The Future of Filtration Avoidance

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Kensico Reservoir

NYC Environmental Protection

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New York City Department of Environmental Protection
Bureau of Water Supply

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Introduction

New York City's drinking water system is one of the most closely monitored and carefully managed surface water supplies in the world. For more than three decades, the City has maintained filtration avoidance for its Catskill-Delaware Water Supply by demonstrating that a robust, science-based, multi-barrier approach can protect public health while avoiding the substantial financial, environmental, and operational costs associated with filtration. This approach has been validated through a strong record of regulatory compliance, sustained investment in watershed programs and infrastructure, and enduring partnerships with watershed communities, nonprofit organizations, and state and federal agencies.

At the same time, the risks to maintaining filtration avoidance are not static. Climate change, evolving regulations, and emerging water quality stressors are creating new challenges and amplifying existing risks to filtration avoidance in ways that require DEP to reassess and adapt its programs. DEP developed this report to take a fresh look at the most consequential threats to filtration avoidance, ensuring that the City's watershed protection, monitoring, and operational strategies remain aligned with current and future challenges.

The report will inform ongoing dialogue with our regulators, watershed stakeholders, and the public about how best to sustain the City's water quality protections over the coming decades. In particular, this report is intended to support preparation for the next Filtration Avoidance Determination (FAD) in 2027 by clarifying where the City has strong, well-established barriers to source water contamination, and where the margins for regulatory compliance are narrowing.

Building upon decades of data and research, DEP developed this assessment by convening internal working groups comprised of experts across multiple disciplines, including water quality science, source water protection, treatment and operations, modeling, research, and innovation. Our DEP experts – who are recognized internationally as leaders in their fields – participated in multiple workshops to evaluate the status of existing source water protection programs, forward-looking risks and vulnerabilities, and changes that would help the City meet filtration avoidance criteria well into the future.

DEP also convened an independent Scientific Advisory Panel comprised of 11 subject matter experts from across the United States to review our assessment of filtration avoidance risks and to provide their own scientific analysis of where the City's efforts should be focused. The advisory panel consisted entirely of PhD-level experts who collectively represented expertise across a broad range of areas, including source water protection programs, water treatment, regulatory policy, and climate change. The panel

was asked to challenge DEP's assumptions, validate our conclusions where appropriate, identify and prioritize filtration avoidance risks, and identify scientifically effective strategies to strengthen the protection of public health and regulatory compliance.

Importantly, the Scientific Panel found that filtration avoidance risks identified by DEP were "scientifically sound and appropriately framed." The panel also underscored the importance of prioritizing near-term actions that address the most consequential vulnerabilities related to disinfection byproducts and compound climate change events.

The work of DEP and the Scientific Advisory panel was complemented by additional input from the New York State Department of Health, New York State Department of Environmental Conservation, and several environmental nonprofits and stakeholders.

Building upon the 2020 NASEM Report

This white paper, *The Future of Filtration Avoidance*, builds upon an in-depth analysis of our watershed protection programs that was conducted by The National Academies of Sciences, Engineering, and Medicine (NASEM). The 2020 report by NASEM emphasized that DEP's source water protection programs should be subject to ongoing evaluation to improve their effectiveness and balance program components over time. With that in mind, the Scientific Advisory Panel for this white paper built upon NASEM recommendations to form their conclusions and recommendations. This iterative analysis can be found in the Scientific Advisory Panel summary that is attached as an appendix to this report.

One of the principal findings that emerges from this combined review is that many of the core filtration avoidance criteria established under the Surface Water Treatment Rule are well understood, well managed, and supported by a mature multi-barrier framework. Over decades, DEP and its partners have invested in watershed protections, infrastructure upgrades, and treatment tools that collectively provide a strong foundation for compliance with turbidity and microbial requirements that are central to the FAD.

Many source water protection programs that focused on implementation have matured into long-term maintenance, while others have largely achieved their intended outcomes. This transition marks a turning point for the City and its partners – one that requires a science-based reassessment of how programs should evolve to remain effective at maintaining filtration avoidance.

As risks to filtration avoidance have evolved – particularly disinfection byproducts, climate change, and tightening regulations - DEP and its partners must take a fresh look

at program design and investment decisions to ensure they remain sharply focused on the most significant threats to compliance and public health protection.

As we objectively consider the best methods to maintain filtration avoidance for as long as possible, DEP must also recognize that this work comes with a longer-term reality: it is more and more likely that filtration will be required at some point in the future. For this reason, DEP is continuing the conceptual design of a Catskill-Delaware filtration plant so that the City is prepared if a future regulatory determination, water quality condition, or other circumstance necessitates filtration. The design of this filtration plant is also a requirement of the City's Filtration Avoidance Determination. The City must remain prepared to protect public health by implementing filtration without unnecessary delay if future conditions warrant it.

However, the City's strategic goal – consistent with nearly two centuries of our water supply history – is to extend filtration avoidance for as long as it remains viable and in the public interest.

Working with our regulators and watershed partners, the following criteria should guide our evaluation of upcoming filtration avoidance measures:

Protecting public health and delivering high-quality water: All actions must demonstrably maintain or improve the high quality of the water supply, ensuring that public health protection remains the paramount objective.

Meeting existing regulations and emerging threats: Measures should ensure compliance with current regulatory requirements while focusing sharply on the most immediate and consequential risks that are outlined in this report.

Using sound science and engineering as a basis for decision making: Actions and investments should be supported by credible data, modeling, and peer-reviewed science, with a clear, measurable effect on reducing filtration-avoidance risk.

Focusing on feasibility: Strategies must be technically achievable within the constraints of the existing system, operationally practical, and implementable.

Delivering co-benefits to environmental quality and community vitality: Whenever possible, actions should advance broader goals such as ecosystem health, climate resilience, and the economic vitality of watershed communities.

Choosing actions that are fiscally responsible: Investments must deliver meaningful risk reduction relative to cost, ensuring that ratepayer funds are directed toward the most effective and efficient measures.

In a time of significant concern about affordability, fiscal responsibility is an important framework for DEP's source water protection efforts. Fiscal responsibility in this context

does not necessarily mean spending less; rather, we must ensure that ratepayer investments are directed toward effective strategies that mitigate the most consequential risks to filtration avoidance now.

This report is intended to support that goal by providing a clear, evidence-based foundation for discussions and decision-making. It describes the regulatory framework that governs filtration avoidance, summarizes DEP's operational and watershed protection toolkit, and identifies the risks that pose the greatest threats to filtration avoidance. It then outlines strategic actions—many of them validated by the Scientific Advisory Panel—that DEP and its partners can pursue to strengthen source water protection in the face of our most consequential risks.

As we look toward the next Filtration Avoidance Determination in 2027, the City and its partners must recognize the successes we have achieved together, candidly assess the risks that lie ahead, and ensure that our source water protection programs are strategically aligned with the most significant threats to filtration avoidance and long-term public health protection.

A Brief History of Filtration Avoidance

Protecting water at its source is embedded in the origins and history of New York City's water supply system. New York began to recognize the importance of protecting drinking water nearly 200 years ago, after contaminated water supplies in lower Manhattan contributed to devastating public health crises, including the 1832 cholera outbreak that killed approximately 3,500 people. Waterborne disease outbreaks – and fires that destroyed large swaths of a city without pressurized water for firefighting – drove the City's commitment to secure a clean, protected water source beyond Manhattan and laid the foundation for its enduring emphasis on source water protection.

The concept of source water protection began simply and grew as our understanding of science blossomed. In the 1800s, the Croton System was specifically developed in a portion of the state that was not densely populated, where buffer lands and forests would protect clean water from the newly dammed Croton River. Sanitary codes were passed to restrict swimming and bathing, livestock access, industrial discharges, and other activities that were liable to pollute the new water system. Railroads were even required to shut their bathrooms as trains passed the Croton Reservoir to prevent the discharge of human waste.

These efforts expanded and evolved when New York City built the Catskill System in the early 1900s. Building on existing protections, the City purchased larger buffers around new reservoirs in the Catskills and the Hudson Valley. City employees grew thousands of trees in nurseries and replanted them around the reservoirs – an early nod to nature-based solutions that would become the hallmark of our modern filtration avoidance efforts. The City also built some of the first sewerage plants in upstate New York, recognizing that the adequate collection and treatment of human waste would be essential to the protection of drinking water. The efforts continued in the mid-1900s while the City built the four main reservoirs of the Delaware System in the Catskills.

Our modern source water protection programs – including our Filtration Avoidance Determination – were set in motion nearly 40 years ago. In the late 1980s, public health concerns regarding waterborne disease outbreaks prompted Congress to pass the Safe Drinking Water Act Amendments of 1986. In 1989, the United States Environmental Protection Agency (EPA) promulgated the Surface Water Treatment Rule (SWTR) to protect surface drinking water sources against microbial contamination, mandating that all public water supplies either construct a filtration plant or meet more stringent source water quality requirements. The SWTR addressed fecal or total coliform, turbidity, disinfection, and watershed protection programs.

At the time, New York City's water supply had successfully conveyed safe, wholesome water to residents for almost 150 years. An emerging requirement to filter the City's

surface water could upend how the City had long managed its water supply. At the time, the City consumed almost 1.4 billion gallons of water per day from the Catskill, Delaware, and Croton watersheds. Constructing a filtration plant at that scale would irrevocably increase the cost of water to City residents for decades to come. In addition, the City already had a foundation for future watershed protection in the form of regulated septic systems, constructed wastewater plants, acquired buffer lands, and managed erosion through sustained forest cover. These factors, combined with relatively low watershed development, gave the City the confidence to become the largest unfiltered water supply in the United States when the first-ever FAD was issued in 1993. (While the City achieved filtration avoidance for its Catskill-Delaware System, it did not pursue a waiver for the Croton System because it did not believe the system could meet the objective and subjective criteria for water quality and watershed control.)

In the mid-1990s, as the City developed its case for long-term filtration avoidance, DEP proposed a strict set of watershed regulations to exert control over activities that might contaminate water in its reservoirs and watershed streams. These proposed regulations ignited significant opposition and ultimately brought together the Coalition of Watershed Towns,[1] the counties of Putnam and Westchester, the Watershed Agricultural Council,[2] environmental stakeholders, along with the State of New York and the EPA. These parties convened for discussion that yielded the historic 1997 Memorandum of Agreement.

The Memorandum of Agreement established partners to implement many programs to protect source water and ensure the economic vitality of watershed communities. It set forth a framework for the Watershed Protection Partnership Programs and the City's Watershed Rules and Regulations. It also established the Watershed Partnership and Protection Council and defined funding and oversight for watershed protection programs administered by the Catskill Watershed Corporation.[3] Thirty years later, the agreement continues to underpin each subsequent iteration of the filtration avoidance determination.

Since that time, the scope and reach of watershed protection has grown and adapted to shifting regulatory requirements and water quality goals. The 2017 FAD includes

[1] The Coalition of Watershed Towns is an inter-municipal body composed of the municipalities located wholly or partially within that portion of the New York City Watershed that lies west of the Hudson River.
[2] The Watershed Agricultural Council is a nonprofit organization that administered voluntary programs for farmers and forest landowners in the New York City watershed to protect water quality while supporting the economic viability of working lands.
[3] The Catskill Watershed Corporation is a locally based nonprofit organization that administers programs funded by DEP to help watershed communities support water quality protection, improve infrastructure, and support local economic development.

watershed protection programs designed to protect land, limit nutrients, and manage turbidity, and mandates specific limits for turbidity and pathogens (*Giardia lamblia, Cryptosporidium*, and *Escherichia coli*) at critical sites. Over the years, there have also been several capital projects including construction of a filtration plant for the Croton System, an ultraviolet light disinfection facility for the Catskill-Delaware system, and the conceptual design of a Catskill-Delaware filtration plant to minimize delays if filtration was needed in the future.

