New York City Department of Environmental Protection

Watershed Protection Program Summary and Assessment

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Lisa F. Garcia, Commissioner
Paul V. Rush, P.E., Deputy Commissioner
Bureau of Water Supply

Cover Photo: Rondout Reservoir taken by Kristen Artz

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List of Acronyms

ADM	Anti-Diarrheal Medications
AEP	Annual Exceedance Probability
AGOL	Arc GIS Online
APA	Access Permit Areas
ART	Ashokan Rail Trail
ASR	Annual Status Reviews
AUV	Autonomous Underwater Vehicle
AWSMP	Ashokan Watershed Stream Management Program
BAP	Biological Assessment Profile
BMP	Best Management Practice
BWS	Bureau of Water Supply
CAI	Conservation Awareness Index
CAPA	Citywide Administrative Procedures Act
CAT/DEL	Catskill/Delaware system
CCCD	Catskill Center for Conservation and Development
CCE	Cornell Cooperative Extension
CCEUC	Cornell Cooperative Extension of Ulster County
CDUV	Catskill/Delaware Ultraviolet Disinfection Facility
CE	Conservation Easement
CE-QUAL-W2	Reservoir water quality model
CFI	Continuous Forest Inventory
CMIP6	Coupled Model Intercomparison Project – phase 6
CREP	Conservation Reserve Enhancement Program
CRISP	Catskill Regional Invasive Species Partnership
CSAP	Collaborative Streamside Acquisition Program
CSBI	Catskill Streams Buffer Initiative
CSC	Catskill Science Collaborative
CUNY	City University of New York
CWC	Catskill Watershed Corporation
CWMP	Community Wastewater Management Program
DCSWCD	Delaware County Soil and Water Conservation District
DBP	Disinfection By-Products
DBPfp	Disinfection By-Products formation potential
DEIS	Draft Environmental Impact Statement
DEM	Digital Elevation Model
DEP	New York City Department of Environmental Protection
DMAP	Deer Management Assistance Permit Program
DOC	Dissolved Organic Carbon
DOHMH	New York City Department of Health and Mental Hygiene
DOI	Department of Investigation

DP	Dissolved Phosphorus
DSEIS	Draft Supplemental Environmental Impact Statement
DUA	Day Use Area
EAB	Emerald Ash Borer
EAE	Ashokan East basin
EAW	Ashokan West basin
ED	Emergency Department
EFC	New York State Environmental Facilities Corporation
EIS	Environmental Impact Statement
ELAP	Environmental Laboratory Accreditation Program
EOH	East of Hudson
EOHWC	East of Hudson Watershed Corporation
EPT	Ephemeroptera, Plecoptera, and Trichoptera
ESRI	Environmental Systems Research Institute
EV	Economic Viability
FAA	Federal Aviation Administration
FAC	Flood Advisory Committees
FAD	Filtration Avoidance Determination
FBO	Flood Buy Out
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FIA	Forest Inventory and Analysis
FMP	New York City Forest Management Plan
FSA	Farm Service Agency
FSI	Forest Stand Improvement
GCM	Global Climate Model
GCSWCD	Greene County Soil and Water Conservation District
GI	Gastrointestinal Illness
GIS	Geographic Information System
GPS	Global Positioning System
GWLF	Generalized Watershed Loading Function
HAA5	Five Haloacetic Acid
HAA5fp	Five Haloacetic Acid formation potential
HEC-RAS	Hydrologic Engineering Center River Analysis Software
IRP	Interim Release Protocol
IRSP	Individual Residential Stormwater Permit
ISAC	Invasive Species Advisory Committee
LAP	Land Acquisition Program
LFA	Local Flood Analysis
LFHMP	Local Flood Hazard Mitigation Program
LHPRISM	Lower Hudson PRISM
LiDAR	Light Detection and Ranging

LOCA	Localized Constructed Analogs
LOP	Letter of Permission
LOWESS	Locally Weighted Scatterplot Smoothing
LRAA	Locational Running Annual Average
LUP	Land Use Permit
MaMA	Monitoring and Managing Ash
MACA	Multivariate Adaptive Constructed Analogs
MAP	Management Assistance Program
MFO	Master Forest Owner
MGD	Million Gallons Per Day
MOA	New York City Memorandum of Agreement
MS4	Municipal Separate Storm Sewer System
NASA	National Aeronautics and Space Administration
NASEM	National Academies of Science, Engineering and Medicine
NEIWPCC	New England Interstate Water Pollution Control Commission
NHD	National Hydrography Dataset
NMC	Nutrient Management Credit
NMP	Nutrient Management Plan
NOM	Natural Organic Matter
NOV	Notice of Violation
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Unit
NWI	National Wetlands Inventory
NYC	New York City
NYCDOHMH	New York City Department of Health and Mental Hygiene
NYCFFBO	New York City Funded Flood Buyout Program
NYNHP	New York Natural Heritage Program
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOT	New York State Department of Transportation
O&M	Operation and Maintenance
OECD	Organization for Economic Cooperation and Development
OST	Operations Support Tool
OTC	Over the counter
PA	Priority Area
PAA	Public Access Area
PBIAS	Percent Bias
PCR	Polymerase Chain Reaction
PFAS	Per- and Polyfluoroalkyl Substances
PFM	Precision Feed Management Program
PFOA	Perfluorooctanesulfonic acid

