NDWAC MDBP Rule Revisions Working Group

National Drinking Water Advisory Council (NDWAC)

Meeting 3 Summary

September 20, 2022

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

The third Working Group (WG) meeting was held to continue problem characterization discussions on opportunistic pathogens and disinfectant residuals; to create a common understanding of the current regulatory framework related to the Disinfectants/Disinfection Byproducts Rules (D/DBPRs); and begin problem characterization discussions on disinfectant byproducts.

This document provides a summary of presentations and discussions from the meeting on September 20th, 2022. Two-page documents on disinfection byproducts (DBPs) and related topics (e.g., Haloacetic Acids, Precursors; Source Water; Nitrosamines; Chlorite and Chlorate; Consecutive Systems; and Seasonal Chlorination), along with background videos, and reference articles were shared with the WG ahead of the meeting. In addition to WG members, approximately 140 observers attended the meeting.

Segment 1: Agenda Review and Meeting Procedures

Elizabeth Corr, Environmental Protection Specialist, Office of Ground Water and Drinking Water (OGWDW), Office of Water, EPA

Ms. Corr welcomed all to the third 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 the panelists for their unique input and deeply valued discussions from prior meetings. She acknowledged DBPs as a persistent public health risk to consumers of drinking water, to which this group's expertise would provide valuable insight. An overview of the day's agenda was also provided.

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 depth of technical information provided, with emphasis on a wide understanding by the panel on varying levels, to foster discussions and deliberations. Mr. Kricun echoed thanks to the team, and to EPA for providing information needed for participants in the group. He emphasized meaningful input with an understanding of materials shared for healthy and productive discussions.

Robert Greenwood, Principal, Ross Strategic

Mr. Greenwood reviewed controls for the Zoom platform and provided an overview of the agenda. It was noted that WG panelists are providing their unique points of view and are not representing those from affiliated organizations. Segment 2 of the meeting will include problem characterization discussions on opportunistic pathogens and disinfectant residuals, as a follow-up from points raised during Meeting #2. Discussion of problem areas will continue in greater detail through Meeting #4, with implementation challenges also to be covered. Mr. Greenwood emphasized the need for assessment of current implementation challenges, as echoed by panelists in previous meetings. Mr. Greenwood noted a specific suggestion by Working Group members for inclusion of technical analysts in panels supporting discussions, which is incorporated in today's meeting.

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

Ken Rotert, OGWDW, EPA thanked the WG for attending today's meeting. Mr. Rotert presented slides which answered questions from WG members raised during Meeting #2, and noted all answers were strictly provided by technical analysts.

'What's being done in blended waters?': According to the technical analysts, there was no indication that blended water is at any more risk for pathogen growth than surface water or groundwater.

'What is the problem with disinfectant residuals?': It was noted that opportunistic pathogens (OPs) can grow in distribution systems where residuals are low. When measuring for such residuals, some sampling and testing methods can produce uncertainty and may not accurately reflect low levels. This may especially bear consequences for small systems that may take corrective actions as a result, leading to short- and long-term impacts. Current rules allow up to 5% of a distribution system to not meet disinfectant residual targets. Analysts pointed out not all distribution site samples may be collected at consistent locations, which holds implications for overall compliance.

'What are the implications for oversized systems?': It was explained that such systems may have areas of low flow and stagnation where disinfectant residuals can dissipate. However, oversizing may sometimes be necessary to meet fire flow requirements. Some analysts noted that it's important to make a distinction between systems with depopulation versus those that were built oversized, because systems experiencing depopulation are less able to afford infrastructure repair and maintenance due to a decreased revenue base, which may make those systems more vulnerable to contamination. One example is that they may have backflow preventers that are not maintained, not present, or correctly installed. Additionally, they are more vulnerable to contamination due to lower water utilization, which increases the water age in the system, due to lower customer water demand.

Some analysts also referred to situations termed "flowing stagnation," in oversized systems where water velocity was insufficient to prevent stagnation and biofilm growth along pipe walls. This may be notable at ends of a water system, main loops, transmission mains sized for low head loss, in oversized building fire protection systems, building plumbing sized for future expansion, and in modern plumbing systems designed per outdated plumbing codes.

'What happens to water in the distribution system?': Technical analysts noted bacterial growth can occur under specific circumstances as water flows from treatment plants towards customers. Managing or preventing this growth is key to maintaining water quality including low turbidity and chemical stability, biofilm control, disinfectant residuals, retaining effective corrosion control, ensuring good circulation in pipe networks, and removing sediments. Technical analysts suggested that much of the 'sediment' found in distribution systems are likely biologically active and can aid in formation of biofilms. Once established, biofilm will resist disinfection and proliferate unless prevented from doing so by source nutrient removal or preventative maintenance. Distribution storage water tanks are also frequent locales for stagnant water, especially some with single inlets and outlets. Additionally, water may not be turned over in tanks at regular intervals. Such configurations are sometimes sources of nitrification.

'What are root causes for growth of opportunistic pathogens?': Aging and undermaintained infrastructure were noted as contributing factors. Testing has demonstrated filtered water systems cannot remove all bacteria and those which escape treatment may proliferate in distribution systems, and frequently are protected and nourished by biofilms.

'What is the water use in aerosol-generating devices?': Anything producing water as an inhalable droplet size, becomes a transmission source which people can breathe. Examples include showers, cooling towers, and spas.

'Where is *Legionella* found in the treatment train?': *Legionella* are naturally found in raw water. Analysts suggested seeking additional data on *Legionella* in finished water that meet Surface Water Treatment Rule / Enhanced Surface Water Treatment Rule (SWTR/ESTR) requirements. Analysts also reminded that disinfectant residuals are components in a much larger picture of maintaining healthy water quality.