In practice, today's FAD includes a range of monitoring, programs, and requirements, including environmental infrastructure; source water protection programs; watershed monitoring, modeling, and GIS programs; regulatory programs; ongoing filtration plant design updates; and in-City programs.

Reflecting on accomplishments and identifying opportunities for improvement underscores the ongoing success of source water protection and filtration avoidance. In addition to annual and semi-annual publications, DEP has convened workshops to ground research on disinfection byproducts and understand emerging considerations for future filtration planning. The National Academies of Sciences, Engineering, and Medicine assessed watershed protection twice, most recently in 2020, each time determining that filtration avoidance is successful, viable, and in the public interest.

The next key moment in watershed protection is now, as DEP and its regulators and watershed partners prepare to negotiate a new FAD that is based on a common understanding of risks, scientific approaches, and common goals.

Background

In this section of the report, we provide a brief background on the regulations that govern New York City's water supply system, with a particular focus on regulatory thresholds that must be met to maintain filtration avoidance. We also review the operational strategies, treatment capabilities, water quality monitoring, and source water protection efforts that have been used in combination thus far to comply with filtration-avoidance regulations and protect public health.

Regulatory Background

To maintain filtration avoidance for its Catskill-Delaware system, DEP must meet strict source water quality and treatment performance criteria, achieve required levels of microbial inactivation, maintain a watershed control program, meet maximum contaminant limits for disinfection byproducts in the distribution system, and conduct regular monitoring and reporting to demonstrate compliance. These criteria are outlined in several federal and state regulations.

While the concept of filtration avoidance was originally established under the 1989 SWTR, the full set of requirements for filtration avoidance was shaped by multiple subsequent federal rules and state regulations. The FAD issued to New York City under the SWTR is foundational to maintaining our unfiltered status, but it is not the only requirement our water supply must meet to continue operating without filtration. In addition to complying with the original SWTR criteria – such as source water turbidity limits, fecal coliform levels, watershed protection programs, and disinfection performance – DEP must also meet ongoing requirements under subsequent federal rules and state regulations. Maintaining filtration avoidance therefore requires continuous compliance with a broader regulatory framework that goes beyond the SWTR and the FAD.

In particular, the SWTR, the Interim Enhanced Surface Water Treatment Rule (IESWTR), and Title 10 of the New York Code of Rules and Regulations (NYCRR) require that all surface water supplies provide filtration unless they meet specified source water quality, disinfection, and site-specific filtration avoidance criteria. In addition, unfiltered systems must comply with other applicable National Primary Drinking Water Regulations that are not explicitly identified as filtration avoidance criteria, including requirements under the Stage 2 Disinfectants and Disinfection Byproducts Rule (Stage 2) and the Long Term 2 Enhanced Surface Water Treatment Rule.

Water Quality Background

DEP is responsible for monitoring water quality within the reservoirs and their tributaries, at the outfalls of certain wastewater treatment plants in the watershed, and throughout the in-city distribution system. The data collected by our water quality scientists are used to inform the operation of the reservoir system, to demonstrate compliance with all drinking water quality regulations, and to monitor the progress of source water protection efforts. These data are also used to support research and innovation programs at DEP.

In 2025, DEP's water quality team collected more than 36,000 samples and performed more than 577,000 analyses at our four water quality labs. Those samples were collected from 325 sampling locations across the watershed, and from 962 dedicated sample stations located throughout the distribution system of all five boroughs. Analyses were performed on those samples for about 350 parameters including the following:

- Pathogens (*Giardia* and *Cryptosporidium*)
- Microbiology (Coliform bacteria, *E. coli*, phytoplankton)
- Nutrients (e.g., phosphorus and nitrogen)
- Physical properties (e.g., turbidity, pH, temperature)
- Metals (e.g., calcium, iron, lead)
- Organic compounds (e.g. disinfection byproducts)

DEP also operates and maintains real-time Early Warning Remote Monitoring and Robotic Monitoring Networks for water supply operational decision-making and reservoir modeling. The robotic network includes 11 profiling buoys, six fixed-depth buoys, and three fixed-depth under-ice buoys that are used to maintain continuous monitoring during the winter. DEP also maintains 14 hydrology monitoring stations at key watershed streams. In total, these robotic monitoring instruments provided more than 3 million water-quality measurements in 2025. The Early Warning Remote Monitoring network includes more than 60 online water quality monitoring stations throughout the watershed and the distribution system.

Since filtration avoidance began in the 1990s, DEP's enhanced water quality monitoring efforts have resulted in the collection of an estimated 80 million data points that are used to make operational decisions, monitor the status and success of source water protection projects, and demonstrate regulatory compliance.

Operational Background

To maintain filtration avoidance and comply with the regulatory framework, DEP has utilized and expanded the operational flexibility of its reservoir system and treatment facilities. Informed by robust water quality monitoring, DEP's core operational strategy has focused on identifying and delivering the best quality water from our reservoir system on a continuous basis. This is done through the following methods:

- **Selective diversion from reservoirs:** Utilizing the flexibility within its system of 19 reservoirs and three controlled lakes, DEP regularly changes its operations to select different sources based on water quantity and water quality. At several reservoirs, DEP can also choose the depth from which to draw water based on the quality at different elevations within the water column.
- **Blending:** DEP can blend water from distinct basins of the same reservoir, from reservoirs within the same system, or across the three major reservoir systems to improve water quality. Our blending operations include the following:
    - East and West Basins at Ashokan Reservoir – Water can be diverted from the East Basin, the West Basin, or a combination of both to manage water quality and quantity.
    - Catskill System and Croton System – Water from the Catskill Aqueduct can be diverted directly into the New Croton Aqueduct through an interconnection adjacent to the Croton Lake Gatehouse. This was historically used to manage challenges related to color in the Croton System, and has more recently been used to manage naturally occurring taste and odor compounds. Catskill System water can also be diverted into New Croton Reservoir. This was done most recently during the 2024 shutdown of the Delaware Aqueduct for repairs. This blending operation increased the delivery capacity of the Catskill Aqueduct and helped to balance reservoir storage throughout the system.
    - Delaware System and Catskill System – DEP expanded its capability to blend water through the development of the Catskill-Delaware Interconnection at Shaft 4. This project was completed in 2016, allowing DEP to blend water from the Delaware Aqueduct into the Catskill Aqueduct. In addition to optimizing water quality, this connection allows DEP to ensure the delivery of water to our wholesale customers when portions of the Catskill Aqueduct are offline. (Water from the Catskill System and Delaware System also blend under normal operations when their aqueducts discharge into Kensico Reservoir.)

- **Bypass and Float:** DEP can prevent or minimize the diversion of water from certain reservoirs by placing a reservoir in bypass or float mode. In bypass mode, water is delivered via a bypass tunnel to exclude the delivery of water from a reservoir. Most often this operation is done to enhance the quality of water traveling through the system by limiting the introduction of water from a reservoir with temporarily impaired quality. In float mode, water is delivered primarily via a bypass tunnel with only minimal water delivered from the bypassed reservoir to meet demand that exceeds the capacity of the bypass. DEP has this capability along the Delaware Aqueduct at West Branch and Kensico reservoirs.
- **Croton System Pump Station Operations:** With written approval from the New York State Department of Health, DEP can introduce water from Croton Falls Reservoir and/or Cross River Reservoir into the unfiltered Catskill-Delaware water supply system. Conditions of approval include demonstrating continued, substantial compliance with the watershed protection program elements that are implemented in the Croton Falls and Cross River watersheds, and extensive water quality monitoring. The FAD restricts use of these pumping stations to times of drought and infrastructure outage.
- **Routine Treatment:** DEP applies chemical and non-chemical treatment on a routine basis for disinfection (i.e. gaseous chlorine, ultraviolet light, and sodium hypochlorite), dental health (fluoride), pH adjustment (caustic), corrosion control (orthophosphate), and oxidation of metals (chlorine dioxide).
- **Event-based treatment:** DEP can implement additional chemical treatment in response to natural events, such as severe storms, that could impair water quality. Our current capabilities include the following:
    - Aluminum Sulfate: DEP has implemented aluminum sulfate (alum) treatment a dozen times since 1987 to manage turbid water leaving Ashokan Reservoir before it enters Kensico Reservoir. Alum is a coagulant that reduces turbidity by causing fine suspended particles to clump together and settle. Treatment is conducted by DEP under a permit with the New York State Department of Environmental Conservation. While currently prohibited, DEP also has the capability to add alum to Delaware Aqueduct water at Shaft 17. In preparation for recent aqueduct shutdowns, DEP conducted alum bench studies using blended water from Croton Falls and Cross River reservoirs, which can be pumped into the Delaware Aqueduct upstream of Shaft 17. These studies showed that disinfection byproduct formation potential was significantly reduced through the addition of alum. DEP will seek approval for a full-scale pilot of this treatment application in the future.

- Sodium Hypochlorite (chlorination) / Sodium Bisulfate (dechlorination): DEP can add sodium hypochlorite at both the Rondout Effluent Chamber and Delaware Aqueduct Shaft 10 at West Branch Reservoir to provide supplemental disinfection. Dechlorination facilities are at Delaware Aqueduct Shaft 9 prior to discharge into West Branch Reservoir, and at Delaware Aqueduct Shaft 17 prior to discharge into Kensico Reservoir.
- Copper Sulfate: Historically applied at many locations until the mid-1990s, DEP began treatments on the New Croton, Muscoot, Croton Falls, and Cross River reservoirs in 2022 to control nuisance algae. It has been effective in reducing natural occurring taste-and-odor compounds such as geosmin and 2-Methylisoborneal (MIB).
- Fluoridone: DEP has been treating the New Croton Reservoir with fluoridone since 2017 to manage hydrilla, an invasive aquatic plant that can degrade water quality.

Source Water Protection Background

New York City's modern source water protection efforts, which began in the 1990s, are carried out in partnership with local communities, landowners, and nonprofit organizations. The comprehensive watershed protection program – comprised of land conservation, forest and stream management, wastewater upgrades, stormwater controls, agricultural best management practices, and more – is considered a worldwide model for protecting water at its source.

The science-based programs have played an essential role in allowing the City to avoid filtration for its Catskill-Delaware water supply, which provides about 90% of our daily supply. The National Academies of Sciences, Engineering & Medicine (NASEM) conducted an in-depth review of the City's watershed protection program in 2020.[4]

Nonprofit partners play a vital role in implementing and sustaining our source water protection strategies. Organizations such as the Catskill Watershed Corporation, the Watershed Agricultural Council, county soil and water conservation districts, and others have delivered on-the-ground projects to reduce contaminated runoff and nutrient loading.

This public-private partnership has yielded nearly 10,000 discrete projects to protect water quality and public health. These include:

[4] The report and a full description of the programs can be found here: https://www.nationalacademies.org/projects/DELS-WSTB-17-02

- More than 50 wastewater treatment plant upgrades
- More than 7,100 septic system remediations
- Nearly 550 stream management projects
- Whole farm plans across more than 128,000 acres of land
- More than 200 stormwater management and retrofit projects
- Forest management plans across more than 60,000 acres
- More than 190,000 acres of land preserved and protected by DEP, and more than 400,000 total watershed acres preserved by the City, the State of New York, and private land conservancies

The City has spent or committed approximately $2.9 billion toward these and other source water protection efforts since the mid-1990s.