PFOS	Perfluorooctanoic acid
PHL	Public Health Law
PMC	Plant Materials Center
RCMP	Riparian Corridor Management Plan
RDP	Remote Desktop Protocol
REP	Regulatory and Engineering Programs
ROV	Remote Operated Vehicle
RPT	Rondout Pressure Tunnel
RWBT	Rondout-West Branch Tunnel
SAP	Streamside Acquisition Program
SCSWCD	Sullivan County Soil and Water Conservation District
SDWA	Safe Drinking Water Act
SEQRA	State Environmental Quality Review Act
SFI	Stream Feature Inventories
SKT	Seasonal Kendall Test
SMIP	Stream Management Implementation Program
SMP	Stream Management Program
SPDES	State Pollutant Discharge Elimination System
SSMP	Septic System Management Program
SSTS	Subsurface Sewage Treatment System
SSURGO2	Soil Survey Geographic Database
STRP	Stream Turbidity Reduction Projects
SUNY	State University of New York
SUVA	Specific Ultraviolet Absorbance
SWAT	Soil and Water Assessment Tool
SWC	Surface Water Criteria
SWCD	Soil and Water Conservation District
SWPPP	Stormwater Pollution Prevention Plan
SWTR	Surface Water Treatment Rule
TASC	Terrestrial and Aquatic System Converter model
TBM	Tunnel Boring Machine
TDA	Trend Detection Assessment
TDP	Total Dissolved Phosphorus
TLC	Trained Logger Certification
TN	Total Nitrogen
TP	Total Phosphorus
TSI	Trophic State Index
TTHMfp	Total Trihalomethane formation potential
UAS	Unmanned Aerial Systems
UCSWCD	Ulster County Soil and Water Conservation District
UREI	Urban/Rural Education Initiative
USDA	United States Department of Agriculture

USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UV254	Ultraviolet light at absorbance of 254 nm
VFS	Vegetative Filter Strip
WAC	Watershed Agricultural Council
WaLIS	Watershed Lands Information System
WAP	Watershed Agricultural Program
WDRAP	Waterborne Disease Risk Assessment Program
WIRC	Watershed Investigation and Repair Crew
WFIT	Watershed Forestry Institute for Teachers
WFP	Whole Farm Plan
WJWW	Westchester Joint Water Works
WMP	Waterfowl Management Program
WQSP	Water Quality Stream Project
WOH	West of Hudson
WOW	Women Owning Woods
WR&R	New York City Watershed Rules and Regulations
WSP	Water Supply Permit
WWP	Water Withdrawal Permit
WWQMP	Watershed Water Quality Monitoring Plan
WWTP	Wastewater Treatment Plant

Acknowledgements

The New York City Department of Environmental Protection is charged with providing an ample supply of clean water to more than 9 million people daily. DEP meets this mandate through the efforts of hundreds of dedicated professionals. This report provides a description of the implementation of the many elements of DEP's source water protection program, followed by an examination of their effects on water quality, over more than 30 years. Although the staff members who help make all this possible are too numerous to mention here, their efforts are recognized and appreciated. We acknowledge the Bureau of Water Supply, under the direction of Deputy Commissioner Paul V. Rush, P.E., and its Directorates of Drinking Water Operations, Water Quality, Source Water Protection, and Strategic Operations and Research. The vital support of Core Services, along with the Bureaus of Police and Security, Legal Affairs, Information Technology, Engineering Design and Construction, and the NYC Law Department is also acknowledged.

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The second section describes the work of the Water Quality Directorate under Lori Emery. Primary authors include: Jim Broderick, Rich Kowalczyk, Kelly Cahalan, and Kerri Alderisio. Staff at the New York City Department of Health and Mental Hygiene (DOHMH) provided text and graphics to describe the Waterborne Disease Risk Assessment Program.

The third section of this report describes modeling work on programs and water supply management and was primarily authored by Jerry Mead and Rakesh Gelda, Ph.D., under the direction of Senior Director Jen Garigliano. Additional authors include: Rajith Mukundan, Ph.D., Vivian Jensen, Ph.D., and David Van Valkenburg.

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This report is dedicated to Michael Risinit who passed away in 2024. Michael started at DEP in 1992 in water quality, left in 1998 to pursue a career in journalism and then returned to DEP in 2016 where, among many other things, he worked on FAD reports like this one. We deeply miss his writing, editing and publication expertise but most of all his sense of humor.