'What clarity can be provided regarding the contribution of distribution systems versus plumbing on conditions that may allow for opportunistic pathogen growth?': The exact answer is unknown. Analysts shared that even with high-quality distribution system water, *Legionella* can grow in building plumbing if conditions are favorable. Building owners/managers, along with utilities must collectively manage *Legionella* risk however some analysts suggested that communication about the role of each is lacking and needs work. Analysts pointed to collecting measurements at entrances and taps within buildings. Research studies suggest water quality in buildings being demonstrably different from incoming supplied water. Some analysts suggested that code-driven plumbing system design may be the biggest contributor to Opportunistic Pathogen (OP) growth, with commercial requirements creating higher risks. Requirements for hot water loops per energy efficiency codes are shown to contribute to high water age and as a side effect, promote biofilm growth and loss of disinfection. Analysts also emphasized complexities in premise and building plumbing systems. In particular, problems with disinfectant residuals and OPs are a function of building/structure plumbing systems that are subject to differing building codes and are further impacted when operated under a variety of differing conditions.

'How would PCR results inform risks that may be present if systems don't maintain adequate disinfect residuals?': Analysts shared these can indicate the presence of genetic material but not if cells are viable or infectious. Detecting DNA of certain bacteria would not imply any risk, as DNA do not make people sick – living organisms do.

'How specific are PCR data?': PCR can be specific for the genus, species, or even strain of bacteria however, conventional techniques cannot indicate viability. There are culture techniques (e.g., Legiolert) that can quantify viable cells in a sample. Other analysts noted that they've seen Legiolert provide false positives – e.g., a high prevalence of *Pseudomonas* will cause the media to turn with no *Legionella pneumophila* present. Some analysts recommended that all presumptive Legiolert positive tests be confirmed by serotyping.

'How are sampling locations chosen with regard to disadvantaged communities?' This is unknown as relatively little monitoring for *Legionella* has been done in distribution systems. Utilities need the technical, financial, and managerial capabilities to monitor, maintain, and review such a measure. Analysts suggested challenging existing presumptions on pressure zones, specifically that these are explicitly known and monitored. Many systems may not have newly validated and up-to-date hydraulic models of their distribution systems, and therefore existing sampling protocols may not align with assessing the greatest potential water quality risk areas. (Note: the questions also applied to monitoring for disinfectant residual, however, panelists did not respond to that aspect of the question.)

'What are the ecology and life cycles of opportunistic pathogens?': Many OPs are associated with biofilm, and analysts suggested better control of its formation will be reliant on improved nutrient control prior to entry points, optimal plumbing sizing to promote self-cleaning velocities on a routine basis, and better water system/plumbing maintenance. Other analysts pointed to preliminary and unpublished data from low vs. high water age, whose data indicate formation of nutrients can increase with water age. This suggests biogeochemical cycling that occurs in distribution systems is poorly understood but may be critically important to OP survival and proliferation.

Technical Panel Presentations and Discussion

A 3-person technical panel was invited to provide their input and perspectives concerning OPs and disinfectant residuals. Each panelist was introduced by Mr. Greenwood.

Dr. Nancy Love, Professor of Civil and Environmental Engineering**,** University of Michigan, was introduced and noted that the quality of information within distribution systems is important for future monitoring measures, and that there's an increasing cost with the detail of information sought. Adequate and high-quality data, along with incorporation of historic data will also be essential for OP monitoring. She cited Flint, Michigan as an example using a model-generated map presented from a technical advisory group for the council in Michigan. The map showed chlorine residual monitoring points during and preceding Flint's water crisis – which were largely driven by the RTCR monitoring requirements, and not necessarily representative of areas that showed varying levels or low levels of residuals. She also mentioned that, for the Flint system, the monitoring locations had not changed even after the large population loss. Dr. Love noted differing alignments of public health data compared to data collected at the utility-level resulting in a challenge to overcome the risk-gap. Automated data collection tools were pointed out as an example that may be

able to help overcome this gap. She referred to cellphone and cloud-based tools, including automated data collection of chlorine residuals using accessible test-strips which could allow for more reliable data for water users and utilities. Dr. Love emphasized use of computers to more readily identify strip colors, as such information would not only inform the public but also utilities. She stated that improved risk communication is needed.

Dr. Andrew Jacque, Chief Scientist and Founder of Water Quality Investigations, presented his research findings that after analysis of thousands of samples from a variety of systems, biofilms are a key source of issues in systems. Microbially-induced corrosion creates a situation for increased growth of opportunistic pathogens, and residual demand is also connected to biofilms. It was noted systems which meet regulatory requirements can clearly still have biofilm problems. Outside of the existing regulatory framework, unregulated nutrients in source waters are another issue, particularly at entry points of distribution systems and buildings, which can lead to water quality changes. In addition, plumbing codes were pointed to as contributing to stagnation and growth of OPs. Plumbing for fire-flows while simultaneously meeting water efficient 'green' building requirements can make it difficult to maintain water quality. A lack of flushing creates water-quality problems and low-flow fixtures reduce flow through pipes. Dr. Jacque pointed to hot-water recirculating loops which create a very high stagnant environment where biofilms may grow and DBP precursors become available. Plumbing codes that are well intentioned however don't necessarily align with other codes is commonplace and may lead to unintended water quality consequences.