Risks to Filtration Avoidance

In this section of the report, DEP reviews the key compliance standards required to maintain filtration avoidance and identifies the most significant risks to filtration avoidance based on its internal evaluation of monitoring data, modeling analyses, and regulatory changes, combined with the independent assessment conducted by the Scientific Advisory Panel.

As we noted in the section on regulatory background, maintaining filtration avoidance requires continuous compliance with a broad regulatory framework that goes beyond the SWTR and the FAD. Our analysis of long-term monitoring data, combined with decades of experience managing the reservoir system through extreme weather events and other stressors, demonstrates that the SWTR criteria are well understood, consistently managed, and implemented with a robust multi-barrier framework that has proven effective in protecting water quality and public health.

By contrast, our most significant current and emerging risks to filtration avoidance – particularly disinfection byproducts (DBPs) and the impacts of climate change – are inherently more complex to predict and manage. They are also not supported by the same well-established, multi-barrier controls that have proven effective for SWTR compliance.

To assess and mitigate our most consequential risks, DEP must re-evaluate our long-term source water protection strategies, treatment techniques, and other strategic actions and investment. This assessment of filtration-avoidance risk and the need for proactive action was validated by the independent Scientific Advisory Panel.

In the section below, we review each of the regulatory criteria required to maintain filtration avoidance. For each requirement, DEP describes the regulatory standard, summarizes our history of compliance, outlines the actions taken to strengthen our operations, and evaluates future risks and remaining gaps that must be addressed to ensure continued compliance. To clarify relative vulnerability, we group these

Tight Margins and Big Consequences

Filtration avoidance leaves little margin for error for unfiltered water supplies, as compliance requirements are stringent and closely monitored. Key parameters – including turbidity, fecal coliform, and disinfection byproducts – are tied to strict regulatory thresholds that must be consistently met. A violation of these standards can trigger a requirement for any unfiltered system to install filtration within 18 months, underscoring the high stakes of maintaining compliance and the need for programs to evolve in step with the most consequential risks.

compliance metrics into two categories – standard compliance measures and areas of increasing risk – to distinguish those that are well controlled from those that may pose a greater challenge to filtration avoidance in the future.

Standard Compliance Measures

Turbidity

Turbidity is a measure of the cloudiness of water caused by suspended particles. It is measured in nephelometric turbidity units (NTU).

Requirement: With a limit of 5 NTU, there can be no more than two events of greater than 5 NTU turbidity in the source water over the previous 12 months, and no more than five events in the previous 120 months. (SWTR)

History of compliance: DEP has consistently complied with the criteria. The water supply has only three Tier 2 Treatment Technique violations since 2000.

Date	Aqueduct	Details
6/29/2005	Delaware	Intense storm/construction site runoff. Turbidity reached 20 NTU leaving Kensico Reservoir. Stayed above 5 NTU for 45 minutes.
3/24/2006	Catskill	Turbidity greater than 10 NTU at Uptake 1, and over 5 NTU for 25 minutes due to Catskill Aqueduct start-up at Kensico Reservoir.
10/29/2012	Delaware	Intense wind event during Hurricane Sandy. Turbidity reached 11 NTU leaving Kensico Reservoir.

Actions: DEP has taken significant steps to address storm-related turbidity events, particularly in the Catskill System, which is more prone to turbidity events because of the steep topography of its watershed, highly erodible glacial soils, and rapidly fluctuating hydrology. Turbidity is not currently viewed as a significant risk to the FAD, although climate change will likely heighten the risk. Advanced modeling and capital infrastructure improvements have provided additional tools to combat episodic turbidity. They include the following:

- Operations Support Tool (OST) (2011) – OST is an integrated computer model that can simulate water quantity and quality throughout the reservoir system. By forecasting when elevated turbidity is likely to occur, OST has helped DEP make proactive operational decisions that minimize the downstream effects of turbidity.
- Croton Filtration Plant (2015) – The Croton Water Filtration Plant provides filtration and disinfection of water from the City's Croton System, restoring the City's full access to up to 290 million gallons per day of Croton System water. This allows the City to reduce its reliance on the Catskill or Delaware system when they are impaired by turbidity.
- Catskill-Delaware Interconnection (2016) – Located at Shaft 4 of the Delaware Aqueduct in Gardiner, Ulster County, the interconnection allows DEP to transfer water from the Delaware Aqueduct into the Catskill Aqueduct to reduce and blend diversions from the Catskill System during turbidity events. The interconnection also allows DEP to deliver water to wholesale customers located downstream of the connection, allowing DEP to take the Catskill Aqueduct offline when necessary.
- Kensico Shoreline Stabilization (2022) – In 2012, extreme winds from Hurricane Sandy generated large waves that eroded the shoreline at Kensico Reservoir and led to elevated turbidity levels near Shaft 18, the City's primary filtration avoidance compliance location. The stabilization project hardened a total of 1,400 linear feet of shoreline at two critical locations near the intake.
- Upgrades at Pleasantville Alum (2023) – DEP has historically used powdered alum for treatment during turbidity events. This recent upgrade allows DEP to add both powdered and liquid alum, greatly increasing both capacity and flexibility to manage turbidity.
- Schoharie high-level intake (2023) – As part of the overall rehabilitation of the Shandaken Tunnel Intake Chamber, DEP constructed an articulating arm that provides the ability to draw water from multiple depths within Schoharie Reservoir to improve the quality of water that is diverted to Ashokan Reservoir. Historically, water could only be diverted from the bottom of the reservoir.

Risks: Climate change will likely increase the risk of episodic turbidity events through more frequent and intense storms that mobilize sediment in the watershed. In addition, shifting seasonal patterns will increase the amount of rain in early winter when trees have shed leaves and vegetative ground cover is minimal. This can also promote erosion, sediment transport, and turbidity.

Future actions: Over the past decade, DEP has taken many steps to minimize its use of alum. Through infrastructure upgrades, scientific modeling, and key operational changes, DEP has tremendously expanded the flexibility of the water supply system while reducing our use of alum. However, DEP must also maintain its ability to treat water with alum during extreme runoff events that create episodic turbidity in the future. Permits must be maintained to ensure that alum treatment can be deployed at appropriate locations and under conditions that warrant its use.

Fecal Coliform

Fecal coliform are bacteria that indicate the potential presence of contamination from human or animal waste in water.

Requirement: Source water testing results must show less than or equal to 20 colonies per 100 mL in 90% of the samples collected over the previous six months. (SWTR)

History of compliance: DEP has always complied with the fecal coliform regulation. It nearly exceeded the criteria following back-to-back hurricanes (Irene and Lee) in 2011. During that event, 8.7% of Delaware source water samples and 6.6% of Catskill source water samples exceeded 20 Colony-Forming Units / 100 mL over the previous six months.

Routine	Repeat
E. coli **(EC+)**	**TC+, EC+, or missing sample**
Total Coliform (TC+)	**EC+, or TC+ with no E. coli analysis**

Actions: One of the greatest success stories for our FAD is the Waterfowl Management Program, which was implemented in December 1993, after waterbirds were identified as a significant source of fecal coliform at Kensico Reservoir. Without this program, DEP would be unable to comply with the fecal coliform criteria under the SWTR. Based on an assessment of the impacts of hurricanes Irene and Lee in 2011, DEP determined that additional measures were required to manage fecal-coliform risks connected to significant storms.

- Wildlife Sanitary Surveys – DEP's waterfowl management contractor conducts weekly wildlife sanitary surveys adjacent to Delaware Aqueduct Shaft 18. All wildlife scat samples collected and removed from the property are identified by their species of origin. Additional surveys are conducted before significant precipitation events. In 2023-2024, passerine birds (mostly swallows) represented 78% of the sanitary samples collected. Canada geese and white-

tailed deer were found in the next highest concentrations at 12% and 6% respectively.

- Upstream chlorination – As noted in the operational background section of this report, DEP maintains the ability to apply sodium hypochlorite at the Rondout Effluent Chamber and at Delaware Aqueduct Shaft 10 to combat fecal coliform bacteria during extreme conditions. Dechlorination occurs before the water enters West Branch and Kensico reservoirs. In response to hurricanes Irene and Lee in 2011, DEP implemented sodium hypochlorite treatment at Shaft 10 from September 9 to October 19.

Risks: Climate change increases the risk of exceeding fecal coliform standards. More frequent and intense precipitation events can generate higher runoff volumes that wash fecal material from agricultural lands, forests, and other sources into streams and reservoirs. Extended dry periods can also increase fecal coliform risk because waste from animals accumulates on the ground and is later carried into waterways during the first significant storms. Changes in seasonal patterns – such as heavier rainfall during the late fall or winter when vegetative cover is reduced and soils are saturated or frozen – can further increase overland flow and fecal transport.

Future actions: The fecal coliform risk relative to filtration avoidance is well understood and well managed. However, the impacts from climate change will significantly amplify the current risks. DEP must remain vigilant by continuing its waterfowl management program and periodic sanitary surveys, maintaining treatment capacity, and minimizing other potential sources of fecal coliform bacteria, particularly in the Kensico Reservoir watershed where treatment cannot be applied before our compliance point at Shaft 18. DEP should also continue its construction of the Kensico-Eastview Connection, a new tunnel to connect Kensico Reservoir to the Catskill-Delaware Ultraviolet Light Disinfection Facility, to ensure the availability of a second aqueduct leaving Kensico Reservoir. Once operational, the new tunnel will increase operational flexibility to manage episodic water quality challenges.

Revised Total Coliform Rule

This rule is a federal drinking water regulation that uses total coliform bacteria as an indicator of distribution system integrity while establishing *E. coli* as a health-based maximum contaminant level to signal potential fecal contamination and acute risk.

Requirement: Unfiltered systems must comply with the Maximum Contaminant Level (MCL) for *E. coli* in at least 11 of the 12 previous months, on an ongoing basis, unless the State determines that a failure to meet this requirement was not caused by a

deficiency in treatment of the source water. (National Primary Drinking Water Regulations) An *E. coli* violation occurs under the following conditions:

Routine	Repeat
***E. coli* (EC+)**	**TC+, EC+, or missing sample**
Total Coliform (TC+)	**EC+, or TC+ with no E. coli analysis**

History of compliance: DEP has historically complied with the Revised Total Coliform Rule.

Actions: Routine coliform management is achieved through many of the same actions that were outlined in the fecal coliform section above, including waterfowl management, along with raising chlorine targets at Kensico Reservoir and Hillview Reservoir and the distribution system entry points. During summer, the residence time for water at Hillview reservoir decreases because of higher demand in the City. When distribution sites experience a positive coliform sample, DEP may also perform hydrant flushing or local booster chlorination.

Risks: Compliance with the Revised Total Coliform Rule is not perceived as a significant risk to filtration avoidance. However, compliance with the Revised Total Coliform Rule and upcoming federal revisions microbial rules, which are likely to establish a minimum disinfectant residual in the distribution system, can increase the risk of disinfection byproduct violations by promoting conditions that favor DBP formation, especially in parts of the distribution system with higher water age.