Executive Summary

New York City's Source Water Protection Program for the Catskill/Delaware Systems

The New York City Department of Environmental Protection (DEP) is responsible for operating, maintaining and protecting the New York City's water supply and distribution system. This document, New York City's 2026 Watershed Protection Summary and Assessment, has been prepared to comply with the New York State Department of Health's December 2017 Filtration Avoidance Determination (FAD) for the Catskill/Delaware Water Supply Systems.

In 1989, the federal Surface Water Treatment Rule (SWTR) was promulgated requiring filtration of all surface water supplies. The SWTR provided for a waiver of the filtration requirement if the water supplier could meet certain objective and subjective criteria. In the early 1990s, DEP embarked on an ambitious program to protect and enhance the quality of New York City's drinking water. DEP was able to demonstrate that the Catskill/Delaware supply met the objective criteria: (1) The source water met SWTR turbidity and fecal coliform standards; (2) There were no source related violations of the coliform rule; and (3) There were no waterborne disease outbreaks in the City. The subjective criteria of SWTR required DEP to demonstrate through ownership or agreements with landowners that it could control human activities in the watershed which might adversely impact the microbiological quality of the source water. As outlined in the SWTR, issues of concern fall into several categories: coliform bacteria, enteric viruses, Giardia sp., Cryptosporidium sp., turbidity, disinfection byproducts, and watershed control.

To demonstrate its eligibility for a filtration waiver, DEP advanced a program to assess and address water quality threats in the Catskill/Delaware system. DEP's strategy is based on a simple premise: It is better to keep the water clean at its source than it is to treat it after it has been polluted. To meet the goal of public health protection, DEP has designed and deployed a mix of remedial programs (intended to clean up existing sources of pollution) and protective programs (to prevent new sources of pollution). These efforts provided the basis for a series of waivers from the filtration requirements of the SWTR (January 1993, December 1993, January 1997, May 1997, November 2002, July 2007, May 2014 and December 2017).

Assessing the Potential Threats to the Water Supply

Since the inception of the program in the early 1990s, the City has made great progress in assessing potential sources of water contamination and designing and implementing programs to address those sources. Each year, DEP collects and analyzes tens of thousands of samples from nearly 330 sites throughout the watershed – at aqueducts, reservoirs, streams, and wastewater treatment plants. The purpose of this intensive monitoring effort is to help operate and manage the system to provide the best possible water at all times, to develop a record to identify water quality trends, and to focus watershed management efforts. This robust monitoring program provides the scientific underpinnings for the source water protection program.

Based on the information collected through the monitoring program, DEP developed a comprehensive strategy for the protection of source water quality, designed to address existing sources of pollution and prevent new sources. Each element of the watershed protection effort is conducted at a specific spatial and temporal scale to ensure the maintenance of the already high quality of the Catskill/Delaware waters. This effort yields benefits for water consumers as well as the tens of thousands of people who live, work, and recreate in the watershed, as well as the millions in communities downstream of the reservoirs.

Implementing the Source Water Protection Program and Achievements to Date

In the 1990s, DEP began the complex process of establishing the elements of a comprehensive, long-term watershed protection program. In January 1997, a new era of source water protection and partnership began when the New York City, New York State, the United States Environmental Protection Agency (EPA), watershed communities and environmental and public interest groups signed the New York City Watershed Memorandum of Agreement (MOA). This unique coalition came together with the dual goals of protecting water quality for future generations and preserving the economic viability of watershed communities. The MOA established the institutional framework and relationships needed to implement the range of protection programs identified as necessary by the City, the state, and EPA.

In December 2017, the New York State Department of Health (NYSDOH), in consultation with EPA, issued a 10-year FAD. The programs identified in the 2017 FAD built on the significant program accomplishments to that time and reflected DEP's continued commitment to long-term watershed protection. The 2017 FAD was the first to include a complete set of program and financial commitments for the full 10-year period. The 2017 FAD demonstrates DEP's ability to continue to implement proven programs, as well as the ability to revise strategies as needed to anticipate and respond to changing conditions. DEP's source water protection program continues to be an international model for sustainable water supply management and public health protection.

Effective implementation of this multi-faceted program depends on vital support from and cooperation with the City's watershed partners, with particular emphasis on implementation of several key watershed protection initiatives: the Watershed Agricultural Program; the acquisition of watershed lands; enforcement of the Watershed Regulations; the Stream Management Program; and the continuation of environmental and economic partnership programs that target specific sources of pollution in the watershed. In addition, DEP continued its enhanced watershed protection efforts in the Kensico reservoir basin and completed the upgrades of non-City owned watershed wastewater treatment plants. Figure ES.1 and Figure ES.2 map the myriad projects completed by DEP and its partners in the Catskill/Delaware basins, located both west and east of the Hudson River, since 1997.