Dr. Mark LeChevallier, Principal Manager with Dr. Water Consulting reflected on material presented in Meeting #2 and expanded on differences in free chlorine and chloramine, with chloramines suggested as being strong enough to affect life cycles of amoeba. He suggested that this is not yet concluded but data points in this direction. It was emphasized that *Legionella* is often focused on from a growth standpoint and not necessarily from an occurrence standpoint. Presence leads into growth where both collectively become a greater risk to public health. Dr. LeChevallier explained that while most documented growth has been in building water systems, the public water supply distribution systems can contribute to the growth. As a result, for building water systems and utility management systems, their focus is on managing growth and keeping this low to protect public health. He found culturable *L. pneumophila* in distribution system water when the temperature was 18ºC or higher, and that some occurrence resulted even with a disinfectant residual. However, growth occurred only when the chlorine residual was 0.1 mg/L or lower. A residual of 0.3 mg/L eliminated growth. Studies have shown ten times higher occurrence and outbreaks in chlorinating versus chloraminating systems. Outbreaks happen when the bacteria grow to high levels. According to Dr. LeChevallier, one study showed a concentration of 1,000 organisms/mL were needed to cause disease. An effective disinfectant residual is an essential tool, along with flushing to eliminate sediments and solids, and maintaining/cleaning systems, all are part and parcel. In moving forward when thinking about national regulations, Dr. LeChevallier suggested that actions should be taken when residual numbers aren't met, which may be more important than the exact number established as an acceptable disinfectant residual range. Sampling could follow when residuals aren't met, or if target residuals aren't as well. He also mentioned that there are problems associated with the 5% allowance in the rule for non-detects of residuals, because if the non-detects are always in the same locations, a system could have no residual for a long time in those locations and still be compliant. Dr. LeChevallier emphasized the actions utilities should take as being most critical, and actions should be instituted in rules on a nationwide level within regulatory frameworks.

Facilitator Key Takeaways from Meeting 2 and Facilitated Discussion

Mr. Greenwood opened the floor for discussion with topics which included:

- Provide any needed report back on technical questions;
- Discuss potential emergent findings related to opportunistic pathogens and disinfectant residuals;
- How much do these problems meet a level that requires attention?
- Confirm sense of the root causes of the problem;
- Confirm the nature of the gap that currently exists.

Working Group Members raised the following questions and observations:

- One member pointed out that distribution systems experience a fairly wide range of temperatures depending on the time of year.
- Some members indicated support for a numeric minimum disinfectant residual, while also suggesting that a range of minimum residual values would need to be explored further.
- One member pointed out that the discussion seems to indicate that the opportunistic pathogen and residual problems are distribution system and not source water issues, and that a minimum disinfectant residual is needed. That member also mentioned that elevated water temperatures can be present most of the year for many water systems.
- Simultaneous compliance alongside other regulations was encouraged, for example with the Lead and Copper Rule.
- Another member requested clarification on differences between an 'oversized system' and 'oversizing systems'. Further clarification was requested on availability of research on healthy building (e.g., LEED) practices contributing to unintended consequences such as growth of *Legionella* or other OPs. The Technical Analysts responded that oversizing of distribution systems occurs for fire protection in communities, where pipes are sized adequately to provide water for fire-fighting (intentionally in exceedance of what is required for drinking water consumption). On the building water side, current practices often place combined water services for consumption and firefighting collectively (such as installing larger water main for combined drinking water and emergency fire use). A trickle-down effect includes lack of flushing to move water in larger piping outside of buildings, as fire-testing systems are generally tested at a frequency of much less often than monthly. This impacts water entering the building over the long-term. In addition, analysts suggested lower flow velocities that are typically used in a building (say 2 feet per second) vs higher velocities in a fire event (say 5-10 fps), which could also factor into lower water quality in a building.
- A member explained how plumbing codes may not recognize the need for adequate flushing because of water efficient fixtures that necessitate less movement and use of water in a building. Therefore, less water moves through mains entering the building, and flushing of debris and sediments do not adequately occur. Technical Analysts noted that with regards to green certifications, focus is usually placed on the hot water side, such as with loops, solar powered mechanisms, or special hot water tanks. Without sufficient disinfection residuals, opportunistic pathogen growth can occur. Discussions led to a notion that, although green certification is well intended, if it cannot positively affect water quality or work in tandem with other codes, unintended consequences will continue to emerge.
- Regarding oversizing larger portions of distribution systems, members noted that shrinking populations may mean that large pipes are often underutilized. This leads to issues with some communities or portions of communities receiving water which do not receive adequate flushing or maintenance.
- A member indicated limited information is available on water movement as it enters neighborhoods and into a home. While PWSs generally are providing water with disinfectant residuals into neighborhoods, there may be areas in homes that are underutilized and hence inadequately flushed. Suggestions were made for the development of guidance to homeowners.
- Green building codes were further raised as potential issues. In some cases, treatment is required, creating a dynamic issue with regards to green infrastructure. Dr. Jacque recalled where buildings with high biofilm content held presence of proteins contributing to proliferation in biofilm.
- With respect to occurrence data, there is interest in additional occurrence data for OPs. At least one member expressed discomfort in making national decisions on the basis of occurrence in ten systems. If more data can be made available to support concerns, then acute vs. chronic concerns can be measured. Dr. LeChevallier clarified data from the CDC acknowledging concerns of *Legionella* as a core and growing issue over the last 20 years. A suggestion was made to consider the availability of examining data about *Legionella* presence in utility distribution systems, particularly for sample collection in areas with known lower disinfectant residuals. Dr. LeChevallier replied that there is a study underway on 50 utilities (some of which are small) and that 3,400 samples have been collected already. Dr. Jacque indicated that proteins can be found in water, which can serve as nutrients for *Legionella*. He indicated that the problem should be focused on the distribution system and the

end water use. Exposures can result following biofilm sloughing events. Dr. Jacque suggested considering the relevant indicators and big data approaches that can be used to evaluate the problem.