Disinfection

Disinfection is required for drinking water to inactivate pathogenic microorganisms – such as bacteria, viruses, and protozoa – that can cause waterborne disease and to ensure that water remains microbiologically safe as it moves through the distribution system.

Requirement: Several disinfection criteria must be met to maintain filtration avoidance. DEP must achieve specific disinfection contact time to inactivate key pathogens. What's more, the water supply must maintain redundant disinfection capability with at least two independent disinfectant feed points and methodologies to maintain disinfection without interruption. DEP must also maintain auxiliary power and show that it can maintain disinfection during power outages. Lastly, unfiltered systems must maintain a minimum disinfectant residual where the treated source enters the distribution system. In particular, the regulations require 0.2 mg/L of free chlorine residual at the entry point

and a detectable residual throughout the distribution system to prevent microbial regrown and ensure public health protection. (SWTR, IESWTR, NYCRR)

History of compliance: DEP has always complied with disinfection standards required for unfiltered supplies.

Risks: Currently there are no risks for DEP's continued compliance with these rules and regulations.

Areas of Increasing Risk

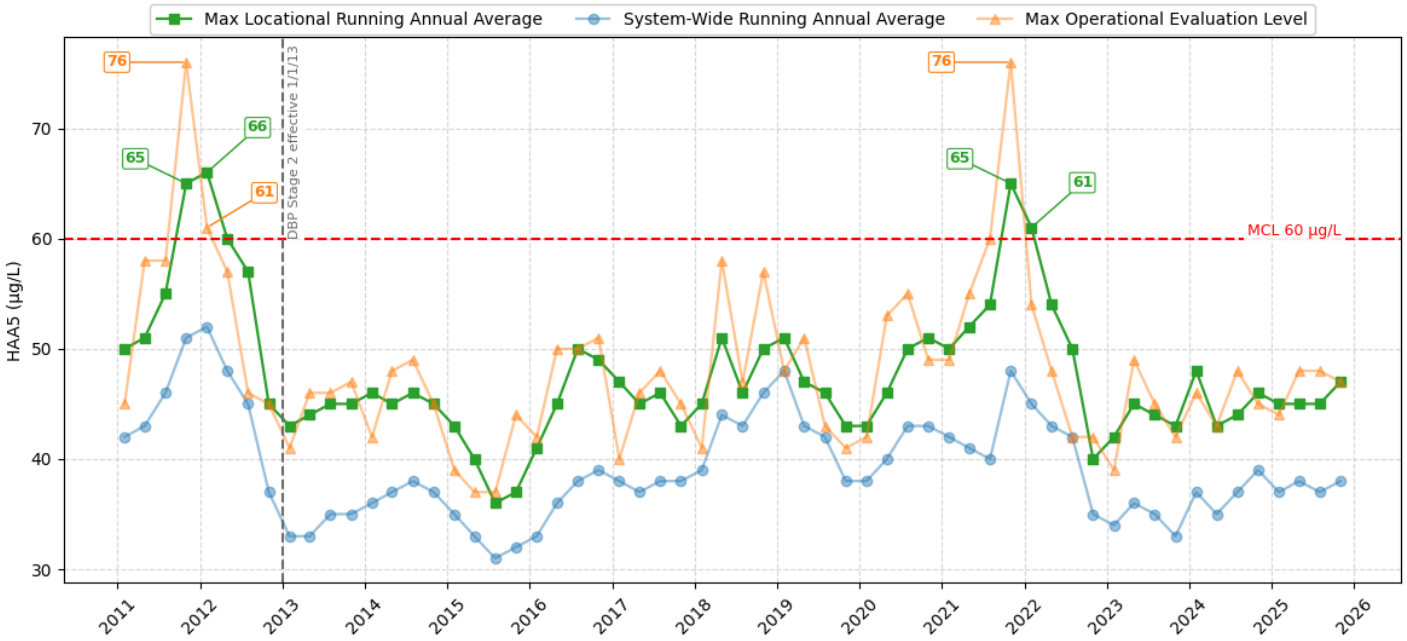
Disinfection Byproducts

DBPs are chemical compounds formed when disinfectants such as chlorine react with naturally occurring organic matter during the water treatment process.

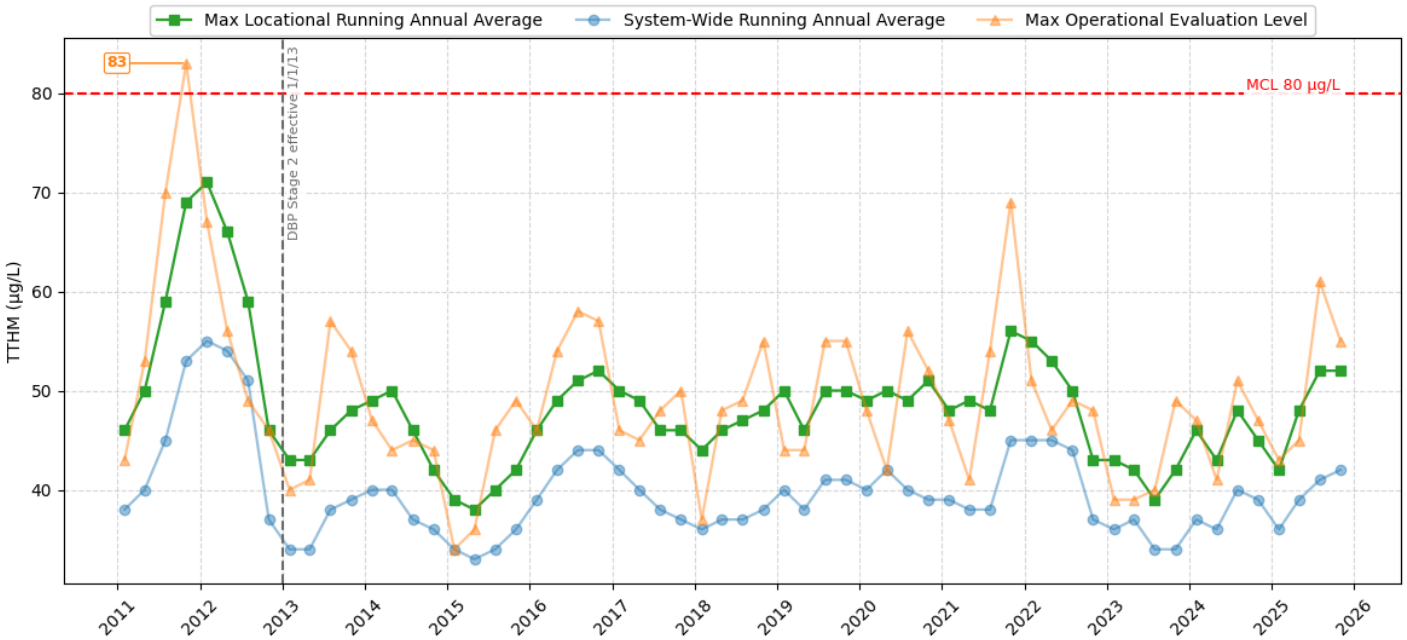
Requirements: Water supply systems must identify specific locations in the distribution system with the highest disinfection byproduct concentrations. DEP monitors these byproducts at 20 locations in the distribution system that are known to have the highest concentrations. Two groups of DBPs are regulated for the City's water supply – the total of the four trihalomethanes (TTHM) and five types of haloacetic acids (HAA5). To maintain filtration avoidance, the City's water supply must comply with TTHM and HAA5 maximum contaminant limits – 80 µg/L and 60 µg/L respectively – on a systemwide running annual average based on results from the 20 testing locations (Stage 1). In addition, DEP must comply with each of those maximum contaminant levels based on a running annual average at each individual sampling location (Stage 2). While the systemwide results are directly tied to maintaining filtration avoidance, the locational running annual average is not itself a filtration avoidance criterion. However, unresolved or repeated Stage 2 violations could result in a compliance order from EPA or the New York State Department of Health that would require filtration.

History of compliance: DEP has always complied with the systemwide running annual average that is required under the Stage 1 rule, which is directly connected to filtration avoidance. DEP violated the Stage 2 rule for HAA5 running annual average during the fourth quarter of 2021 and the first quarter of 2022 as the result of a significant rain-on-snow event.

DBP Rule Stage 2 HAA5 Monitoring in the Distribution System (2011-2025)



DBP Rule Stage 2 TTHM Monitoring in the Distribution System (2011-2025)



Actions: DEP has taken several steps to reduce the risk of a DBP violation. Most of these actions have focused on estimating the amount of natural organic matter in our reservoirs, predictively modeling the formation of DBPs, and adapting the operation of our reservoirs to minimize DBP formation whenever possible. This work has included the following:

- UV254 monitoring - The City is now measuring UV254 absorbance throughout the reservoir system. UV254 is a good surrogate measure of DBP precursors because it utilizes a wavelength of light that is strongly absorbed by natural organic matter that are particularly reactive to chlorine and are major contributors to TTHM and HAA5. Whenever it is operationally feasible, DEP is favoring source water with lower UV254 and lower temperatures to minimize DBP formation.
- Treatment adjustments - We have also adjusted treatment to minimize DBP formation. For example, an increased dose of ultraviolet light can be applied to the drinking water for disinfection, allowing DEP to minimize its use of chlorine. This balancing of treatment techniques must be done carefully to ensure compliance with total coliform and chlorine residual standards in the distribution system, which are key to maintaining filtration avoidance. DEP has also tried to minimize booster chlorination within the distribution system because it can exacerbate DBP formation.
- DBP modeling – In 2025, DEP began the development of a model to predict both HAA5 and TTHM in the distribution system. This model will help to inform water supply operations and minimize DBP formation. In addition, the Operations Support Tool will be upgraded in the future to predict levels of DBP formation potential in source water, allowing for more refined operational modeling and decision making.
- Treatment testing - DEP recently completed a bench-scale test evaluation of alum to assess its effectiveness in reducing natural organic matter and, in turn, lower DBP formation potential. The testing was performed on a blend of water from Cross River Reservoir and Croton Falls Reservoir. It demonstrated promising reductions in organic content. Based on these favorable results, a pilot-scale study within the reservoir system may be warranted to further evaluate operational feasibility and performance.

Risks: Disinfection byproducts, especially HAA5, are the most significant near-term risk to the loss of filtration avoidance. DBPs present the narrowest margin of regulatory compliance and the greatest long-term vulnerability, particularly with respect to changing regulations that could consequently increase DBP formation. This risk is amplified by many factors that include the following:

- Regulatory changes – Proposed changes to the Microbial and Disinfection Byproducts (MDBP) rules, including minimum disinfectant residuals in the distribution system, could significantly affect the City's ability to simultaneously comply with DBP limits. The EPA is currently reviewing the MDBP rules. EPA recently announced that it anticipates proposed MDBP revisions in Summer 2027. In particular, EPA may propose a minimum numeric level of 0.2 mg/L or higher for chlorine and total chlorine secondary disinfectant residuals across water distribution systems to further protect against pathogens. Under the current SWTR framework, the City is required to have a detectable residual throughout the distribution system, however there is no minimum value for that residual. A minimum residual would create operational tension with existing DBP regulations. Maintaining higher chlorine throughout the distribution system would increase disinfectant concentrations and, therefore, the likelihood of greater DBP formation. As a result, DEP could face a further narrowing compliance margin, where efforts to strengthen microbial protection by increasing chlorine residuals simultaneously elevate the risk of exceeding DBP maximum contaminant levels. This would be a significant risk to filtration avoidance.
- Tight margins and limited tools: DEP has a relatively wide margin of compliance for turbidity and fecal coliforms. It also has multiple operational, source water protection, and treatment tools that can help with compliance. The compliance margins and toolkit for DBPs are notably smaller. DBPs, particularly HAA5, are already close to the regulatory thresholds at certain compliance locations in the distribution system. And DBPs are influenced by myriad variables that are difficult to control, including watershed processes, reservoir dynamics, treatment chemistry, distribution system behavior, and regulatory change.
- Climate change: An increase in the frequency and intensity of large runoff events will mobilize greater amounts of natural organic matter from soils, forests, wetlands, and streambanks. These storm-driven inputs may result in measurable increases in dissolved organic carbon (DOC), which DEP is already seeing in some reservoirs. Higher DOC concentrations provide more precursor material for DBP formation. There is also concern about sequential weather events, such as short-term droughts followed by intense rainfall, which can amplify this risk. Accumulated organic materials on the landscape could be rapidly flushed into reservoirs in a concentrated pulse, producing sharp increases in DOC and DBP formation potential. The hydrologic changes could further narrow our compliance margins and pose a substantial risk to filtration avoidance.