Key watershed protection program highlights include:

Watershed Agricultural Program

Since 1992, the Watershed Agricultural Program (WAP) has advanced a voluntary, incentive-based, farmer-led strategy to reduce agricultural pollution while sustaining farm economic viability. Through its long-standing partnership with the Watershed Agricultural Council (WAC), the City supports the development of Whole Farm Plans and the implementation of structural and agronomic best management practices across the watershed. By the end of 2025, WAC has completed 480 Whole Farm Plans, with 277 active plans covering 135,122 acres east and west of the Hudson River. Nutrient Management Plans were maintained on more than 90% of farms requiring them, and 51 farms participated in the Precision Feed Management Program. The Conservation Reserve Enhancement Program enrolled 130 landowners and 1,306 acres of sensitive riparian buffer lands, while 831 participants attended 34 Farmer Education Events.

This assessment period also marked continued expansion of the Economic Viability Program, which awarded 55 micro grants totaling $199,982. Marketing initiatives and greenhouse/raised-bed expansions were the most frequently funded projects, with the latter created in response to the City's 2023 climate action plan to incentivize fruit and vegetable production within the New York City (NYC) watershed.

Watershed Forestry Program

Since 1997, Watershed Forestry Program has promoted and supported well-managed working forests as a beneficial land use for watershed protection and economic viability through a longstanding partnership with the Watershed Agricultural Council and support from the United Stated Forest Service (USFS). City funds support the development of forest management plans, the encouragement of forest stewardship activities, the implementation of best management practices (BMPs) on active timber harvest projects, professional training for loggers and foresters, and educational programs for landowners and school-based audiences.

Land Acquisition

The Land Acquisition Program (LAP) seeks to protect sensitive lands from development through willing seller/willing buyer transactions. Watershed-wide, the various elements of LAP have secured 155,069 acres. Overall, the City and state now protect approximately 40% of lands in the Catskill/Delaware system. While the overall level of protection is impressive, even higher levels of protection have been achieved in the key basins – Ashokan, Rondout, West Branch and Kensico – which range from 43% to 68% protected.

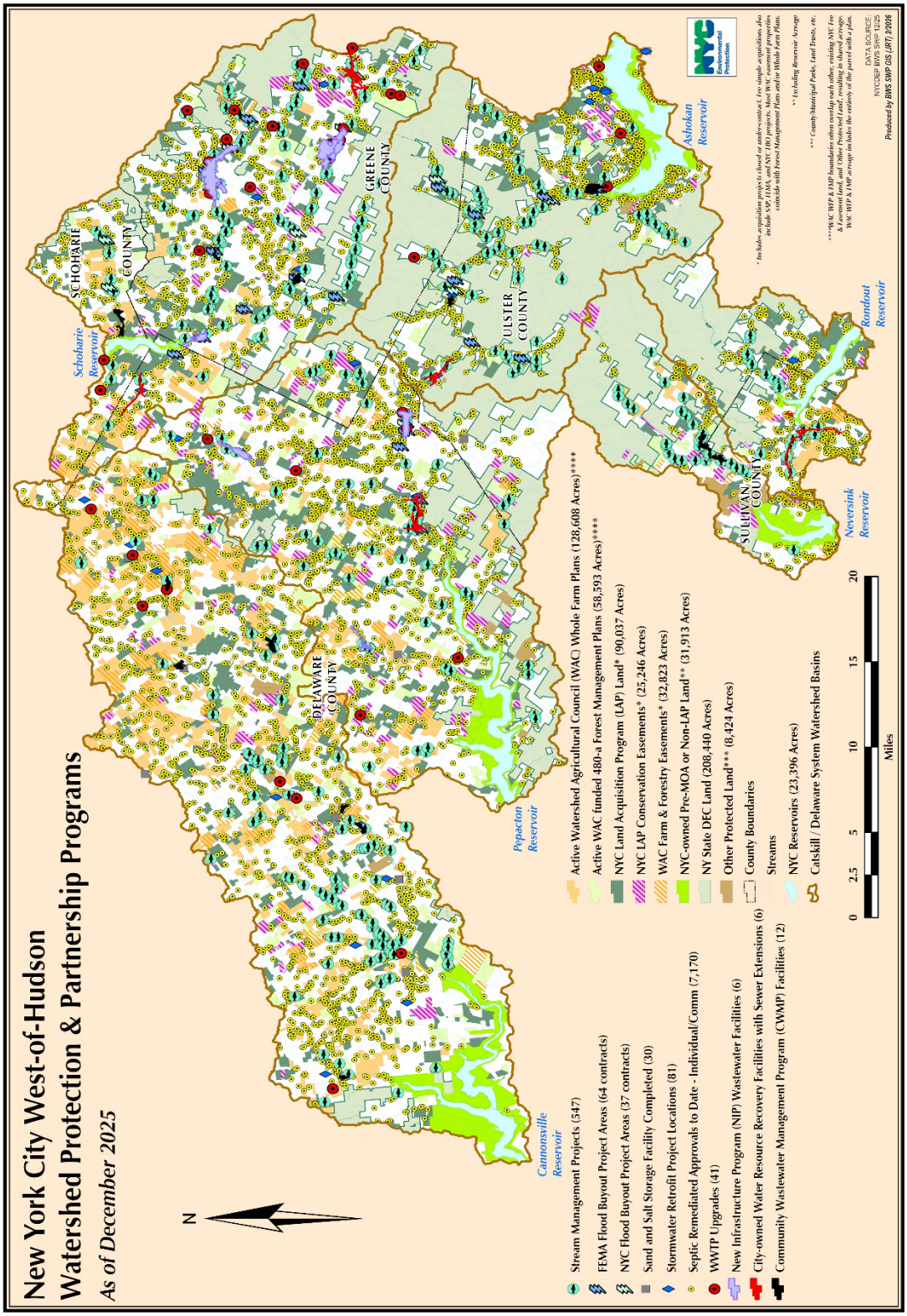


Figure ES.1 Map showing status of the partnership programs West of Hudson.

