was not aware of testing for TSS. Turbidity samples were collected but have not been evaluated.

Another WG member asked if the data presented by Dr. Edens showing *Legionella* incidence varying by race was also correlated with poverty, compared to only race-specific data, or if personal health risk and/or degraded infrastructure was also included in the assessment, suggesting this as important for Environmental Justice (EJ) communities. Dr. Edens noted a lack of available socioeconomic data leading to limitations in further evaluation of potential linkages at this time. Locational data is constrained to being only drawn down to the county level which limits looking at more localized social determinants. Dr. Edens noted 15 to 20% of reported cases have no racial data and approximately 30% of reported cases have no ethnicity data. Mr. Greenwood suggested further discussion about EJ topics is being planned for the 5th WG meeting.

Discussions shifted to a discussion about achieving an optimal balance of disinfectant, and Dr. Speight suggested a lack of information needed to answer that question. She indicated that disinfectant residual as an indicator of a how well a system is run and managed. She further pointed to hydraulic maintenance as another potential measure of 'distribution system health'. The issue circled back to biofilms which is still an active area of research irrespective of 'how much' chlorine residual is 'right' or 'wrong'. Biofilms may also be misunderstood and could potentially help control ecosystems in some cases, but more clarity and research are needed. Dr. McElmurry added an observation that a detectable presence of a residual may not be adequate. He also said that starving organisms may be a successful strategy, while indicating that the long view has to be considered. Ms. Owen indicated it is a balancing act between enough disinfectant and not too much. She stated that a hospital in Texas saw a decrease in LD with the use of chloramines. She said that the goal should not be to get rid of biofilms altogether, as it is impracticable. Ms. Owen also discussed flushing levels, referencing a study where iron was trapped in biofilm and later released resulting in 'red' water. 'Aggressiveness' of flushing remained a point of question because public perception and complaints could result if not managed correctly.

A WG member noted that all the data lead to implications for DS and how they are being maintained and operated. The member noted that even with reverse osmosis treatment, re-stabilization of pH and nutrient introduction is still required to meet other regulatory system requirements, which shows the importance of the maintenance and operation of the distribution system. The member suggested that all PWSs have leaks or cross-connections that could lead to biofilms. Discussions circled back to looking at regulatory processes and existing best practices and instilling those two together, whether this includes some type of variable flushing program, or directional flushing. Some WG members indicated that giving systems flexibility to figure out which is best for them may be important for overall success nationwide.

Another WG member provided perspective from experience that some systems do not raise chlorine quickly because higher residuals may cause taste and odor issues with finished water that are perceived by customers as a problem. The WG raised a question was raised about why the western U.S. is not seeing increases in cases of LD with warmer weather becoming an increasing trend. There was a follow-up question with regards to person-to-person transmission rates for LD as a hypothesis about the low incidence of LD in 2020 during pandemic restrictions on group gatherings. For the first question, one member clarified that density plays a role in terms of population count and components that can spread disease, to which the Northeast has a higher burden in areas with higher case counts, such as New York City. Members suggested a deeper dive to tease out why the Northeast and Midwest, and Great Lakes Region have a higher burden compared to other parts of the U.S. This member also noted that cooling towers and population density should be considered. For the second question, a WG member noted there is only one recorded case of person-to-person transmission of *Legionella* in the world literature. A report about that case is available in the New England Journal of Medicine. The member noted that aerosol is the clear method for acquiring *Legionella* and it is possible that wearing masks could prevent inhalation of aerosolized *Legionella*, which could also be a factor in the decrease of cases in 2020.

Segment 3

Existing Regulatory and Policy Context for Risk Balancing/Interdependencies

Presentation

Richard Weisman, OGWDW, EPA provided a presentation on interdependencies of balancing risks while managing microbial pathogens and DBPs.