- One member made a point for moving from a response-oriented strategy to address water quality problems (e.g., when residuals are not detected) to one that includes more proactive options. This member noted finding sediment or lack of residual is generally an issue found too late and that proactively predicting the problems with relevant indicators would be better. The member asked about what can be explored or developed that would help proactively tackle these issues and prevent the problem and how this could also incorporate environmental justice. This member asked what could be evaluated before the end of this process to better address these problems.
- Mr. Rotert noted ongoing discussions with CDC staff who are in the process of seeking to pull information about PWS observations out of CDC's internal reports on waterborne outbreak data.
- Discussion shifted to Legionnaires' Disease and the lack of tests which can produce results beyond *L. pneumophila* Serotype 1. The concern was not enough dynamic testing will have skewed CDC reports. New York City was referred to with the presence of multiple serotypes detected in water samples and multiple species of *Legionella* which could interplay and cause illness. Flint, Michigan was cited as an example where other tests were not employed on a large scale to check for species of *Legionella* which could contribute to illness. One member pointed out how different species of *Legionella* were noted to have caused illness in humans in Australia. This member also indicated that non-*pneumophila* species are more common and that efforts could target systems with low residuals.
- Managing disinfectant residuals also incorporates looking at water age and other distribution system related parameters. Also, species apart from *Legionella* were suggested for testing as ecology can often be broad and encompass more OPs. It was mentioned that certain countries test for other *Legionella* species. Data from Denmark shows most diseases resonate more closely with Serotype 1. There is still the issue of which should be the target. About 50 species of *Legionella* exist and one member noted only about half have been associated with disease.
- A hybrid approach was encouraged if other species are being tested for, in particular to weigh presence of *L. pneumophila* in water systems versus the presence of bacteria from other nearby settings including garden hoses, shower heads, and faucets.
- Meaningful crossover knowledge between microbial growth and corrosion control was encouraged for the WG process as it moves forward. Maintaining consistent residuals throughout a system are meaningful measures to improve water quality as it is a target for preventing DBPs but also a surrogate for handling microbial growth and corrosion control and obtaining better water quality.
- Questions were raised as to the requirements and state variations with implementing calculations of CT (Concentration x Time), including the required frequency, minimum levels, and potential reassessments. One member suggested a focus on recordkeeping related to CT values, especially since there's high variability among the states.
- Technical analyst said a major purpose of monitoring disinfectant is to validate treatment, not necessarily to identify problems.
- One member suggested a find and fix approach using a toolbox of options.
- Environmental justice was raised with a member noting that the allowance for potentially 5% of a distribution system holding potential zero residual is a very low bar. Members asked about the expectation for those parts of systems that may not to have a residual. A member stated that the 5% areas of high water age and low residual are often in the most marginalized and underpopulated areas of a distribution system, allowing these locations to fall through the cracks just like the 10% allowed under the LCR. Clarification was sought on interpretation of this within regulatory frameworks. Another member noted that the origin for 5% rule is to stay within margins, and many sampling plans work around this standard by only sampling where there will be a residual. Members noted samples are not always representative of the worst water in a system. This becomes a key issue for the data quality notion as raised by other WG members. Discussions underscored a need to capture if there are areas where residuals aren't present which current sample collection processes can miss.

- A member asked what current compliance data shows about the percentages of systems that are not meeting the required residual criteria. The member noted that given what we know about how easy it is to design a disinfectant sampling program that always detects residual, it will be very important to get current compliance data for how many systems are actually getting violations for not meeting the minimum disinfectant requirement. Data would assist in addressing current states of distribution system water quality. This member noted that, in addition to managing disinfectant residual, water age, nutrients, TOC, and *Legionella*, we also need to consider *Mycobacteria* and *Pseudomonas*, especially when distribution system water management can manage multiple contaminants at the same time.
- Water quality improvement strategies in distribution systems and preventative measures were underscored. Members encouraged simultaneous compliance to appropriately balance trade-offs. Further, members emphasized the potential to have multiple water quality benefits from improved distribution system water quality (e.g., reduced water age, control of biofilm growth). It was noted that such improvements to distribution systems could be relatively easy to understand but may not be so easy to implement. One member noted that maintaining water quality is a good surrogate goal.
- Members shared concern about how U.S. infrastructure is often under-invested in, and it was reiterated that financial resources are present but not always accessible or sufficient to address the challenges water systems face in regard to water supply and regulatory compliance. Members expressed the importance in understanding the status of water systems in this country and where they are now. At least one member suggested the group not lose sight of the risk tradeoffs.
- One member pointed out that water system operations are complex, and that the approach should focus on prevention, rather than reaction.

Segment 3: Regulatory and Policy Framework for D/DBPRs

Richard Weisman, OGWDW, EPA provided a presentation on Regulatory and Policy Framework Related to the Disinfections / Disinfection Byproducts Rules (D/DBPRs).