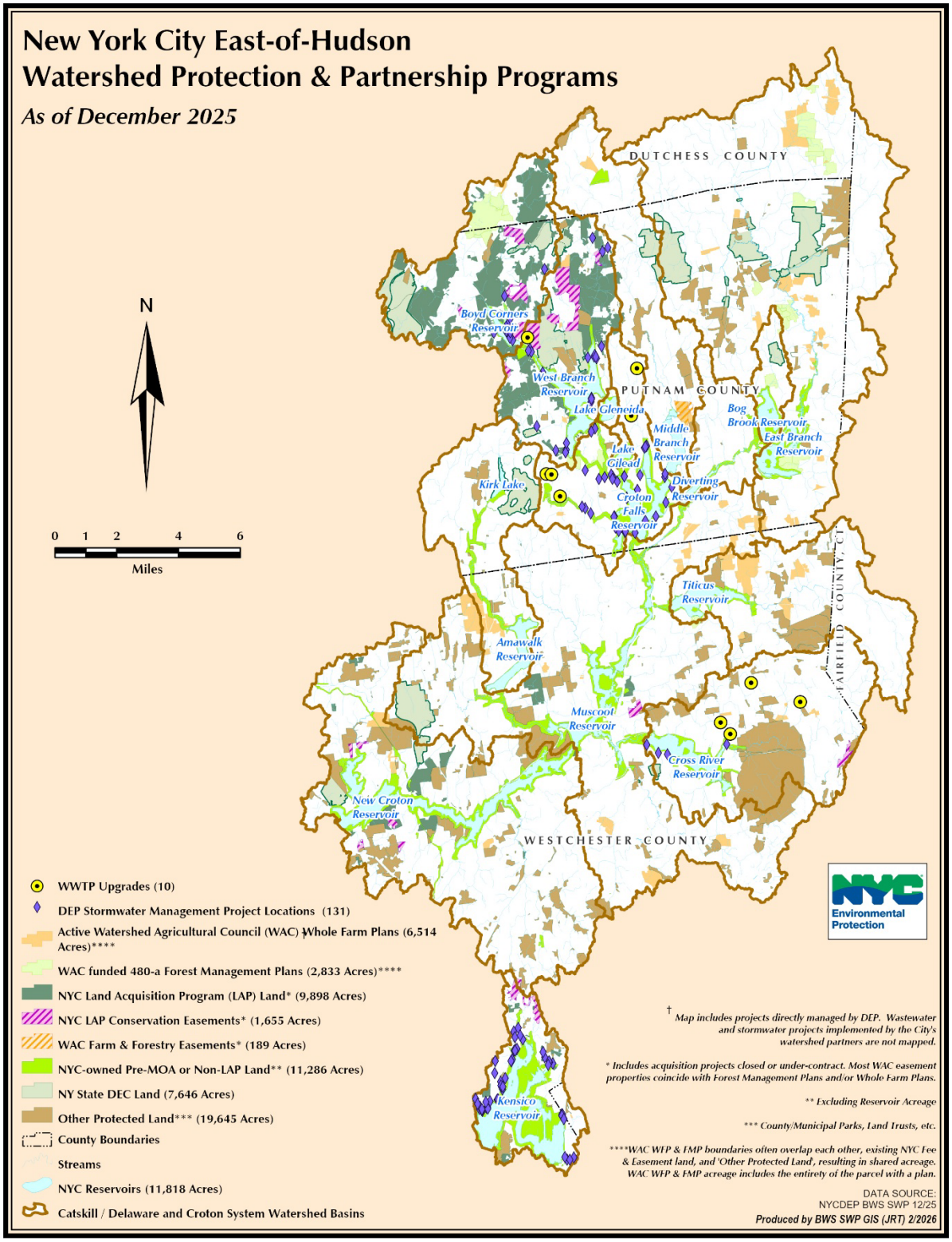


Figure ES.2 Map showing status of the partnership programs East of Hudson.