Mr. Weisman described regulatory requirements for disinfectant residual monitoring under the Surface Water Rule (SWTR) including that samples must be collected at the same time and location in distribution systems as those for coliforms under the Revised Total Coliform Rule (RTCR). The SWTR provides flexibility in sampling locations for systems using both surface and ground water sources where the state determines that points other than the TC points are more representative of treated water quality within the distribution system. Systems must collect samples according to a written sample siting plan. Plans ensure systems collect samples at locations representative of the distribution system. Mr. Weisman provided an overview of IDSE vs routine compliance monitoring requirements for regulated DBPs as well as the Treatment Technique requirements for precursor removal in the Stage 1 D/DBPR (the so-called "3x3 matrix"). He described the requirements (under the Interim and Long-Term 1 Enhanced Surface Water Treatment Rules) related to disinfection profiling and benchmarking (intended to address interdependencies). Mr. Weisman noted how consecutive systems must meet the same requirements for D/DBPR Maximum Contaminant Levels (MCLs) and Maximum Residual Disinfectant Levels (MRDLs) and SWTR disinfectant residuals in distribution systems as non-consecutive systems. Compliance schedules must be based on the population of the largest system in the combined distribution system.

Provisions for consecutive systems under 40 CFR 141.29 allow states to modify monitoring requirements for combined distribution systems. When justified, states may treat combined distribution systems 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. Regarding sanitary surveys, these must be conducted at all PWSs in the U.S. to assess capability for supplying safe drinking water. Surveys 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. Moving into compliance information, Mr. Weisman provided additional information about violations of the D/DBP rules, which were noted as the rules with the most health-based violations. He indicated that the number of health-based violations for the D/DBPRs has been decreasing over the last five years, with the number of violations down by about 40%. Most of those violations originated from surface water systems. Mr. Weisman also presented examples of TT violation types under the SWTR, IESWTR, and LT1 as well as a time series trend showing number of systems with health-based violations under the SWTR and LT1.

Facilitated Discussion

Mr. Greenwood presented the following points to follow Mr. Weisman's presentation:

- 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?

A WG member requested clarity on representation of samples across distribution systems and if anomalous situations are considered. The member asked what criteria are provided by EPA for sample site selection. Mr. Weisman explained that representation is identified on a system-by-system basis with state approval, and representative means throughout the distribution system but not specifically dead ends or peculiarities. Anomalous situations such as with dead-ends or storage tanks might be of concern and WG members may wish to identify those in their deliberations. EPA provides guidance for use in identifying representative sampling locations through guidance developed under the RTCR; these include pressure zones and retention times.

Another member requested clarification on benchmarking and profiling, as well as TOC removal. Mr. Weisman provided clarification on current requirements, and broadly covered filtration processes associated with TOC removal.

One WG member noted that consecutive and combined systems can be treated as a combined distribution system for decreased monitoring allowances, but they are typically not evaluated as a combined system for water quality trends. This member also asked for clarity on notification to the public regarding deficiencies found during sanitary surveys, specifically when is a deficiency a violation and when is public notice required. The WG member expressed how this is an important piece of interaction with water systems, and if systems don't provide information to the community, then communities may not understand the quality of the water being received. Further, a question led into inquiring the number of violations relating to MDBP rules, especially with regard to health-based violations. A member pointed out how identifying MCL violations is easier than a treatment technique violation, as the latter requires some form of analysis and requires more human intervention, state resources, and oversight. The member noted a system that did not complete benchmarking in 2012 but was not identified as a violation until 2021. Mr. Weisman clarified deficiencies found during sanitary surveys are not necessarily for public notice however, failure to implement an associated corrective action according to a schedule may result in a violation that would be associated with the public notice. With regards to health-based violations, EPA has information on this and it's in large part intended for tracking violations by specific rules. With regard to ease of identification of an MCL versus a treatment technique violation, this is a question that could be pulled into future discussions around implementation challenges.

A WG member pointed out differences between surface and groundwater systems need to be kept in mind, such as with TOC removal when looking at source water. Furthermore, there may be a benefit to consider future requirements for TOC removal to be applied to both direct filtration plants and conventional treatment plants. The member also asked whether the benchmarking requirements apply forever. Mr. Weisman responded that the 3x3 matrix applies to conventional treatment plants and that others are excluded. He also replied that the benchmarking requirements are ongoing.

A WG member described that residual monitoring for small systems may occur only once per month, and it's not during DBP monitoring. Systems serving up to 33,000 people have to monitor no more than once per day. The member also noted that benchmarking and profiling applies to only surface water systems, and that TOC removal goes beyond systems with conventional treatment.

A WG member requested more information on 'repeat' violations either by violation or by system. In addition, demographics of where repeated violations occur might be helpful, if even broken down by large, medium, and small system-sizes.