Mr. Weisman described the regulatory requirements for source water monitoring of Total Organic Carbon and Alkalinity per the Stage 1 D/DBPR (1998) as it applies to all surface water (including GWUDI) treatment plants using a conventional coagulation/filtration treatment process (i.e., coagulation, flocculation, sedimentation, and filtration). Based on levels of TOC and alkalinity in source water, the Stage 1 D/DBPR requires meeting a specified percentage of TOC removal before delivering the water to the distribution system, unless meeting alternative criteria (treatment technique [TT] requirement). This applies to all community and non-transient noncommunity water systems that add a chemical disinfectant in any part of the drinking water treatment process. Mr. Weisman also described the regulatory requirements for meeting maximum contaminant levels (MCLs) for trihalomethane-4 (TTHM, also referred to as THM4) and haloacetic acid-5 (HAA5) in the Stage 1 and Stage 2 D/DBPRs along with the MCLs for bromate (for systems using ozone) and chlorite (for systems using chlorine dioxide). He also described the maximum residual disinfectant levels (MRDLs) for chlorine, chloramines, and chlorine dioxide. He noted the MCLGs and MRDLGs upon which the MCLs and MRDLs are based. Mr. Weisman covered Operational Evaluation Levels (OEL), and Initial Distribution System Evaluation (IDSE), as well as calculations required for TTHM and HAA5 monitoring. Further, he noted the Stage 2 requirement for consecutive water systems. An inventory of disinfecting Public Water Systems (PWS) was provided based on population served in the U.S, and on system type.

Facilitated Discussion

Mr. Greenwood opened the floor for discussion topics including:

- Clarifying questions?
- Based on your experience, are there further features of aspects of the rules that you would like to highlight for WG consideration?
- Are there other aspects of the D/DBPR regulatory and policy framework you would like to learn more about to inform Working Group discussions and why?

Working Group Members raised the following questions and observations:

- A member raised re-visiting CDC outbreak data for PWS characteristics as a potentially useful breakout tool, as applicable to distribution systems and populations served. Crossover with OPs and disinfectant residuals might aid in analysis as well. A member suggested that having a similar level of system-specific information about characteristics associated with elevated DBPs would also be helpful. Mr. Weisman noted there are tentative plans to discuss interdependencies at a subsequent WG meeting. This member also suggested exploring the characteristics of systems that have compliance problems for DBPs.
- A member asked about testing accuracies for presence of pathogens or residuals at low levels, consistency of testing, and whether testing accuracy is a problem in terms of compliance.
- One member raised the question of whether updated Initial Distribution System Evaluations (IDSEs) might be needed. Mr. Weisman noted that the IDSEs were a one-time requirement many years ago and systems have changed a lot over time, so updated IDSE's might be useful.
- Members raised other questions including: What kind of national data is available on Total Organic Carbon (TOC) in different types of systems? What distribution system-level data is available for DBPs? What data is available on the status of distribution systems such as things like water loss, main breaks, nationally? What information is available on precursor removal?
- Mr. Rotert noted some national data will be presented later in this meeting by the Technical Analysts, and data from EPA is provided in the meeting presentation slide appendices, including information on unregulated DBPs. Technologies on precursor removal will require some additional research.
- For utilization of Operational Exposure Level (OEL), one member shared it might not work for all systems especially considering the amount of time it takes for samples to be collected and entered into databases. It was noted that this process could take 6 weeks or longer and thus lead to delays inaction time frames associated with OELs. A member asked if there is an alternative way of providing the trigger and associated actions. A related concern included missing water systems with DBP issues due to sampling collection times and interspersing collection dates, whether due to staff constraints, sampling requirements, or seasonal issues. This member mentioned that water ages tend to be higher in the winter. Further, a question was raised about the adequacy of a reduced DBP monitoring schedule for some very small systems (which might be only once per 3 years) in terms of identifying systems needing attention.
- Members asked about why the TT requirement for Total Organic Carbon reduction was only included for conventional plants and not for additional plant types used for water treatment and why it did not include smaller plants or treatment zones.
- Members asked if TTHM and HAA5 samples are taken at the same location and suggested that this might not be reflective of actual formation as research has shown they don't necessarily form in the same place.
- A member questioned the testing accuracy for DBPs and the associated QA/QC criteria for labs. In particular, noting their experience of +-30% differences among local agencies. Further, the member asked for clarification on how to interpret the potential health implications of a sampling result that is only a relatively small amount higher than the regulatory standard (e.g., 81 or 82 ug/L vs a MCL of 80 ug/L).

- Another member encouraged linking monitoring plans to a comprehensive plan, to ensure systems utilize all of their data to make informed decisions.
- A member noted that utilization of public health data, whether this includes specific endpoints, CDC biomonitoring programs, or other points which allow prioritization based on comparison of estimated burden of disease, will allow better measures of success of current regulations and potential future regulations. A member suggested using other health endpoints beyond bladder cancer, the need for a good exposure assessment, and the past estimates on the burden of disease reduction.
- One member noted how systems do not overlap their data collection measures. There are differences in public health monitoring, system monitoring, and utility-level monitoring at varying levels of government. An example was cited in Flint, Michigan, where officials found it difficult to transpose data from the county level health agencies to that of the utility.

Segment 4: Problem Characterization on DBPs

Mr. Greenwood introduced **Dr. Kirsten Studer**, OGWDW, EPA; and **Dr. Casey Lindberg**, OST, EPA, both speaking on the topic of unaddressed or newly emergent health risks from DBPs. This included unregulated HAAs, remaining DBP risks, and developmental/reproductive concerns. Dr. Studer provided historical background information on the four TTHMs and HAA5 regulated in the Stage 2 D/DBPR. She noted that researchers have identified other DBPs in addition to those that are regulated but that TTHMs and HAA5 typically occur at higher concentration levels. She explained how EPA used DBP exposures and potential risks for bladder cancer in the development of baseline risks in the Stage 2 D/DBPR. Further, she noted that in the Stage 2 FR notice, EPA indicated that reproductive and developmental health effects data at that time did not support a conclusion as to whether exposure to chlorinated drinking water or DBPs causes adverse developmental or reproductive health effects but did support potential health concerns. She presented preliminary information about how epidemiology studies point to potential adverse reproductive and developmental health effects when using TTHMs as a surrogate for chlorinated drinking water. Dr. Studer also discussed the availability of a Chinese Hamster Ovary (CHO) bioassay that has been used to evaluate potential cytotoxicity among DBPs. Further, she presented information about potential health risks and occurrence for nitrosamines (based on UCMR2 data) and chlorate (based on UCMR3 data).