Future actions: Between our changing climate and changing regulations, the risk profile and narrow margins for DBP compliance requires considerable actions in the near term to maintain filtration avoidance.

- Integrated modeling and data sharing – To remain proactive, DEP must continue to strengthen its DBP modeling capabilities. This includes refining existing models with improved characterization of reservoir-specific DOC contributions and mixing dynamics, as well as integrating data from a distribution system model to better predict DBP formation as a function of water age. Achieving this level of predictive accuracy will require sustained collaboration and data sharing between the Bureau of Water Supply, the Bureau of Water & Sewer Operations, and others within DEP.
- Treatment pilots – DEP must pilot chemical treatment methods that can reduce DOC in the source water and minimize the formation of DBPs. Pilots for ozone and alum should be performed on a representative sample of the source water to judge whether they are viable non-filtration alternatives.
- Source tracking for DOC – DEP will soon acquire Excitation Emission Matrix (EEM) spectroscopy equipment to analyze the sources of DOC in our reservoirs. This will be helpful for assessing DBP precursors.
- Investigate watershed-scale actions – The input for this white paper included a divergence in opinion about whether watershed protection efforts could be effective in reducing NOM and DOC, thereby reducing DBP formation potential. More research – potentially aided by the EEM data – will help DEP understand whether land management, stormwater management, or other tactics can help at the watershed scale to minimize DBP levels.
- Engagement on regulations – DEP should remain actively engaged in ongoing microbial rulemaking discussions to help ensure that regulators, lawmakers, and other stakeholder fully understand the operational, financial, and public health implications of potential changes, including those that could risk filtration avoidance. Continued engagement will allow DEP to both uphold its commitment to public health protection and provide transparent, data-driven analysis of those costs, benefits, and practical consequences of proposed regulatory changes.
- Filtration and treatment planning – DEP should continue its planning for filtration and treatment facilities, including cost estimates related to capital construction and annual operations. These cost estimates would inform EPA's regulatory development and review processes, including cost-benefit analyses that are required for new federal drinking water rules. Updated cost information would provide a more accurate understanding of compliance costs as regulators balance the need to protect public health with the goal of maintaining long-term affordability.

Climate Change

Ongoing changes to the climate pose significant challenges to source water protection, water quality, and public health by intensifying extreme weather events, altering watershed processes, and increasing the variability and uncertainty that affect drinking water quality and regulatory compliance.

Requirements: There are no regulatory requirements directly connected to climate change. However, climate change could affect the water supply's ability to comply with a host of existing regulations. These examples have been explained in the sections above.

Risks: Climate change does not introduce entirely new risks to the New York City water supply, but it does amplify existing vulnerabilities. Droughts, intense storms, rising air and surface water temperatures, and seasonal shifts in hydrology could all stress the systems compliance with filtration avoidance measures. These risks include the following:

- Increased Turbidity: More frequent and intense precipitation events can increase runoff, streambank erosion, and sediment transport into reservoirs, leading to episodic turbidity spikes that challenge SWTR source water limits.
- Elevated Fecal Coliform Levels: Heavy rainfall and flooding can mobilize fecal contamination from agricultural lands, wildlife, and other sources, increasing the risk of exceeding microbial water quality criteria.
- Greater DBP Formation: Intensified runoff can wash higher loads of NOM into reservoirs, increasing DOC and DBP precursor concentrations, thereby narrowing compliance margins for TTHM and HAA5.
- Drought Followed by Heavy Rainfall: Prolonged dry periods can allow organic material to accumulate on the landscape, which may then be rapidly flushed into reservoirs during intense storm events, causing sharp spikes in turbidity and DOC.
- Algal Growth and Cyanobacteria Blooms: Warmer air temperatures and surface-water temperatures, longer stratification periods, and nutrient loading can promote harmful algal blooms, increasing risks related to cyanotoxins and operational complexity.
- Taste and Odor Compounds: Climate-driven increases in algal activity can elevate compounds such as geosmin and MIB, affecting finished water aesthetics and potentially requiring additional treatment responses.
- Low Dissolved Oxygen and Internal Phosphorus Release: Warmer temperatures and stronger thermal stratification can reduce dissolved oxygen in bottom waters,

triggering the release of phosphorus from reservoir sediments, which can further stimulate algal growth and degrade raw water quality.

Together, these stressors increase variability, compress regulatory compliance margins, and heighten the overall risk profile for maintaining filtration avoidance.

Emerging contaminants

The phrase “emerging contaminants” refers to chemicals or substances that are newly detected in the environment, newly understood to pose potential risks to human health, and are not yet fully regulated in drinking water standards. DEP broadly uses this term to refer to cyanotoxins, perfluoroalkyl substances (PFAS), and microplastics.

Requirements: There are no regulated maximum contaminant levels established for cyanotoxins or microplastics, although guidance values and advisory thresholds for cyanotoxins are typically used to support public health decisions when blooms occur in reservoir. In 2015, EPA issued 10-day Drinking Water health Advisories for two cyanotoxins: for microcystins the advisory levels were 0.3 µg/L for bottle-fed infants and preschool-age children and 1.6 µg/L for school-age children and adults; and for cylindrospermopsin, the levels were 0.7 µg/L for young children and 3.0 µg/L for school-age children and adults. These are non-regulatory guidance values intended to help protect health over a 10-day exposure period. Testing for microplastics in drinking water is undergoing development and validation of standardized analytical methods.

Two types of per- and polyfluoroalkyl substances (PFAS) – PFOA and PFOS – are regulated in New York at a limit of 10 parts per trillion each (ppt). This family of compounds has also been the subject of federal regulatory action. In 2024, EPA announced new limits for six PFAS in drinking water: PFOA, PFOS, PFHxS, PFNA, and HFPO-DA. Each of these contaminants has individual MCLs. In addition, PFAS mixtures containing at least two or more of PFHxS, PFNA, HFPO-DA, and PFBS were regulated using a hazard index MCL to account for their combined and co-occurring levels in drinking water. EPA also finalized health-based, non-enforceable maximum contaminant level goals for these PFAS. Additional federal action on these compounds is expected to ensure the determinations and any resulting drinking water regulations follow the Safe Drinking Water Act process.

History of compliance: DEP has historically complied with the regulations for PFOA and PFOS, as neither has been detected leaving our unfiltered source water.

Actions: For cyanotoxins, DEP has treated certain reservoirs with copper sulfate to control algae and reduce the production of taste-and-odor compounds. The City has also blended Catskill Aqueduct water into the Croton System, where algae have been most likely to grow, to reduce the impacts of taste and odor compounds. In 2025, DEP

began to use molecular testing to detect and quantify genes responsible for harmful algal toxin production. This method will continue to help our water quality scientists proactively detect the presence of toxic strains of algae to inform additional monitoring, treatment, and operational decisions. DEP performs regular monitoring for PFAS. This will continue to ensure compliance with state regulations.

Risks: Currently, the most salient risks for emerging contaminants are related to public scrutiny and perception. As scientific equipment improves and testing limits become smaller and smaller, DEP could feasibly detect infinitesimally small amounts of certain compounds in its source waters. This could affect public confidence, willingness to finance watershed protections, and create pressure to provide filtration without ever violating state or federal health standards. This is especially true for PFAS and microplastics, which are both the focus of public scrutiny and concern.

Cyanotoxin blooms, often referred to as harmful algal blooms (HABs), may also cause challenges related to consumer confidence. Certain reservoirs may become seasonally affected if algal growth produces elevated levels of taste-and-odor compounds that render the water aesthetically unacceptable to customers. In such cases, DEP may need to blend water among systems, reduce diversions from some reservoirs, take some reservoirs offline, or implement copper sulfate treatment. Climate change can amplify this risk, as warmer air and water temperatures and increased nutrient loading can promote more agal growth.

While none of these issues pose a near-term risk to filtration avoidance, they could become more significant depending on regulatory changes or shifts in public perception.

Future actions: DEP will continue to research and monitor emerging contaminants as the scientific understanding of them develops. That will include some of the following actions:

- The City will also continue to apply treatment, such as copper sulfate, and test other treatment methods, such as ozone, to combat algal blooms and reduce taste-and-odor compounds in the source water.
- DEP will stay abreast of efforts to develop a standard method for the measurement of microplastics in drinking water. Our water quality and research teams will perform a literature review of sample collection methods. One of the key challenges in testing for microplastics is developing a reliable field filtration strategy that captures representative particles across a range of sizes while minimizing contamination and ensuring that the resulting sample is analytically valid. DEP will perform additional testing based on the establishment of recognized methods and sample collection procedures.

Looking Forward: The Future of Filtration Avoidance

New York City remains committed to protecting our drinking water at its source and avoiding filtration for as long as possible. Decades of data have shown that source water protection is environmentally sound, fiscally responsible, and effective at protecting public health. However, tightening regulations and the deepening effects of climate change have increased the likelihood that New York City will one day be required to filter all its drinking water.

Against the backdrop of evolving regulations and climate threats, DEP has developed this white paper to answer an essential question about the future of our water supply system: How can the City be prepared for filtration while pursuing the research, modeling, treatment methods, and science-based programs that will protect the public health and extend filtration avoidance for decades into the future?

In this section of our report, DEP summarizes efforts that will be required to better understand our challenges and confront them with proven science, research, adaptive planning, and focused implementation. The strategic actions in this section primarily address New York City's highest risks to filtration avoidance, which were validated and ranked by the scientific advisory panel. Many of the proposed measures would also continue to address the original filtration avoidance criteria in the Surface Water Treatment Rule, including turbidity and fecal coliforms.

The strategic actions outlined in this section were informed by the following groups:

- DEP held internal workshops to review decades of water quality data, climate modeling outputs, evolving regulations, and other information supplied by our scientists, engineers, and planners. These forward-looking sessions yielded many strategic ideas to address the water supply system's most consequential filtration-avoidance risks.
- The Scientific Advisory Panel, comprised of 11 subject matter experts from across the United States, provided a list of strategic actions to help maintain filtration avoidance. These recommended actions were related to monitoring, scenario analysis and modeling, targeted treatment, and adaptive planning to sustain public health protection and long-term system resilience.
- The New York State Department of Environmental Conservation provided written input from experts in its Division of Water.
- Environmental nonprofits, who have been partners and stakeholders in DEP's source water protection efforts since the 1990s, also provided written and verbal input to that informed the strategic actions outlined in this section of the report.