The members initiated a separate dialogue regarding violations not reported in SDIWS, where states reach agreements with utilities to remedy potential issues. It was one WG member's understanding that audits ceased several years ago, and asked how those potential violations are reconciled in terms of 'type' and 'count', compared to those officially entered into the SDWIS system. The member mentioned that the information provided covered only health-based violations, and that there are three times more monitoring and reporting violations. A related concern is to isolate systems with recurring issues, whether addressed or ignored, especially if those mask potential health violations.

WG members underscored stratifying sampling sizes for distribution systems for MDBPs and OPs, particularly because of variations in size of the systems across the U.S. and for establishing a hierarchy of importance relative to other existing or future requirements.

Discussion ensued on understanding how well affordability is measured with public health protection for consumers. Members suggested to input this into future discussions, specifically on the interdependencies and evaluation of balancing risk with required monitoring and treatment. WG members pointed out the selection of sample sites, and encouraging states to review sampling plans, with regards to accessibility as something not straightforward in some distribution systems.

A WG member pointed out that all distribution systems are unique. This member stated that the WG needs to determine priority and expressed an opinion that there is a lack of correlation between DBPs and public health effects. The member further suggested this is related to his concern about potentially high costs for TOC removal, with those costs passed on to consumers. The member noted a previous EPA presentation which suggested a near zero correlation of DBPs and bladder cancer. Another WG member responded by citing bladder cancer as the most consistent DBP related long-term health effect. That member also referred to short-term reproductive and developmental effects associated with DBPs and referenced a recent paper about a Swedish study which examined 600,000 cases throughout the country. Countries such as Sweden have strong data collection measures in place for studying health effects.

One WG member stated that even though the focus of this workgroup is on surface water systems, ground water systems have problems as well. Spatial distribution of samples was reiterated to ensure samples are representative of the entire distribution system. Discussions circled back to oversight through monitoring plans, and how development of this rule revision might provide states with a good chance to review existing sampling plans which might have aged or fallen off radars. There are many things states can do to ensure worst case scenarios when looking at water storage, interconnections, areas of high-water age, or zones with frequent coliform detections. Another option would be to engage public buildings in areas where there is difficulty in obtaining samples in residential zones, as well as the increased use of sampling stations.

Segment 4

Problem Characterization on Risk Balancing/Interdependencies

Presentations

Mr. Greenwood introduced **Dr. Scott Summers** with the University of Colorado, Boulder. Dr. Summers reviewed three approaches for increasing disinfectant residuals in distribution systems. The first included optimizing distribution

system management, the second noted increasing removal of compounds (in source waters) which could react with chlorine, and the third overviewed increasing disinfectant doses.

In general, distribution system best management practices yield positive impacts on chlorine demands and DBPs. Dr. Summers overlaid formation of THMs with this information, illustrating the impact on chlorine demands and DBP formation. Chlorine demand from low organic matter associated with the presence of microorganisms was indicated to be lower compared to consumption of chlorine from byproduct reactions. He presented percentages of chlorine consumption relative to the formation of DBPs to the WG.

Dr. Summers pointed out that where inorganic or organic compounds occur, this should be looked at more closely in distribution systems such as in sediments or along pipe walls. Controlling presence of these indicates better control of chlorine demand and most disinfection byproducts inside distribution systems. Waters with higher levels of inorganic compounds and organic matter create higher chlorine demand, particularly in higher temperatures. Dr. Summers pointed out that based on this information, disinfectant residuals in the distribution system can be increased without exceeding DBP MCLs.

Dr. Summers shared best management practices ranging from the flushing of sediments from pipes, corrosion control, to pipe replacement, which all contribute to better chlorine management in distribution systems. Changing hydraulics can also play role in demand management, especially if re-routing water reduces water age. The relationship between chlorine demand and THM formation was overviewed as well. In conclusion, Dr. Summers shared how disinfectant residuals in distribution systems can be increased without exceeding DBP MCLs if system management is optimized, if disinfectant doses increased, *and* there is an increased removal of compounds in source water that may react with chlorine such as organic matter and inorganic compounds.