Watershed Regulations

Since 1997, DEP has reviewed more than 24,000 applications for approval of various regulated activities, performed routine compliance inspections at wastewater management and treatment facilities, responded to water quality violations, addressed non-compliance with permit standards, and enforced remedial and corrective actions, as necessary. DEP coordinates with applicants to ensure land development in the watershed is undertaken in a manner that is fully protective of critical water supply resources. Overall, more than 99% of regulatory applications obtain DEP approval. In February 2025, DEP amended the Watershed Regulations. The amendments include a revised definition of the term "wetland" to ensure continuity and consistency with NYSDEC as state freshwater wetlands regulations were updated on January 1, 2025. Accordingly, the 2025 amendments to the Watershed Regulations preserve DEP's prior jurisdiction over activities within specified limiting distances to wetlands.

Wastewater Programs

DEP has implemented an array of programs intended to improve the treatment of wastewater across the watershed. The City, in conjunction with its partners, has continued to implement programs that have remediated more than 7,300 failing septic systems. In recent years, DEP and its partners have expanded program eligibility to new classes of properties, ensuring availability of resources to address failure when they happen. All wastewater treatment plants (WWTPs) in the Catskill/Delaware basins – including City- and non-City-owned – have been upgraded to tertiary treatment, and DEP funds a significant portion of ongoing operation and maintenance. New WWTPs, or other community wastewater solutions, have been implemented in four additional communities over the past five years, essentially concluding the Community Wastewater Management Program with the sole exception of the Shokan wastewater project.

Stream Management Program

The Stream Management Program (SMP) promotes the protection and restoration of stream system stability and ecological integrity by providing for the long-term stewardship of streams and floodplains. DEP and its partners at County Soil and Water Conservation Districts (Greene, Ulster, Delaware and Sullivan) and Cornell Cooperative Extension of Ulster County (CCEUC) apply state-of-the-science river and floodplain management principles to implement programs and projects, working with stakeholders whose individual actions are fundamentally important to stream stability and riparian integrity. Over the past five years, DEP completed 10 stream restoration projects with a primary focus on water quality; completed 14 Stream Feature Inventories (SFI) covering 57.3 miles of stream; awarded 63 Stream Management Implementation Program (SMIP) grants; completed five Local Flood Hazard (LFA) analyses covering nine population centers; restored over 7.3 stream miles through 69 completed Catskill Stream Buffer Initiative (CSBI) projects; and continued to support various education, outreach and training initiatives aimed at streamside landowners, local officials, highway departments, flood response professionals, and the scientific community. A highlight of 2025 was the rollout

of the newly created municipal officials training entitled Stream Process 101 which is a self-paced training that introduces core stream process concepts and floodplain management considerations for municipal officials.

Waterborne Disease Risk Assessment Program

New York City's Waterborne Disease Risk Assessment Program (WDRAP) continues to collect, analyze, and report health-related data towards two core objectives: (1) To learn about giardiasis and cryptosporidiosis in NYC -- in terms of illness rates, and collecting demographic and risk factor information; and (2) To track gastrointestinal illness and related indicators to ensure rapid detection of any waterborne outbreak, should one ever occur. A highlight from this assessment period includes better detections due to the now broadly used syndromic multiplex panels. This is a continuation of the previously observed increase noted before the decline in testing during the pandemic. The COVID-19 pandemic impacted WDRAP; however, all program components continued uninterrupted. There was no evidence of waterborne disease in NYC during this period. WDRAP is a partnership program involving DEP and New York City Department of Health and Mental Hygiene (NYCDOHMH).

Scope of Water Analysis

Water quality analyses presented here include evaluation of status, trends, indices based on macroinvertebrates, pathogens, and comparison on trophic characteristics with standards developed by the Organization for Economic Cooperation and Development (OECD) for eutrophication control. Significantly, we have retained the information from previous years such that water quality analyses cover a longer time period than the five-year period of the assessment. Approximately 32 years of data (i.e., 1993 through 2024) are used to provide a long-term context for interpretation. Selection of a sufficiently long time captures changes in water quality in response to watershed protection programs. It provides a view of these changes in the context of natural variation caused by events such as floods and droughts, which are not sufficiently represented in a five-year period.

Water Quality Summary for the Catskill System

Water quality status in the Schoharie inflow, reservoir, and outflow from 2022-2024 was good overall based on the status of key analytes. Monthly median fecal coliform counts did not exceed benchmarks and both monthly median turbidity and phosphorus concentrations were low overall. Trophic status ranged from oligotrophic to mesotrophic for the status evaluation period. Water quality status in the Ashokan West basin inflow (E16I), both basins (EAW and EAE), and the reservoir outflow at EARCM from 2022-2024 was good overall based on the status of key analytes. Monthly median fecal coliform counts did not exceed benchmarks and both monthly median turbidity and phosphorus concentrations were low overall. Trophic status was primarily mesotrophic for the status evaluation period at EAW and ranged from oligotrophic to mesotrophic at EAE.