Dr. Lindberg provided a historical overview of HAA health effects analyses under SDWA. EPA re-evaluated available health effects data for HAA5 and four additional unregulated brominated HAAs as part of the 2016 Six Year Review 3. As a result, in 2017, EPA initiated a systematic literature review of health effects information for the four unregulated brominated HAAs. The goal was to support efforts in evaluating health effects associated with the four unregulated HAAs and to consider the extent to which available information might support development of an MCLG for one or more of those HAAs. She described the process used in a systematic review of the health effects literature for the four unregulated HAAs and gave an update on the review status. The systematic review identifies literature through database searching, identification of those which are relevant, and identifying study qualities. Data extraction, synthesis, and evidence integration can produce visualizations showing ratings of each study compared to different domain studies. She noted that EPA also follows guidelines for carcinogen risks assessment to determine cancer classifications.

Stuart Krasner, Metropolitan Water District of Southern California, retired**,** presented on the occurrence of regulated and unregulated DBPs in drinking water. Mr. Krasner provided a brief timeline of national datasets relevant to DBP occurrence information; and noted temporal variations and precursor occurrence and effects. He pointed out that co-occurrence of HAA9 vs HAA6Br appears to be independent of system size and disinfectant residual type. He also noted that HAA6Br vs HAA9 trend line has a greater slope for higher bromide waters. No close relationship was observed between THM4 and HAA9 occurrence.

Dr. Jimmy Chen, OGWDW, EPA, presented on a summary of data evaluating changes in DBPs over time. During the past 10 years of implementation of the Stage 2 rule (and Revised Total Coliform Rule (RTCR)), the following temporal trends were observed: Decreased levels of THM4 and HAA5 (as well as THM3Br), particularly among systems with high DBP levels (even as disinfectant residual levels were found to increase as shown in Meeting #2); and slightly increased TOC removal and slightly decreased finished water TOC levels. Dr. Chen presented on the number of disinfecting systems and associated populations, fraction served by purchased water, and systems using chlorinated vs chloraminated water; occurrence of DBP precursors in source water; yearly trends of MDBP-related water quality; changes on disinfectant types used after implementation of Stage 2 DBP rule (and RTCR); and factors affecting DBP occurrence/co-occurrence, particularly TOC and bromide levels in source water. He indicated that related literature could be analyzed to help develop further understanding of DBP occurrence/co-occurrence (including those for iodinated DBPs).

Mr. Krasner continued, providing an overview of factors affecting DBP formation. Some included organic matter, natural organic matter, algal organic matter, wastewater effluent, and inorganic products including bromide and iodide. Anthropogenic products include certain pharmaceuticals and x-ray contrast media. A review of factors which affect DBP formation was reviewed with the WG, including but not limited to biofilm and microbial by-products, with influences including contact/residence times, switching of disinfectants, and water chemistry. It was found that use of strong pre-oxidant can minimize formation of NDMA and iodinated DBPs. Specific factors affecting formation of DBPs were reviewed, including but not limited to chlorine application locations and doses, chlorine forms used, storage temperature, mixtures of disinfectants, and on-site generation of chlorine. Based on data from the WRF 4711, TOC is higher in surface water than groundwater across the continental US. TOC in most groundwater is less than 2.0 mg/L with exception of Florida. Bromide is higher in the groundwater and surface water in California and Florida, due to salt-water intrusion influences in both states. Texas has the same issue which might be attributed to oil-field brines.

Mr. Krasner also addressed a question from a WG member about the potential use of an MCL for chloroform separate from the DBP grouping of THM4 with an emphasis on relevant risk data. He noted that an MCLG is the level of a contaminant in drinking water below which there is no known or expected health risk to humans. If there was a separate MCL for chloroform--assuming the MCLG were to remain unchanged--the MCL would be 0.070 mg/L (70 µg/L) or higher. Chloroform is regulated with the other 3 THMs at 80 µg/L for the sum of the four. In low-bromide waters, chloroform is ~80-90% of the sum. Mr. Krasner suggested that chloroform would be less than 64-72 µg/L in low-bromide waters that comply with the MCL and thus a separate MCL for chloroform would not result in a lower chloroform level in drinking water.

Dr. Chen resumed with a presentation on concerns about compliance with current DBP regulations including results from a deep dive report. The SDWA requires states to report drinking water information periodically to EPA and this information is maintained in the Safe Drinking Water Information System (SDWIS) Federal Data Warehouse. SDWIS includes basic information about each public water system including system name and ID number; violation data; and enforcement information. The database is typically updated quarterly. Over the past 6 years, the number of systems with health-based violations of the D/DBPRs have been decreasing. For FY 2021 (Compliance Period Dates), SDWIS reported approximately 3,000 health-based violations of the D/DBPRs for CWSs comprising the following approximate number of violations: MCL: 2,641; Treatment Technique: 264; and MRDL: 22. In a recent in-depth report, EPA identified compliance challenges with the Stage 2 D/DBPR in consecutive systems including conducting a national data analysis, site visits to state partners, incorporation of input from other states through ASDWA, and production of a final report on lessons learned with best practices.