Mr. Greenwood then introduced the next presenter, **Mr. Stuart Krasner**, retired from the Metropolitan Water District of Southern California. Mr. Krasner presented on formation of emerging DBPs. In general, control of regulated DBPs controls the formation of many emerging DBPs. Emerging DBPs include nitrogen-containing DBPs (e.g., haloacetonitriles [HANs]), some of which are more toxic than regulated ones. Mr. Krasner provided an overview of specific types to be discussed and separated into those which are not currently regulated.

Mr. Krasner pointed out which groups of DBPs are preferentially formed in chloraminated waters. He explained that where chlorine or ozone are used as the primary disinfectant and chloramines as a secondary disinfectant, decreased formation of certain DBPs results. He provided that increased contact time with chlorine is an example that led to greater formation of specific DBP types.

In conclusion, Mr. Krasner shared that chlorination of drinking water forms brominated DBPs beyond those in THM4 and HAA9 and 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 was 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, and consecutive systems with higher water age.

Discussion

Mr. Greenwood then opened the floor for clarifying questions from WG members. A WG member asked a question about distribution systems and water age, and if mixers have assisted with related issues in water towers. Mixers are capable of stripping out volatile fractions like chloroform, but it also depends on inlet and outlet configurations. Dr. Summers noted that mixers can impact THMs due to aeration.

It was noted that monitoring for chlorine residual at the same time and location as DBP samples is not part of federal regulatory requirements and that some states have independently moved towards that. A member suggested including specific chlorine residual monitoring requirements for future DBP sampling requirements, and focusing studies to narrow out relationships between chlorine demand and HAAs. Dr. Summers noted that the relationship between residuals and HAAs is not clear. Only 46 studies looked at HAAs and some observed decreased concentrations in the distribution system by biodegradation. Dr. Summers also mentioned that studies tend to assume fixed removal of HAAs.

A member mentioned that the downsides to minimizing water age related only to costs, and not health.

Discussion moved to relationships for wider ranges of disinfection byproducts precursor removal. Notably, reducing inorganic and organic matter prior to chlorination is shown to address many problems simultaneously. This point was tabled for the intervention phase of this WG process.

A WG member asked about potentially negative water quality consequences of hydraulic management and precursor removal. Discussion noted removing precursors is primarily advantageous in the long run but the issue is cost and sustainable operations for treatment systems, especially for smaller systems. Infrastructure and maintenance are part of this picture as well. Dr. Krasner noted that different DBPs have different precursors which must also be taken into account.

Another WG member pointed to flushing being an effective tool for distribution system management, specifically for reducing water age however, this becomes a sensitive issue in drought-stricken areas. A member responded that flushing can be an issue with sampling because if flushing is not done routinely and only before taking DBP samples, then the sampling is not an effective measure of usual DBP levels.

A member raised simultaneous compliance as being important for the WG to keep in mind. Some members suggested looking at multiple sources of information such as from Contaminant Candidate List 5, or other DBP studies from research communities who are working with utilities in regions which frequently see DBP as an issue (to help fill information and data gaps as the WG moves forward).

A WG member asked to ensure labs capture disinfectant residuals and pH at time of analyzing for DBPs, in case the water supplies or state wouldn't have sample data at time of capture. Another member noted in their region, if this information is not collected at the time of sampling and provided to labs by delivery, then samples are ultimately rejected, and a notification is then supplied noting such.

A member asked whether emerging DBPs would be included in future UCMRs. Mr. Krasner mentioned that there were emerging DBPs in prior UCMRs, but that a level of concern is not noted in the UCMRs. He also noted that the fifth Contaminant Candidate List just came out, and that research on emerging DBPs has been going on for many years. Mr. Krasner also said that there are safety factors built into the data Mr. Weisman presented.

A WG member stated that DBP samples have to be dechlorinated and in a correct pH range to be accepted.

Presentations

Mr. Greenwood introduced **Gary A. Burlingame**, retired Laboratory Director for Philadelphia Water Department and Senior Scientist for the Environmental Science, Policy and Research Institute. Mr. Burlingame presented an overview of the Sanitary Survey process and described its purpose to evaluate and document capabilities of water system sources, treatment, storage, distribution, network operation and maintenance, and overall management. Surveys identify any deficiencies that may adversely impact the public water systems ability to provide a safe, reliable water supply.

EPA and state 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, educate operators about proper monitoring and sampling procedures, provide technical assistance, and inform them of any upcoming changes in regulations. Mr. Burlingame noted this helps connect water utilities and their regulators to make sure safe drinking water is provided.