Long-term upward trends were identified in the Schoharie basin for turbidity and conductivity, while downward trends were identified for total phosphorus. The decline in phosphorus is attributed to recovery from high loads produced by periodic flood events, load reductions associated with the 2001-2002 drought, and from WWTP upgrades. The conductivity increases are likely due to the use of road deicers. Long-term downward trends were evident for total phosphorus at Ashokan's inflow, the reservoir itself and the outflow. These reductions are likely due to WWTP construction and to the cumulative effects of watershed protection programs. Downward fecal coliform trends were considered virtually certain at the inflow (E16I), Ashokan East Basin, and the outflow. The decrease can be attributed to low frequency of extreme rain events since 2011. Long-term downward turbidity trends were observed in both basins, showing a marked decrease after 2011, most likely due to the lack of extreme rain events. Long-term upward conductivity trends were identified for all sites in the watershed and likely linked to road deicer usage. Long-term trophic state index (TSI) decreases were apparent in both reservoir basins. Periods of low water clarity and the long-term decrease in total phosphorus (TP) are two likely factors. The most recent five-year period shows tight clustering of each basin in the OECD plots indicating a relatively steady state condition. Turbidity can severely diminish light penetration in Schoharie, and the West Basin of Ashokan, for months at a time and this presents a severe limitation to algal growth. In the most recent five-year period, all three basins' (Schoharie, Ashokan West, and Ashokan East) values tend to cluster within the 80% confidence intervals and have moved closer to the expectation indicated by the OECD standards.

Benthic macroinvertebrate biomonitoring results from 2022 through 2024 indicated that the biological communities of the main inflows to the Ashokan and Schoharie reservoirs (Esopus Creek and Schoharie Creek, respectively) and their sampled tributaries were in good health. Results were derived from assessments made at multiple sites along both stream systems. The mean Biological Assessment Profile (BAP) score for all sites sampled in the region was 7.90, which is above the threshold of 7.50 for the non-impaired category.

Water Quality Summary for the Delaware System

Overall, the water quality status of all four Delaware System basins for 2022-2024 status assessment period continued to be very good, which reflects, in part, the ongoing investment in watershed protection. Monthly median fecal coliform counts were generally low for all reservoirs and their outflows, with median values for the three-year period all non-detect except for at the Neversink outflow (1 fecal coliform 100 mL-1). Monthly median turbidity was low throughout the system, with a median of 0.6 NTU and corresponding median phosphorus value of 8 µg L-1 for the outflow from Rondout Reservoir (RDRRCM), the terminal reservoir in the Delaware System.

Long-term trend analysis for the Delaware System continues to show a decline in TP and TSI for all basins except for Neversink, which had an unclear trend. These long-term decreases are largely due to the cumulative effects of various watershed protection programs. The TP decreases in the Cannonsville basin, despite the large and shifting agricultural presence, are of

note. Long-term conductivity increases were ubiquitous throughout the system and likely the result of road deicer usage. The locally weighted scatterplot smoothing (LOWESS) curves show a decrease of conductivity at Rondout Reservoir and its outflow at RDRRCM since approximately 2017 and may be due to fewer storms requiring deicers during that period. Fecal coliforms within Delaware System reservoirs continue to show a strong attenuation, typically an order of magnitude or lower than the stream inflows. The four reservoirs of the Delaware system are well aligned with the OECD standards, showing a decrease in biomass in line with a decrease in phosphorus levels. In decreasing order, Cannonsville, Pepacton, and Neversink each cluster around a characteristic biomass level set by their nutrient contents. As a blend of the other three reservoirs, Rondout is in an intermediate position. This indicates that phosphorus is controlling the level of algal standing crop and eutrophication continues to be controlled through reduced phosphorus concentrations. Variation was greater in the maximum chlorophyll than annual mean chlorophyll. The maximum values may not always be captured due to low frequency of sampling, and maxima may not always be attained if other factors depress the standing crop. Since all the relationships tend to lie below the OECD line, it can be concluded that factors in addition to chlorophyll limit light in all the Delaware System reservoirs. Time series of the changes in central tendencies over the past 25 years show that there have been vast improvements in reducing the trophic condition of Cannonsville Reservoir, where the greatest phosphorus load reduction has been achieved, in agreement with the long-term trending using LOWESS curves and Trend Direction Assessment.

From 2022 to 2024, DEP conducted benthic macroinvertebrate biomonitoring on two sites on the primary river inflow to the Pepacton Reservoir (East Branch Delaware River), five sites on the primary river inflow to the Cannonsville Reservoir (West Branch Delaware River), and three sites on the inflows to Neversink Reservoir (West and East Branch Neversink Rivers, and Neversink River). The mean BAP scores across all sites sampled for each region indicated non-impaired status for the Pepacton (8.22), Neversink (8.06), and Rondout (8.40) basins, with the Cannonsville basin scoring on the higher end of slightly impaired (7.23).