Mr. Greenwood introduced the next presenter, **Jackie Logsdon** from the Kentucky Department for Environmental Protection to present on concerns about compliance with DBP regulations in consecutive systems. She spoke about DBP compliance activities for the state of Kentucky, noting that a high percentage of non-compliant systems were

consecutive systems. An area-wide optimization program was utilized for operator training to empower smaller systems, including parent systems when possible, to encourage coordinated efforts. Trainings helped inform these smaller communities and encouraged relationship building with parent systems. Ultimately root causes were developed and where additional work might be needed at the parent system levels. This included technical one-on-one assistance and use of an Agreed Order that required master meter monitoring (despite no KY regulatory requirement for such monitoring).

Technical Panel

A 3-person technical panel provided their input and perspectives concerning DBPs. Each panelist was introduced by Mr. Greenwood.

Dr. Zaid Chowdhury, Water Treatment Practice Leader at Garver, **Susan Teefy**, Certified Water Treatment Operator, East Bay Municipal Utility District, California, and Mr. Stuart Krasner were introduced as technical analysts for this segment's panel discussion.

Dr. Chowdhury noted the importance of considering Haloacetonitriles (HANs), given their relatively higher toxicity, but encouraged focused inclusion of rule formation centered around the most toxic chemical components which could enter or form within drinking water supplies. Dr. Chowdhury explained that HANs occur at low levels. Dr. Chowdhury also felt that controlling precursors will help manage both the known and unknown DBPs. He further emphasized biological stability of the finished water, whether natural or deliberate. He stated that a lack of pre-oxidation can result in more problems with chloramination DBPs. In conclusion, he underscored if there is less biodegradable material entering the distribution system, then there is less of a chance for opportunistic pathogens to grow there.

Ms. Teefy gave a brief overview of the PWS she works at in California including the relatively large number of reservoirs and treatment plants they use and noted that some are older than EPA. Wildfires and droughts are big problems in California; in addition, water conservation efforts have led to increased water age. For removal of additional DBPs, East Bay MUD would have to explore costly removal options including use of Granular Activated Carbon (GAC). Other considerations include local electric utilities shutting off power to their treatment plant (to prevent grid damage or sparking related to wildfires). East Bay MUD requires use of pumps to send water to customers. As a result, reservoirs are filled in advance though this increases water age. High levels of nitrosodimethylamine (NDMA) are observed during those times. Proactive measures taken outside of formal regulatory requirements include inspecting tank and mix water and finding methods to flush (where possible) or investing in mixers. Considerations for newly instituted measures including balancing operational needs against potential rate increases, as this affects disadvantaged communities and customers. She noted that East Bay MUD continuously seeks ways to keep consumer cost rates down responsibly and are very aware that resources are not infinite; also that good sanitary practices are undertaken and instituted but further measures beyond best practices and efforts may be costly.

Mr. Krasner touched on three issues. The first was risk balancing. Mr. Krasner explained there may be no easy balance but carefully weighing of options is critical. The second is precursors. Fracking waste and power facility waste often lead to increased concentrations of bromide in source water. This is important because enhanced coagulation and processes like GAC do not remove bromide. In addition, there are water providers who never encountered bromide as an issue and are now encountering this issue. A third item relates to the bladder cancer studies. The exposure many decades ago is often incorporated – but that exposure was pre-Stage 1 and Stage 2 rules, so current exposures post Stage 2 are not represented.

Facilitated Discussion

Mr. Greenwood moved into discussion topics which included:

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

Working Group Members raised the following questions and observations:

- One member asked if there is a disinfectant method that minimizes DBPs and maximizes disinfection. Dr. Chowdhury noted there likely isn't one, and answers require a mixture of chemicals and processes. Mr. Krasner pointed to use of ultraviolet radiation however, noted it doesn't carry a residual through the distribution system, and sometimes necessitates the use of chlorine and chloramines. He also mentioned that there can be a variety of different DBP precursors, such as those from upstream wastewater discharges. Bromide and iodide are anthropomorphic and can provide operational challenges. Mr. Krasner stated bromine-controlling mechanisms, including ozone-chloramines or chlorine-ammonia processes, could prove helpful however, Ms. Teefy added these options are all expensive and keeping rates affordable with aging pipes makes it difficult to incorporate. She explained how solutions are often non-linear; costs may rise in orders of magnitude as the next significant improvement becomes even more expensive than the last. Ms. Logsdon added that precursor removal can help maximize disinfection.
- One member emphasized the expense of capital improvements that is needed for aging water treatment plants, raw water collections, and storage. The member suggested that public health is important, and also maintaining reliable systems.
- Members asked follow-up questions about topics such as identifying cost-effective measures for tackling precursors (as addressing precursors would address both disinfectant residuals and DBPs; the root causes of DBP problems, and whether it is solely precursors. Mr. Krasner noted that root causes lead back to precursors, which are hard to control in source waters due to a variety of potential factors including wastewater, TOC, anthropogenic chemicals, and travel time to plants. Dr. Chen and Ms. Logsdon agreed that precursor removal before the water enters the distribution system is key to maximizing disinfection and minimizing DBP formation. Other members agreed on how effective measures in reducing precursor material would cause notable drops in DBP formations as seen in a variety of available research.
- Ms. Teefy noted that adding chlorine after precursor removal requires adding a chlorine contact basin which requires space and significant expense, supporting the point of the members noting the capital costs involved in some of the approaches being discussed, which would defer resources from other necessary improvements and maintenance water system face.
- Dr. Chowdhury noted that the TT requirements for conventional plants were informed partially by the need to have sedimentation basins where TOC could be removed, and thus were not as relevant for direct filtration systems. He also noted correlations between TOC and UV254, as monitoring measures and noted that many studies have used UV254 as a surrogate measure. Pulling these kinds of information will be important as indicators, and as comparison measures for different sources. Dr. Chowdhury responded to an earlier question about why CT values are provided for only conventional treatment plants and said it had to do with solids handling. Mr. Krasner noted UV254 as a very useful tool, especially for indicating TOC – it's an indicator of how many humic stances are in the water and is useful for measuring advanced coagulation. Dr. Chowdhury suggested UV254 could be useful in a system-specific evaluation, as it indicates reactive TOC but was less useful for examining national data.
- One member noted the process and method to minimize DBPs are consistent but the decisions to optimize disinfection and minimize DBPs are site specific. In addition, LCR and corrosion control should also always be