Mr. Burlingame provided additional overview on the background and requirements of Sanitary Surveys. Class 1 Sanitary Surveys are required in periodic three-to-five year ranges as an on-site comprehensive audit with a Class 2 falling under when States require a survey to follow-up on a Class 1-type. Inspector roles, identification of deficiencies, and corrective actions are part of these surveys with examples provided to the WG. Mr. Burlingame noted Sanitary Surveys run in parallel with SDWA compliance reporting and monitoring, along with State engineering reviews of plan changes.

Mr. Burlingame noted multiple barriers that are evaluated in Sanitary Surveys, specifically in checklists, helping to categorize potential hazards from causing a consequence, as that could follow in a public health risk, and siloing of work units. He referred to a recent study (Heinrich et al., 2022) which found examples of common deficiencies such as for finished water storage. That study showed an increase in occurrence with larger systems because those tend to have more finished water storage facilities. For smaller systems, violations were seen where operators may not have been full time or not up to date on their required certifications. Other smaller issues may be held within institutional knowledge of inspectors or local municipalities, particularly on long-term trends seen with specific systems. Elements of risk management are often utility-specific, and management of those risks may be spread across different utilities or organizations. Capturing such information in a national database is more challenging. Additional stressors include retirement of water system employees, knowledge gaps, and hiring challenges.

Mr. Greenwood introduced the next presenter, **J. Alan Roberson, Executive Director with ASDWA**, discussing D/DBPR compliance challenges and disinfectant residuals. Mr. Roberson underlined how simultaneous compliance with all regulations is critical to protecting public health. He provided an example of studies with University of South Florida looking at the effectiveness of nitrification action or management plans. There are a small number of states with these plans in place, and understanding what the elements are, how they work, and how effective they are will be important for attending to simultaneous compliance issues. He noted challenges for small systems when there are physical space limitations for additional treatment because of existing infrastructure. Simultaneous compliance may be particularly difficult in areas with consecutive systems that have multiple boards or organizations managing a supply, as well as with consolidated rural systems which have smaller populations and multiple contracts for purchasing water from different systems. In case of the latter, water quality might meet all adequate and required criteria at the point of entry, but this quality may change once water makes it though adjoining pass-through points for different communities. Two other issues might include decay of treatment chemicals and water age. He made a

point about community water systems lacking full-time operators (those serving 3,300 or fewer people) who fill gaps with part-time operators or contractor operators who work on multiple systems. Systems serving fewer than 500 people typically have no governance structure. In conclusion, Mr. Roberson encouraged to keep recommendations simple and to avoid over complicating solutions for utilities and communities which leads to significant increases in workloads of states that are already overburdened.

Mr. Greenwood introduced the next presenter, **Dr. Vanessa Speight**, who provided an overview of drinking water storage issues. She recognized the critical role played by finished water storage tanks in protecting water quality. Water from these tanks is often what consumers are exposed to and could lead to cascading issues of contamination if not carefully managed. She noted equalization storage as an element to consider for meeting demand, as well as fire storage requirements and related insurance ratings. Dr. Speight suggested reviewing practices with operators and understand demand to assess volume movement. A key contributor to water age depends on volume, operation, design, and mixing conditions such as flows, temperature, and water quality within storage tanks. Engineering re-designs can also aid water systems with issues relating to DBPs, and additions to treatment and storage systems including mixers can resolve issues as well. Though there is not a one-solution to fit all issues, enhancements to tanks and distributions over the long-term can contribute to better water quality.

Dr. Speight suggested a need for more research on DNA from microorganisms extracted from distribution systems, as there's more to understanding them and their ecological habitats. For example, she noted a study showing *Legionella* is more related to biofilm activities than physical breaches in storage tanks. Sampling a tank will not clearly show everything happening inside of it, and encouragement was lent towards deeper analyses into them and to their relative roles and locations for a distribution system. Dr. Speight pointed to technological advancements including use of remotely operated submarine vehicles to help with inspections where there are safety issues, such as with climbing or with confined spaces.