- Many of the strategic actions were also informed by the 2020 NASEM report, which set the foundation upon which this white paper was built.

The majority of the strategic actions outlined in this section of the white paper were offered by all or most of the groups that provided input, indicating broad consensus around the risks to filtration avoidance and the science-based actions that DEP should pursue to confront those risks.

Strategic Actions to Maintain Filtration Avoidance

The strategic actions outlined below will inform future discussions with our regulators, FAD partners, and watershed stakeholders to develop each in more detail. DEP is working on several of the recommended actions already. Those active efforts are noted in the text. Many of the other actions would require DEP to adjust existing programs or commit additional resources.

Unlike the scientific advisory panel's summary report, the strategic actions below are not ranked or listed on a priority basis. Rather, DEP has grouped together strategic actions that address similar risks or programs so that each can be understood in relation to the others.

- **Complete the conceptual design and cost estimates for a Catskill-Delaware Water Filtration Plant.** DEP is already working with expert consultants on a conceptual design for a filtration plant for the Catskill-Delaware system. This design was required by the 2017 FAD. Although filtration avoidance remains scientifically viable and in the public interest, DEP must be prepared for a scenario in which filtration could be required. The design of filtration concepts should also be accompanied by cost estimates, both for construction and annual operation. By understanding the cost of protecting public health in the future, New York City can have an informed discussion about filtration with its customers, regulators, watershed communities, and other key stakeholders.
- **Develop a robust operational toolkit to deal with the challenge of disinfection byproducts.** The scientific advisory panel validated DEP's outlook that DBPs are the most pressing risk to filtration avoidance because of tightening regulations and climate change factors that will result in more natural organic matter in the reservoir system. The challenge of DBPs will require a comprehensive strategy that includes research, modeling, treatment, and monitoring. That comprehensive approach should include the following actions:
    - **Integrated modeling:** In 2025, DEP began the development of a model to predict the formation of DBPs in the water distribution system that serves the five boroughs of New York City. This modeling should be further developed, expanded, and refined. In particular, DEP is working to equip

the model with information about flow pathways and water age in the distribution system, which affects DBP formation. This requires data sharing between the Bureau of Water Supply and the Bureau of Water & Sewer Operations. DEP scientists are also investigating the effects of in-reservoir mixing on DBP formation, and the contribution of natural organic matter from individual reservoirs. All these efforts move DEP toward a model that will predict DBP formation from reservoir to tap.

  - **Treatment testing and piloting:** Several well-established treatment techniques – including ozone and alum – are known to reduce DBP formation. DEP should test and pilot these methods on representative quantities of Catskill-Delaware water to analyze their effectiveness. If testing and piloting are effective, DEP should pursue the regulatory permits and facility modifications that would be necessary to implement treatment.
  - **Research NOM sources and protection efficacy:** DEP is in the process of acquiring Excitation Emission Matrix spectroscopy equipment, which would allow our scientists to better understand the sources of NOM/disinfection byproduct precursors in our reservoirs. Consequently, this source tracking information would help DEP investigate whether any source water protection efforts would be effective at the watershed scale to reduce NOM and, in turn, minimize DBP precursors.
  - **Ongoing research:** DEP should continue to advance its DBP research with credible partners, nonprofits, and other utilities.

- **Expand and integrate water supply modeling to focus on key FAD risks.** DEP has developed one of the most robust and complex water supply modeling programs in the world, including models for water quantity, water quality, and climate change. Expanding and integrating our modeling work is necessary to analyze scenarios that represent critical risks to filtration avoidance. This work should include modeling compound and sequential events – such as droughts of various lengths followed by extreme rainfall – that could test the water supply's compliance with regulations related to turbidity, fecal coliforms, and DBPs. DEP has already begun to test and analyze some of these scenarios. As noted above, DEP should also continue to integrate its modeling for the reservoir system and the distribution system to have a more complete view of DBP formation potential.
- **Incorporate climate change impacts into program planning.** As DEP continues to measure and model the effects of climate change, that information should be used to inform source water protection efforts. Climate change is likely to affect the size of roadway drainage infrastructure and stormwater best-

management practices, flood hazard mitigations, the type of invasive species that survive and thrive in the watershed, the long-term makeup of our forests, and other variables in the natural and built environments that protect water quality.

- **Establish a facility to test and pilot treatment methods.** The combined challenges of regulatory change and climate change will likely require DEP to adjust or expand its treatment capability to meet regulatory standards during certain seasons, extreme runoff events, or sequential drought-rainfall events. Before they can be implemented, treatment changes must be tested for effectiveness on representative samples of Catskill-Delaware water. This work may benefit from a dedicated facility that can access Catskill-Delaware water, and from pilots at existing treatment facilities.
- **Leverage DEP's data for effective programming and research related to filtration avoidance.** Since the modern filtration avoidance program started in the 1990s, DEP has collected tens of millions of data points related to water quality, water supply operations, and source water protection programs. This extensive dataset is a strategic asset that should be made available to everyone within DEP to strengthen the integration of our work, expand data-based decision making, and promote research. These data should also be used, where possible, to assess the effectiveness of existing source water protection efforts.
- **Update source water protection programs to reflect three decades of progress, emerging filtration avoidance risks, and science-based metrics of success.** When the modern source water protection program began in the 1990s, DEP and its partners were focused on launching a specific set of remedial and preventative programs to help the City meet federal criteria for filtration avoidance. Three decades later, many of our legacy programs have matured from implementation to maintenance, and some programs have achieved their intended goals to such an extent that they can be significantly reduced or phased out. At the same time, new risks outlined in this report are narrowing the margins on filtration avoidance in ways that were not contemplated in the 1990s. Operation, protection, and treatment strategies must account for the success DEP has achieved with its partners, new environmental risks, and an evolving regulatory regime. Failure to adapt in this way could hasten the end of filtration avoidance. Working with its partners, DEP must use its extensive data and research capabilities to prioritize source water protection programs that deliver a strong return on investment. Using quantifiable metrics of success, each program should be assessed on its ability to promote environmental quality, protect public health, and meet the regulatory requirements for filtration avoidance. DEP must also show that its programs are fiscally responsible in a time of deep concerns about affordability. In this case, fiscally responsible does not necessarily mean

spending less. Rather, it means spending ratepayer dollars on source water protection programs that demonstrably work best to produce high-quality water, protect public health, and meet regulatory requirements.

- **Investigate and develop a scientific framework that measures the performance of nonpoint source watershed protection programs.** To effectively update our source water protection programs, DEP will need to examine methodologies that can quantify the effectiveness of each program. Historically, this measurement of performance has been easiest for point-source remediation projects, such as wastewater treatment plant upgrades, where before-and-after conditions can be easily quantified. By contrast, measures of success for preventative or nonpoint source programs have been more reliant on anecdotal evidence or indirect metrics, as quantifying efforts to combat dispersed pollutants is incredibly difficult. DEP should investigate scientifically valid methods to measure the success of these programs through tracers, mass-balance approaches, and modeling. If available and effective, these methods could provide an objective basis to analyze our source water protection programs and adjust them with our partners to focus on those that are most effective, relevant to the current risks, and cost efficient.
- **Consider the diversification of programs that pay private landowners in exchange for land preservation and management that protects water quality.** DEP should investigate models to pay private landowners in the Catskills in exchange for conserving and protecting their lands in ways that promote water quality. Similar efforts have shown promise in other countries, such as Costa Rica, which fought deforestation by paying private landowner to preserve and retore rainforests, and Bolivia, where farmers were paid to maintain forests that protected water quality and rare bird habitats. Similar programs exist in the United States. For example, the City of Bellingham, Washington, pays private landowners to preserve land and improve water quality within the Lake Whatcom watershed.
- **Consider updates to septic management programs that prioritize protection efforts near streams, rivers, reservoirs, and other hydrologically connected waterbodies, consistent with State of New York regulations.** Research indicates that targeting repair and replacement of septic systems located within close proximity to surface waters will continue to protect water quality while improving the efficiency of protection programs. Microbial source-tracking analyses by DEP have found that fecal indicator bacteria in surface waters are predominantly

from wildlife sources, with human wastewater signatures detected only rarely.

- **Update the DEP General Land Management Plan to strengthen coordination among individual programs and optimize their combined outcomes.** DEP has made significant progress to break down program-specific silos and improve its interdisciplinary approach to management of City-owned watershed lands and their associated streams, forests, and other natural assets. This work must continue by updating the land management plan. By integrating work across multiple programs, the updated plan should aim for a comprehensive set of outcomes that include improved water quality, resilient ecosystems, and the co-benefits they provide.
- **Continue monitoring and research related to emerging contaminants.** Contaminants such as harmful algal blooms, per- and polyfluoroalkyl substances (PFAS), and microplastics are the subject of growing interest among regulators and water consumers. Although none of these presents an immediate threat to filtration avoidance, DEP must remain vigilant in its core mission to protect public health. For example, DEP has recently implemented molecular testing that can detect and quantify specific genes that are responsible for harmful algal toxin production. By performing these tests, DEP can determine whether toxin-producing algae are present in our reservoirs and adjust our reservoir operations and water quality monitoring based on that information. Similar research and proactive monitoring by DEP will ensure the City's water consumers are well protected against a range of emerging contaminants.
- **Ensure that adequate resources are available for water quality monitoring and analysis.** Many of the strategic actions outlined in this report – treatment testing and piloting, enhanced modeling, and source water protection assessments – will either require or benefit from sustained water quality monitoring. This requires a sustained investment in personnel and other resources necessary to collect the sound science that DEP and its partners will use to make decisions about filtration, source water protection, and other efforts to protect public health.

Conclusion

DEP remains committed to filtration avoidance and source water protection as effective strategies that protect public health, sustain environmental quality, and keep water rates affordable for our customers. As the Scientific Advisory Panel concluded, filtration avoidance remains “viable, defensible, and in the public interest.”

However, we also recognize that our margins to maintain filtration avoidance are tightening, especially with respect to evolving regulations and the deepening effects of climate change. Our operational strategies, treatment methods, and source water protection programs must evolve in step with our most consequential risks for DEP to achieve its goal of maintaining filtration avoidance for decades to come.

This will require a pragmatic approach. DEP must continue to make evidence-based decisions about the operation and protection of the City’s water supply system, rooting our future actions in sound science, research, and monitoring that guides our approach. In this white paper, DEP has broadly outlined strategic actions that will help us refine or expand our work in these areas. Several of these forward-looking actions are directly connected to our next Filtration Avoidance Determination.

DEP must approach the future of filtration avoidance in a manner that is scientifically rigorous and fiscally responsible. Building on 30 years of successful source water protection with our partners, we must objectively assess the current state of our efforts and the future scale, scope, and effectiveness of our programs to ensure that we achieve the greatest possible protection for each dollar invested.

It is also important to recognize that many of the compliance metrics associated with filtration avoidance leave little margin for error – a single violation would cause the City to lose filtration avoidance. This reality underscores the need for DEP to continue its planning for filtration to ensure the City can protect public health under any future scenario. It also reinforces the importance of focusing our source water protection and treatment efforts on the risks that matter most and the strategies and protective barriers that are found to be most effective through sound science.