front of mind when we are talking about risk balancing and simultaneous compliance. In future discussions, Working Group members will need to be talking about LCR and corrosion.

- Members asked about how DBP health assessments compare to the risk posed by other regulated contaminants and whether a side-by-side comparison is available.
- One member discussed the potential for exponential impacts on small systems and related concerns about affordability including asking if there are issues arising with utilities who focus solely on a single treatment standpoint, and whether resources are being directed in the correct direction for needed solutions.
- Another member asked why consecutive systems are more challenged than non-consecutive systems. Ms. Logsdon noted that water age is an issue, especially in systems without very good TOC removal. In some instances, the only ways to reduce water age are flushing, tanks management and tank turnover.
- One member stated the presentations show a public health risk that is not yet being adequately controlled and that there appears to be multi-benefit opportunities. Another mentioned that measures such as precursor removal and source water protection could address an array of risks, including DBP peaks which may lead to short-term effects. Furthermore, this member stated that EPA's Office of Water has the authority to use Clean Water Act (CWA) permitting to protect source water. The member asked how the predicted reductions from past rules compare to actual reductions achieved.
- A member requested brominated species health endpoints and non-cancer endpoints for other species. Members agreed it would be helpful to look at brominated byproducts – as sources of these are known in some places. The member seconded considering CWA permitting to protect source water as a potential remedial solution.
- A member asked about the extent of uncertainty being addressed and the level that the WG can live with in working through individual issues. Simultaneous compliance was reiterated as integral to WG discussions.
- One member made an observation about the likely 10% residual risk from bladder cancer associated with chlorination DBPs and noted that the bladder is only one of a number of human organs that can be affected by DBPs but was reported on because it had the greatest certainty at the time of the D/DBPR rule formation.
- Another member noted that DBPs are a significant problem and the risk data presented during the meeting is the minimal level of what is affected by DBPs. This member noted that there are 81,000 cases per year of bladder cancer in the US. There are currently about 712,000 people living with bladder cancer im the U.S. right now. Bladder cancer was focused on in prior MDBP groups because it was the health effect with the strongest linkage known. There are other health effects. Ten percent of bladder cancers are thought to be associated with DBPs, which translates to 8,100 cases of bladder cancer every year associated with drinking water. The member noted this is not a minor public health impact because 17,000 people die every year from bladder cancer, and this is a minimal estimate of impact of DBPs.
- This member also noted that source water is a critical factor in reducing DBP formation and health effects. This member further noted that particularly in sequential systems, sometimes water is treated multiple times, which presents significant challenges.
- Another member noted that it is important to recognize that reproductive and fetal health effects can occur from short term spikes of DBPs, and reducing risks would require reducing peaks or short term spikes.
- A member noted it would be helpful to know what risk reductions were projected prior to adoption of the Stage 1 and Stage 2 SWTRs in regard to DBPs compared to what actually has occurred.
- One member stated that UV254 can be used as a measure for fulvic and humic substances, and that EPA's Area-wide Optimization Program (AWOP) can be used to maximize treatment processes. Mr. Krasner responded that UV254 is a good tool for enhanced coagulation and a determination of the water's treatability, but a point of diminishing return can be reached.
- Members and analysts encouraged maximizing treatment processes to lessen DBP formation and not to seek silver bullets. However, the entire system should be profiled, not just the distribution system, as this could be a tremendously useful tool for utilities, in particular considering parent and consecutive systems as a whole.

- Sampling locations where a change in ownership can occur at a point of connection might be helpful to control issues; for example, this might occur at the interconnection, from parent to consecutive user.

Segment 5: Meeting 4 Agenda and Next Steps

Ryan Albert, OGWDW, EPA thanked all for their input, especially for considerations not typically involved in rulemaking. He suggested that there were several topics to tee-up which are preliminary for the next meeting. This included: sanitary surveys, SWTR compliance (consistent with some points from Meeting #2), nitrification, details on legionellosis cases, finished water storage, DBP tradeoffs, water quality entering distribution systems, and additional unregulated DBPs.

Mr. Greenwood noted an e-mail will be shared with all to the following discussion topics:

- Do you have additions or refinements to the proposed topics?
- What background materials, presentations, or other resources will be helpful to you to prepare for the Meeting 4 discussions?
- Mindful of time and resource limitations prior to the next meetings, what supplemental technical analyses would you like on the topics to help inform discussions?

Mr. Greenwood noted the dates for Meeting 6 (January 24) and Meeting 7 (March 9) are now set, both from 11AM-6 PM ET. Feedback on the working group process was invited by Mr. Greenwood.

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 – September 20, 2022

Name	Attendance
Andy Kricun, WG Co-Chair	x
Lisa Daniels, WG Co-Chair	x
Alex Rodriguez	x
Benjamin Pauli	x
Bill Moody	
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