Discussion

Mr. Greenwood opened the floor for discussion. One WG member expressed that wholesalers of water hold a responsibility to downstream consecutive systems to maintain water quality. This includes facilitating additional storage tanks and monitoring of residuals across tanks to which they provide water services and supplies or working with adjoining utilities to do the same and compare data. Emphasis was on water age, chlorine residuals, and pH (especially at inlets and outlets). Regarding Sanitary Surveys, the WG member expressed that though requirements are sound, it's often in their experience that inspectors generally don't have enough time to look at everything across a system. The member also suggested that the best elements of Comprehensive Performance Evaluations, and Area-Wide Optimization can be looked at. The members stated that Sanitary Surveys can be improved without a lot of burden.

Discussion on Sanitary Surveys suggested requirements be developed for new systems. In addition, surveys might benefit with special attention to the financial capacity of water suppliers, particularly funds are being spent to maintain infrastructure and water quality.

A WG member asked about requirements for tanks in Colorado, where new requirements focus on tanks. The member also inquired about the elements in the UK standards. Another member provided insight that Colorado's rules focus on water quality sampling, followed by investigations and remediation, if needed. It also focuses on tank integrity, holding adequate tank management plans, requirements for periodic inspections, and maintaining records. Dr. Speight noted that the UK has no equivalent requirements. There are also cleaning histories to consider, as well as adaptive responses. Mr. Roberson replied that the Colorado rule is focused on tank integrity and inspections as a response to the Alamosa outbreak.

A member raised a separate question on large distribution systems, such as those with thousands of miles of pipes. Interest was expressed with chloramine and water age with those types of systems. Mr. Roberson responded that different portions and zones can change frequently with time depending on all types of actors. There is often a running balance of compliance monitoring versus process monitoring for them. In addition, those systems tended to carry out additional monitoring based on financial constraints. Mr. Burlingame added that zones of piping can be viewed as individual small systems and are also modeled so operations of their hydraulics can better inform staff and maintenance requirements. Causes of water age in those systems include dead ends, closed valves, or even storage tanks that are kept full in anticipation of emergencies, such as a lack of water or inclement weather such as hurricanes. Dr. Speight noted that some large systems were designed for industries which are no longer present, and this is becoming an increasingly large problem as downsizing of pipes is needed to manage smaller customer bases. Otherwise, unused portions saddle areas with greater maintenance costs and compromised water quality.

A follow-up question related to input about options that may be available for consecutive systems that are vulnerable to disinfection byproducts at or near the MCL, noting that in some cases wholesale and consecutive systems may not communicate well. Members raised consolidation and a limited number of treatment options. Mr. Roberson noted that aeration could be an option, but there could be a menu of consolidation approaches. He noted this as sharing of staff, equipment, and other means to improve water quality. A key point was maintaining good relationships of staff between systems or devising a solution where the consecutive system could handle one end of treatment, while the originating system or wholesaler handles the other. A member mentioned consecutive systems paying for a portion of the wholesaler's treatment. A WG member reminded the group that some states are already overwhelmed by current SDWA responsibilities suggesting that any rule revisions shouldn't be complicated or prescriptive.

Technical Panel

Mr. Greenwood re-introduced Dr. Scott Summers, as well as **Dr. Chad Seidel** who is President of Corona Environmental Consulting, and **Dr. Kerry Howe** with Howe Water Science. Panelists provided insight on areas and topics of concern with emphasis on topics touched on by WG members.

Dr. Seidel shared that gaps in implementation exist that cause negative public health outcomes, but not for lack of intent from the regulatory system. He noted challenges in characterizing smaller systems, particularly ones which are under-resourced. The most egregious problems happen where there is an underlying gap or failure associated with managerial and technical capabilities, not because of a regulatory gap. One aspect includes source water protection. In this case, one or more suppliers would need to apply and maintain disinfectant residuals, all while balancing constraints with other regulatory drivers of minimizing disinfection by products.

Dr. Summers emphasized a need to accomplish goals under the current regulatory framework and to ensure lessons are learned from where utilities succeeded or failed in certain areas. The WG will benefit by understanding these areas. Dr. Summers raised a question: Is there a requirement for disinfection residuals to be taken and reported at the time that DBP samples are? Mr. Weisman noted this is not a federal requirement however, based on a publicly posted review (i.e., the SYR4 ICR data), a number of samples show a residual along with THM data. Therefore, some states are doing that, and follow-up could be helpful to gain further clarity on this question. Dr. Summers replied that a lot of problems would be solved if residual measurements were taken with DBPs.