Ultimately, maintaining filtration avoidance will depend on our ability to adapt, collaborate, and continuously improve. DEP will continue to work closely with its watershed partners, regulators, and scientific experts to ensure that our programs remain responsive to changing conditions and grounded in the best available science. Through these efforts, we can sustain the nation’s largest unfiltered water supply system to protect public health, support watershed communities, and deliver lasting value to the millions of New Yorkers who depend on the water supply every day.

Appendix A: Scientific Advisory Panel Summary Report

This appendix contains the summary report that was issued by the independent Scientific Advisory Panel for this white paper.

Integrative Panel Summary

Scientific Advisory Panel for Future of the Filtration Avoidance Determination (FAD) - Catskill/Delaware Water Supply System

January 31, 2026

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Purpose, Charge, and Format of Panel Responses

The New York City Department of Environmental Protection (DEP) convened an independent Scientific Advisory Panel to evaluate the future viability of the Filtration Avoidance Determination (FAD) for the Catskill/Delaware (Cat/Del) water supply system. This system is the largest unfiltered surface water supply in the United States and provides drinking water to more than nine million people. The FAD is granted and periodically renewed under the federal Surface Water Treatment Rule (SWTR) and the New York State Sanitary Code, contingent upon continuous demonstration that the City maintains high-quality source water, robust watershed protection, effective disinfection, continuous monitoring, and sound system management. The panel reviewed the historical status of the FAD program. Multiple regulatory reviews, including the 2020 NASEM assessment, have already confirmed that DEP's watershed protection program has been effective and remains a national model.

The panel's charge was to assess whether evolving scientific understanding, climate change, regulatory developments, and system constraints may affect the City's ability to continue meeting filtration avoidance criteria requirements, and to inform forward-looking strategies to preserve public health protection and regulatory compliance under future conditions. The panel therefore considered the implications of these evolving scientific, regulatory, and operational factors for maintaining filtration avoidance in the long term.

The panel's deliberations were informed by reviewing NYCDEP-provided background documents, followed by an in-person workshop held on November 5, 2025, detailed DEP responses to panel questions, a closed-door synthesis session, and individual panelist technical reports. This summary reflects an integrative, system-level assessment, focused explicitly on risks to filtration avoidance, not on general watershed health alone.

The Scientific Advisory Panel structured its assessment around three overarching questions that guided all deliberations: (1) whether the risks identified by DEP are scientifically sound and consistent with current research and practice, including whether any risks are overstated or understated in terms of likelihood or severity; (2) how those risks should be prioritized from highest to lowest based on their probability of occurrence and potential impact on the City's ability to maintain filtration avoidance; and (3) whether additional scientific, regulatory, or environmental risks not identified by DEP could affect the future viability of the FAD. These questions were examined across seven major topic areas that collectively address the scientific, regulatory, and operational dimensions of filtration avoidance for the Catskill/Delaware water supply system: (1) filtration avoidance and long-term filtration planning; (2) regulatory considerations and emerging contaminants; (3) disinfection byproducts and their precursors; (4) climate change impacts on watershed processes, water quality, and system resilience; (5) agricultural management practices and their influence on nutrient, sediment, and pathogen loading; (6) septic systems and their role in diffuse nutrient and microbial contamination; and (7) land management, including land acquisition, stream management, invasive species, wetlands, and recreation, as they relate to protecting source water quality. Detailed reports from each panel member are provided separately (as Appendices). This Integrative Panel Summary identifies common themes and priorities based upon the individual panelist reports.

I. General Assessment of Risks to Filtration Avoidance

Scientific Validity of Risks Identified by DEP. The panel finds that the risks identified by DEP are **scientifically sound and appropriately framed** for the Cat/Del system. Importantly, the panel found no evidence that DEP has overlooked any major category of risk that would threaten filtration avoidance. The panel found DEP has been making good progress in several areas, but some risks may require greater attention:

- Successes by the DEP. The agency has invested heavily in long-term monitoring, high-frequency turbidity sensing, watershed modeling, and operational decision-support tools. DEP has also been proactive in anticipating regulatory change, particularly with respect to disinfection byproducts (DBPs), and has initiated multi-year research programs to better understand DBP formation potential across the watershed, reservoirs, and distribution system. DEP has not quantified the magnitude of reduction in risks to violating the FAD from each of these historic actions.
- DEP has implemented a broad portfolio of watershed, storage, and treatment programs; strengthening the integration of quantitative performance and return-on-investment assessments across DEP staff, sections, and partners would further support strategic prioritization and decision-making.
- While correctly identified, several risks are likely understated in terms of their future importance to filtration avoidance. In particular, the following risks are emerging as system-level constraints that are not fully captured by historical compliance performance alone:
    - disinfection byproducts in distribution systems (and how D/DBP regulations related to chlorine residual minimums may impact HAA5 levels at compliance points),
    - compound climate events in short temporal sequences,
    - customer perceptions about water quality from aesthetic taste and odor (T&O) issues to public visibility around PFAS, legionnaires disease or other water-related issues which could have a cascading effect on the public's willingness to finance watershed protections or treatment upgrades, and
    - loss of operational flexibility in water supply from different reservoirs and watersheds.

Prioritization of Risks for the Cat/Del System. Across panel discussions, there was strong convergence on a risk hierarchy that is specific to the NYC system and to filtration avoidance criteria:

1. **Regulatory compliance risk driven by disinfection byproducts**, particularly haloacetic acids (HAA5), which are already close to regulatory thresholds at certain compliance locations in the distribution system. A critical insight from the panel is that DBPs function as the binding constraint for the FAD. Unlike turbidity or fecal coliforms—where DEP has multiple operational tools and historical margin—DBPs are influenced simultaneously by watershed processes, reservoir dynamics, treatment chemistry, distribution system behavior, and regulatory change.

2. **Climate- and storm-driven amplification of DOC / NOM loading**, which increases DBP formation potential and stresses both treatment and operational controls.
3. **Constraints on operational flexibility**, including hydrologic variability, infrastructure outages (e.g., aqueduct shutdowns), competing flow management obligations, and regulatory limitations on treatment options such as alum use.
4. **Emerging contaminants**, including PFAS and cyanotoxins, which currently pose low direct risk to filtration avoidance but could become more significant depending on regulatory or public perception developments.

Additional Risks Relevant to Filtration Avoidance. The panel identified several additional risks that are not always explicitly framed as FAD risks but are relevant to long-term filtration avoidance:

- **Risk loss of consumer confidence**, for example associated with taste and odor events, particularly those associated with algal activity, which can undermine public confidence even in the absence of regulatory exceedances. Similar risks may be realized associated with emerging contaminants and other issues even if there have been no regulatory exceedances
- **Simultaneous stress across multiple reservoirs**, which could reduce DEP's ability to manage water quality through blending and diversion.
- **Distribution system biostability**, especially under scenarios involving higher disinfectant residual requirements.
- **Compound climate events**, such as drought followed by extreme rainfall, that fall outside the historical record used to demonstrate compliance.
- **Increasing salinization**, particular in the EOH watersheds, indirectly threatens the FAD. Increasing sodium and chloride concentrations may suggest that watershed protections are insufficient at preventing water quality degradation from these constituents.
- **Organizational integration**, particularly the need for tighter alignment between land management, water quality, and treatment planning functions of DEP programs and partners in ways that provide quantitative metrics and response to high priority issues regarding the FAD.

II. Topic-Based Findings and Recommendations

Detailed reports from each panel member are provided as Appendices. This section synthesizes common themes and priorities across the individual panelist reports. As related to the seven topic areas, **Table 1** compares the emphasis of the 2020 NASEM Review with that of the current Scientific Advisory Panel, with additional discussion provided below and in the individual panelist reports.

Table 1 - Preliminary Comparison of Current Scientific Advisory Panel Findings with 2020 NASEM Review

Topic Area	2020 NASEM Review – Primary Emphasis	Value Added by Current Scientific Advisory Panel
1. FAD / Filtration Planning	Evaluated the effectiveness and sustainability of watershed protection programs as the basis for filtration avoidance; emphasized strengthening existing programs and contingency planning without defining explicit filtration triggers.	Introduces the need for clear scientific, regulatory, and operational triggers to initiate filtration planning proactively; supports demonstration-scale facilities to bridge pilots and full filtration.
2. Regulatory / Emerging Contaminants	Cataloged emerging contaminants and regulatory uncertainty; emphasized monitoring, preparedness, and adaptive program evolution.	Distinguishes direct vs. indirect regulatory risk to filtration avoidance; emphasizes simultaneous compliance risk (microbial rules, disinfectant residuals, DBPs); concludes PFAS does not currently threaten the FAD for Cat/Del; cautions against wholesale adoption of statewide practices not tailored to NYC's unique system (e.g., road salt guidelines).
3. Disinfection Byproducts (DBPs)f	Identified DBPs as an important concern linked to NOM, nutrients, and reservoir processes, but not framed as the dominant FAD vulnerability.	Elevates HAA5 as the most credible near-term trigger for FAD non-compliance; integrates distribution system dynamics (water age, chlorine demand, biostability); states explicitly that current watershed controls may not be sufficient for future DBP risk and thus need to be evaluated or enhanced to improve NOM/precursor loading reduction; shows strong convergence on targeted ozone treatment as the most viable non-filtration alternative, with downstream caveats.
4. Climate Change	Treated climate change as a broad stressor affecting turbidity, nutrients, NOM, and hydrology; emphasized uncertainty and adaptive management.	Directly links climate change to specific filtration avoidance failure modes; emphasizes compound and sequential extremes (e.g., drought followed by storms); highlights risk of simultaneous multi-reservoir stress reducing operational flexibility; distinguishes resilience and recovery from peak-event control.
5. Agricultural Management	Found agricultural programs effective but incremental; emphasized phosphorus control, BMP participation, and climate awareness.	Explicitly recognizes diminishing marginal returns for water quality; applies a stronger climate-resilience lens to BMP design and failure modes; prioritizes hydrologic effectiveness and runoff connectivity; more clearly separates nutrient control goals from DBP-relevant NOM loading.
6. Septic Systems	Identified septic systems as a continuing concern; recommended expanded upgrades largely on precautionary grounds.	More explicitly acknowledges limited quantitative evidence linking remaining septic systems to system-wide FAD risk; emphasizes modern tracers and diagnostics to demonstrate impact; argues that distance-to-water alone is insufficient for prioritization; ties septic risks more directly to

		episodic fecal coliform exceedances relevant to SWTR criteria.
7. Land Management	Evaluated land acquisition and management primarily for turbidity, nutrients, ecosystem protection, and community vitality; recommended refining metrics.	More explicitly links land management (forests, wetlands, riparian zones) to DOC and DBP precursor dynamics; elevates forest health, invasive species, and disturbance regimes as long-term water quality drivers; reinforces shift away from acreage-based metrics toward hydrologic relevance; considers impacts on system-wide operational flexibility.

Topic 1: FAD and Filtration Planning

The panel concludes that continuing to pursue filtration avoidance remains the best long-term strategy for New York City, given the exceptional quality of the Cat/Del source waters and the strength of DEP's watershed protection and operational programs. However, the panel strongly emphasizes that filtration avoidance should be treated as a conditional regulatory outcome, and not a replacement for eventual filtration or equivalent treatment.

DEP has already identified potential filtration sites, invested in pilot-scale testing of filtration and advanced treatment processes, and incorporated ozone into all evaluated treatment trains. DEP's Operations Support Tool (OST) provides a level of system-wide operational insight.