Dr. Howe pointed to a semiconductor plant in Albuquerque, New Mexico which must produce water with TOC well below 1 part-per-billion. Water travels into the plant's distribution system and is recirculated at a high velocity. When water ceases to recirculate due to maintenance or other factors, bacteria grow. Even in a system with no carbon source and low levels of nutrients, bacteria will grow if the water becomes stagnant for any period of time. Dr. Howe expressed control over biofilm is more critical than eliminating them outright. Potential benefits might also exist for biofilms within a system, though research is still ongoing on this subject. Also, community perception of wasting water during flushing operations is significant, and this is not just in contexts where drought conditions exist. He further noted that water consumption is down by as much as half due to conservation efforts, which increases water age. Flushing responses can be constrained in some communities, particularly where customers may face fines for wasting or overuse of water (such as running a broken sprinkler).

With respect to filtration and reverse osmosis, Dr. Howe noted drawbacks apart from cost is energy consumption and low water recoveries. There are negative environmental impacts associated with energy production and its excess consumption to produce clean drinking water. Treatment options need to consider such energy draws in communities as this may affect consumers over short or long terms. The water also has to be stabilized (e.g., pH adjustment) after RO treatment because the water becomes too pure. Tradeoffs of treatment are also important to consider due to water aesthetic and innate qualities such as expectations of calcium in water from a positive health perspective. In conclusion, Dr. Howe encouraged thinking carefully on the negative impacts from a health or environmental point of view rather than solely the type of treatment.

An additional point Dr. Howe raised includes challenges in addressing consecutive systems and the intersections between consecutive and small systems. Having distribution systems hundreds of miles long to serve a couple hundred homes or less means an exorbitant expenditure of financial resources not all populations can accommodate (volunteers are often needed to make up for resource deficits). Blended water sources are seeing increased use such

as those with desalinization and/or potable water reuse. Both hold different characteristics in terms of inorganics and organics, and these could potentially lead to some challenges with achieving control of DBPs and the presence of OPs.

Dr. Kirsten Studer, US EPA, was introduced by Rob Greenwood to address a previous question, and noted the continued importance of research and development to further inform the question of causality between DBP exposure and bladder cancer. Dr. Studer noted the information previously published by EPA showing a range of 2-17% for potential risk associated with DBPs and explained that the evidence for a correlation between chlorination DBPs and bladder cancer continues to grow. Mr. Krasner added when most studies were done, they looked back 30 to 50 years. People who have the disease were exposed potentially 30 to 40 years ago, which is prior to initiation of current DBP rules and therefore may obscure comparative relationships. A member added that studies need to find residents who have lived in the same communities for decades. The member stated that NDMA is a suspected carcinogen as indicated by a number of studies. More studies have been performed since the 2-17% range was developed.

Mr. Greenwood moved into discussion topics which included:

- 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?

A member sought clarification on potential risk estimates for bladder cancer and exposure to individual DBPs. Dr. Studer noted confusion might exist between the two terms of causality versus correlation. Correlations exist in many different epidemiological studies which show that exposure to chlorinated DBP's using THM4 as a surrogate for chlorination DBPs correlates with bladder cancer. However, this doesn't mean that DBPs have been proven to cause bladder cancer. There are a lot of studies that support correlation but there is an ongoing need for studies related to understanding causality. Mr. Rotert added that many studies have refined the understanding of the potential risk levels for DBPs since the risk range for the Stage 2 rule was developed in 2005. A follow-up question included if a reduction in bladder cancer cases is being seen since 1982, when the interim rule was developed. A member noted that we would just now be observing the reduced risks. Streamlining collection, reporting, and management of those data to yield a national comprehensive data set is not yet undertaken but noted as a question to follow-up on. Dr. Seidel mentioned that with the Six-Year 4 data release there are some residual data along with DBP monitoring data. The data was recently released, so more analysis is needed.

One member mentioned that an exposure assessment is needed to better inform the health outcomes. The member also mentioned that other health endpoints need to be considered.

A member raised a separate point regarding water consumption being extremely different in different parts of the country, even in systems of similar population sizes and if consumption can be considered as something more universal. The member noted that this could in part explain the geographic variability in disease. A second point related to the notion of water conservation and this causing an increase in water age. Discussion on the second point led to a WG member pointing to design of water conservation measures with capacity in mind, similar to wastewater

practices and scaling capacities and treatment measures into pre-defined orders of magnitude. This member emphasized looking at relative levels.

A separate WG member suggested EPA consider economics and health effects in relation to DBPs. Some studies have not considered natural sources of regulated components in their water, such as bromide. Therefore, the costs of managing contaminants in one area may start off at a higher rate in comparison to another. Mr. Krasner responded that McTigue et al. (2014) published health effects data versus economic impacts of increased bromide in drinking water sources.

A WG member stated that the health effects of DBPs was argued and settled fifteen years ago. The member elaborated that there are probably multiple effects, especially since there have been numerous studies since then, including those with toxicological effects. According to this member, National Toxicology Program studies and global authorities indicate that multiple DBPs, especially brominated DBPs, are associated with cancer. The member concluded that, if prior regulatory findings are to be opened back up in this process, epidemiologists and toxicologists would need to be involved.

A member raised a point that several questions on water-saving measures should be asked when making data-driven decisions to develop a strong foundation for the measures. Adaptive management would be needed according to this member. Questions which should be asked include 'how does one accomplish conservation, why does this matter' but also 'how do conservation measures affect potential DBP formation?' The member stated that more is needed on health effects to establish a strong foundation.

Another member raised a concern that conversation may not be sufficiently complex in some places and in other places overly complex. Feasibility of some conservation efforts will very geographically. It is also important to consider potential unintended outcomes of conservation (e.g., higher water age). The member also suggested that there may be some protection of pipes from corrosion by biofilms. They advocated for simple outcomes where possible. They also shared concern about consideration of environmental justice and having more data on disproportionate impacts would be useful going forward, especially on opportunistic pathogens.

Regarding simultaneous compliance, one WG member suggested looking at risk-balancing and finding multiple benefits where they exist for certain solutions under different rules. A member cited precursor removal as one which has repeatedly been pointed to as a helpful solution. The member also suggested that a lot of terms of art are being used, which may cause some confusion. This needs to be considered as recommendations are being developed.

A WG member requested a chart for the myriad of DBPs as a helpful way to keep track of those discussed. Separately, a point emphasized the unidirectional flushing of pipes and its success in a large system, where removal of microbes and particulates allowed the supplier to consider lowering chlorine usage to achieve required residuals and also lower production of DBPs. Turbidity was also cut in half. They also undertook a robust sanitary survey and worked with the public service commission on an audit, inventory, and finances. It was generally agreed that inventorying storage tanks proved to be a helpful measure, especially when looking at wholesale distribution of water during months of heavier winter freezing. Tanks have been found with a lot of manganese and iron.

Another member mentioned that the WG needs to look at all of the evidence. Different distribution systems need different measures. It's hard to generalize across the country. More recent data is needed in some areas because there are a lot of variables and information is needed from the whole system.

One WG member indicated that DBP precursors need to be further discussed.

A member mentioned that there's a delicate balance with system capability when it comes to consecutive systems, especially since many are trying to get out of the water business.

Mr. Greenwood mentioned the date for Meeting 5 (December 13) from 11-6 PM ET. In addition, areas of follow-up questions addressed as with previous meetings. Presentations and discussions anticipated for Meeting 5 are on environmental justice within the context of the five MDP rules. Input will be welcome from WG members, and outreach will be conducted for further advice on how to best approach structure in conversations for environmental justice, implementation, and compliance challenges.

At the conclusion of this meeting, Co-Chairs Andy Kricun and Lisa Daniels thanked WG members and technical analysts for their participation, interest, and engagement throughout the day.

Ms. Corr closed the meeting.

Appendix 1: MDBP Working Group Meeting Attendance – November 3, 2022

Name	Attendance
Andy Kricun, WG Co-Chair	x
Lisa Daniels, WG Co-Chair	x
Alex Rodriguez	x
Benjamin Pauli	x
Bill Moody	x
Elin Betanzo	x
Erik Olson	x
Gary Williams	x
Jeffrey Griffiths	x
John Choate	x
Jolyn Leslie	x
Kay Coffey	x
Lynn Thorp	x
Lisa Ragain	x
Michael Hotaling	x
Nancy Quirk	x
Rosemary Menard	x
Scott Borman	x