- Where more work is needed is in **formalizing decision triggers** for filtration planning. The panel recommends that DEP explicitly define scientific, regulatory, and operational thresholds—such as sustained upward trends in HAA5, changes to MDBP rules, or loss of critical operational options—that would initiate formal filtration planning before a compliance failure occurs.
- The panel suggests development of a demonstration-scale facility (on the order of 0.1-0.5 MGD) that bridges the gap between short-term pilots and long-term filtration with various blends of water over different climatic events. Such a facility could support operator training, public engagement, technology evaluation, and technology incubator-like innovation hub (sensors, membranes, ozone, etc.).

Topic 2: Regulatory and Emerging Contaminants

Regulatory compliance is key to maintaining the FAD. Some emerging contaminants (e.g., PFAS) are being regulated and may impact the FAD, while others may influence customer / consumer perceptions.

- With respect to emerging contaminants, the panel agrees with DEP that **PFAS does not currently threaten filtration avoidance** for the Cat/Del system. Existing monitoring data, mass balance analyses, and dilution from aqueduct inflows indicate substantial margin relative to current and anticipated MCLs.
- Relative to HAA5 or THM4, no emerging class of DBPs appears to be consequential for the Cat/Del system. DEP is doing the right things by maintaining surveillance monitoring, participating in national research efforts, and proactively assessing regulatory trajectories. However, the panel emphasizes that future regulatory risk is more likely to arise indirectly, through requirements related to disinfection and microbial control, than through direct exceedance of emerging contaminant MCLs. In particular, **proposed**

changes to the Microbial and Disinfection Byproducts (MDBP) rule—such as minimum disinfectant residual requirements—could materially affect the City's ability to simultaneously comply with DBP limits. Impacts from Legionnaires' disease, which is associated with building water systems and inadequate disinfectant residuals, and related regulations may also prompt changes in disinfection practices within distribution systems.

- The panel recommends enhanced communications with the Bureau of Water and Sewer Operations (BWSO) to understand how changes in potable water distribution system operations related to maintenance of chlorine residuals, especially in light of new D/DBP regulations, may require higher chlorine doses to maintain higher chlorine residuals. Higher chlorine dosages or residuals could increase DBP levels in distribution systems. Because HAA5 levels are close to MCLs, which are based upon DBP levels in distribution systems, any changes in distribution system operations could impact the FAD. These enhanced communications may inform bench/pilot/demo scale work related to simulated distribution system (rather than formation potential) testing of DBP levels, and provide advanced planning for DOC management and operational flexibility requirements from the watershed to achieve **simultaneous compliance** of disinfectant residual and DBP levels in distribution systems.

Topic 3: Disinfection Byproducts (DBPs)

DBPs represent the **most immediate and consequential risk to filtration avoidance**. HAA5, in particular, already operates close to the regulatory threshold under certain conditions, leaving limited margin for future stressors.

- DEP is doing important work in this area, including developing DBP formation potential models, deploying UV254 sensors, and analyzing long-term distribution system data. These efforts are essential and should continue.
- However, the panel finds that watershed controls alone may not sufficiently manage DBP risk under future climate and regulatory conditions. The character and timing of DOC delivery-especially during extreme events-introduces DBP precursor loads that cannot be easily mitigated through land management alone. That being acknowledged, DEP should endeavor to quantitatively assess the efficacy of its current water quality source control programs for mitigation of NOM/precursor loading as well as investigate creating new programs that specifically target NOM/precursor loading. The panel strongly recommends increased focus on:
    - Distribution system residence time, chlorine demand, and biostability;
    - Monitoring of DOC, UV254, bromide, and biodegradable organic carbon at locations closer to the distribution system, to augment work in the watershed;
    - Examining new or changing sources of bromide (road-salt, saltwater intrusion, etc.)
    - Evaluation of current land management/source control programs' influence on NOM/precursor loading and enhancement of programs (or development of new programs) to improve efficacy.
    - Improved algae control (and algal organic matter generation) via reduction of nutrient loading or other control methods.

- Evaluation of ozone as a targeted or staged treatment option, with careful assessment of downstream impacts.

Topic 4: Climate Change

Climate change does not introduce entirely new risks to the Cat/Del system but **amplifies existing vulnerabilities**. DEP is doing important work in climate hydrological modeling, downscaling, and scenario analysis, and the panel commends these efforts. Where more work is needed is in evaluating compound and sequential events, such as prolonged drought followed by extreme rainfall, and their implications for turbidity, DOC loading, and algal dynamics.

- The panel also highlights the risk of simultaneous reservoir stress (e.g., high DOC, multiple algae blooms that produce T&O compounds or other HABs) or impacts on salt-water intrusion into main stems of rivers, which could reduce operational flexibility.
- Climate change may also be slowly transitioning forest ecosystems that impact DOC production or recovering from acid-rain impacts in forest ecosystems and lake water quality. Stream restoration, forest health, land acquisition and related watershed programs remain valuable, but their performance should be evaluated not only on peak-event attenuation, but also on recovery time, resilience, and long-term stability.

Topic 5: Agricultural Management

Agricultural programs have delivered meaningful reductions in nutrient loading, particularly in the Cannonsville basin. DEP and its partners should be recognized for sustained investment and engagement with the agricultural community. However, the panel notes that further gains will require more **hydrologically targeted and climate-resilient BMPs**, improved outcome-oriented monitoring where feasible, and closer integration of modeling and empirical data. Quantitative performance of BMPs on DBP precursors should be a priority.

Topic 6: Septic Systems

Septic system programs have addressed many high-risk systems over nearly two decades, but diffuse and legacy impacts remain difficult to quantify.

- DEP is doing well in providing funding and access to repairs, but the panel recommends expanding **before-and-after monitoring**, use of chemical tracers, required preventative maintenance (i.e. periodic inspections and pump-outs), and spatial analysis to better demonstrate quantifiable water quality benefits for nutrients that impact algae activity and DBP precursors (specifically DOC and bromide).
- While some interaction with Publicly Owned Treatment Works (POTWs) in the watershed are ongoing, more partnerships around monitoring or benefits of upgrades are warranted, because POTWs may have a greater mass-loading of nutrients, bromide, and or DOC than septic systems. Quantifying relative mass loading (annual and seasonal) from septic leakage/infiltration versus POTW discharges could strengthen justifications for watershed programs related to human-sewage related impacts in the watershed.

Topic 7: Land Management

DEP's land acquisition program has been and should continue to be a cornerstone of filtration avoidance. As one specific example that should be continued, targeting riparian buffers, floodplains, and wetlands provides disproportionate water quality benefit, and recent refinements

toward hydrologically sensitive parcels are appropriate. The panel encourages greater attention to **forest health, invasive species, and disturbance regimes**, as these factors may influence long-term DOC and sediment dynamics. The panel also encourages DEP to consider conjunctive management approaches that integrate effects on both owned and private lands in the watershed.

III. Closing Perspective

The Scientific Advisory Panel concludes that New York City's Filtration Avoidance Determination remains viable, defensible, and in the public interest. At the same time, the panel emphasizes that **the margin for maintaining filtration avoidance is narrowing**, particularly with respect to disinfection byproducts under a changing climate and evolving regulatory environment. DEP has built an exceptionally strong foundation. The challenge ahead is not correcting past deficiencies, but **anticipating future constraints**. By continuing to invest in monitoring, scenario analysis, targeted treatment options, and adaptive planning, the City can preserve filtration avoidance while responsibly preparing for plausible future conditions. The panel strongly encourages proactive, measured action now, rather than reactive decisions later, to sustain public health protection and long-term system resilience. **Table 2** provides an initial vehicle for DEP to directly identify, prioritize and quantitatively evaluate programs aimed to impact the FAD.

Table 2. Potential Initial Prioritization of Risks and Strategic Actions for Maintaining Filtration Avoidance

Rank	Issue / Strategic Signal	Primary Risk or Benefit to FAD	Time Horizon
1	Disinfection byproducts (DBPs), particularly HAA5	HAA5 dominates regulatory compliance risk and is the most credible near-term trigger for loss of filtration avoidance, driven by storm-related DOC loading, bromide/salinization, distribution system water age, and potential new disinfectant residual requirements.	Near-term (0–5 years)
2	Loss or constraint of operational flexibility	DEP's ability to manage water quality through blending, diversion, and timing is a critical asset; simultaneous reservoir stress, regulatory constraints, or infrastructure outages could materially reduce this flexibility.	Near- to mid-term (0–5 years)
3	Climate-driven amplification of water quality stressors	Climate change increases the frequency and coincidence of extreme storms, short-duration droughts, warming temperatures, and altered ecosystem processes, amplifying DOC, fecal indicators, algal activity, and DBP formation beyond historical compliance conditions.	Near- to mid-term (0–10 years)
4	Limits of watershed controls for future DBP risk	While foundational, watershed protection strategies currently employed by DEP to reduce impacts from other parameters/contaminants, these strategies have not been evaluated or developed for the reduction of NOM/precursor loading. As such, they may not sufficiently control future DBP precursor loading and;	Near- to mid-term (0–10 years)

		additional treatment and distribution system strategies may be required to maintain regulatory margins.	
5	Taste and odor (T&O) events linked to algal activity	Algal-related T&O events pose growing operational and public-confidence risks, are associated with increased turbidity, nitrogenous organics, chlorine demand, and unregulated DBPs, and could occur simultaneously across reservoirs, reducing system flexibility.	Near- to mid-term (0–10 years)
6	Salinity and bromide trends	Increasing salinity from road salt, water softeners, and climate-driven hydrologic changes can elevate bromide, disproportionately increasing regulated DBP mass; salinity trends may be non-linear and episodic.	Mid-term (5–15 years)
7	Proactive filtration and advanced treatment planning	Filtration or equivalent treatment is highly likely over the long term; early site selection and development of a demonstration-scale facility reduces regulatory, cost, and implementation risk.	Mid-term (5–15 years)
8	Integration of quantitative program effectiveness and ROI	DEP operates a comprehensive portfolio of programs, but stronger synthesis of quantitative performance—especially related to DBP precursor reduction—would improve strategic prioritization and regulatory defensibility.	Near- to mid-term (0–10 years)
9	Targeting and climate-resilience of agricultural BMPs	Agricultural programs have delivered meaningful gains, but future benefits will require hydrologically targeted, climate-resilient BMPs and improved evaluation of impacts on DOC and DBP precursors.	Mid-term (5–15 years)
10	Septic systems and human-waste contributions	Septic systems represent a lower but persistent risk; improved quantification using tracers and mass-balance approaches is needed to prioritize actions relative to POTW discharges.	Mid-term (5–15 years)
11	Forest health, disturbance regimes, and land management	Changes in forest composition, invasive species, pests, and disturbance regimes may alter long-term DOC and sediment dynamics, with implications for DBPs and reservoir water quality.	Long-term (10–30 years)
12	Leveraging long-term data through research partnerships	DEP's extensive monitoring and operational datasets are a strategic asset; deeper collaboration with academic partners would improve trend detection, predictive modeling, and adaptive management.	Ongoing / All horizons

Appendix B: Individual Papers of the Scientific Advisory Panel Members

This appendix contains links to each of the individual papers that were written by the Scientific Advisory Panel members.

1. Analysis of Dr. Paul Westerhoff, Scientific Advisory Panel Chair
2. Analysis of Dr. Kate A. Brauman
3. Analysis of Dr. Alissa Cox
4. Analysis of Dr. Tyler A. Groh
5. Analysis of Dr. Kristina M. Gutchess
6. Analysis of Dr. Yuki Miura
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