Water Quality Summary for the East of Hudson Catskill/Delaware Basin System

Water quality in West Branch and Kensico basins continued to be excellent during the 2022-2024 assessment period. Median and peak monthly median values were all well below established water quality benchmarks for fecal coliforms, turbidity, and total phosphorus. Long-term downward turbidity trends were identified in the inflows to West Branch Reservoir and could be attributed to stormwater remediation projects. Upward total phosphorus trends were apparent at the local Croton inflows, the reservoir and the outflow. All reservoir and outflow trends were likely influenced by operational changes which control the blend of waters that comprise the reservoir. Long-term downward trends were identified for turbidity and fecal coliform for Kensico Reservoir and for its Catskill inflow (CATALUM) and outflow (DEL18DT). Long-term conductivity trends were upward in both the West Branch and Kensico

basins, which was attributed to road deicers. A long-term increase in trophic state index was observed at West Branch while a recent decrease was identified at Kensico.

In the most recent assessment period, both chlorophyll and phosphorus have remained low, with Kensico in the mesotrophic range bordering oligotrophy. The most recent years show chlorophyll values all within the 80% PI of the OECD standard, with Kensico displaying lower algal production than West Branch. Secchi depth means show little variation and are in line with phosphorus means. The same observation of low Secchi depth values relative to phosphorus as seen in the Catskill and Delaware System reservoirs was observed for the East of Hudson (EOH) Catskill and Delaware reservoirs, indicating that substances other than chlorophyll reduce transparency. In this assessment period, Secchi depths at Kensico tended to be deep, indicating excellent transparency. These reservoirs, not surprisingly, reflect the same water quality characteristics seen in the other Delaware System reservoirs. In Kensico and West Branch Reservoirs, biomass is not so clearly dependent on phosphorus, and this is likely related to short (often < 1 month) water residence times. Maximum values of chlorophyll seem to develop in years when there is no disturbance from major storms. These two reservoirs follow the same observation of low Secchi depth values relative to phosphorus as seen in all the Catskill and Delaware System reservoirs.

From 2022-2024, DEP conducted benthic macroinvertebrate biomonitoring on the largest inflow to the West Branch Reservoir (Horse Pound Brook), the Boyd's Corners Reservoir (West Branch Croton River), and the Kensico Reservoir (Whippoorwill Creek). The mean BAP score across all sites sampled was 8.76, placing the combined Delaware system in the non-impaired category. Whippoorwill Creek was the only sample site assessed as slightly impaired across the reporting period, with a BAP score of 6.42 in 2024. All sites sampled were assessed as headwaters for the Croton region as per New York State Department of Environmental Conservation (NYSDEC) protocols, with a modifier of 1.3x added to the BAP scores of samples collected using the statewide traveling kick method and analyzed using the statewide multimetric scoring system. The overall influence of local stream input on both Kensico and West Branch Reservoir water quality is small, because of the much larger inputs from the Catskill and Delaware reservoirs via the aqueducts.

Giardia annual mean concentrations have been relatively low at both the inflows and outflows, generally ranging from 0 - 4.9 cysts 50 L-1. Cryptosporidium concentrations continued to be an order of magnitude lower than those for Giardia, making it difficult to discern differences between inflows and outflows with any level of statistical confidence. For the recent report period of 2020 - 2024, the annual mean Cryptosporidium oocyst concentrate ions at the Kensico source water outflow was very low, ranging from 0.06 - 0.4 oocysts 50 L-1.

Water Quality Summary for the East of Hudson Potential Delaware System Watersheds

Water quality status for the assessment period (2022-2024) for Croton Falls and Cross River basins was generally good with few extreme events during the period (noting that Tropical

Storm Ida occurred in September 2021, just prior to the status evaluation period). Fecal coliform levels were low in both reservoirs, although recent years show an increase in Cross River. With fecal coliform and turbidity values being mostly affected by spring runoff and late summer storms, the pump stations are least likely to be available for resiliency at those time periods. Turbidity in both basins was generally low. Total phosphorus monthly medians for the reservoirs were above the target value of 15 µg L-1 for source waters. The median TSI was primarily in the eutrophic range for Croton Falls Reservoir and mesotrophic in Cross River Reservoir.

The current assessment period indicates that the basins of Cross River and Croton Falls are similar in water quality regarding nutrient and algal concentrations. Operational intentional release of West Branch water to Croton Falls may be beneficial for the very recent reduction in specific conductance but this should be separated from overall hydraulic patterns as a genuine cause. This period likely also shows better conductivity because West Branch Reservoir has been placed in reservoir operational mode more frequently than prior periods, where the float operational mode was frequently used. As a result, West Branch takes more of the characteristics of Rondout Reservoir than Boyd Corners Reservoir, which cascades to improve water quality in Croton Falls Reservoir

From 2022-2024, DEP conducted benthic macroinvertebrate biomonitoring on the largest inflow to the Cross River Reservoir (Cross River) and two inflows to the Croton Falls Reservoir (Michael Brook and an unnamed Croton Falls Tributary). The mean score for the combined EOH Potential Delaware region was 7.39, on the high end of slightly impaired. While the two Croton Falls sites were assessed as non-impaired, Cross River was assessed as slightly impaired with a score of 6.59. This is consistent with the mean BAP score for the site over the period of record since 1998 (6.70).

Water Quality Modeling Program

DEP has continued a program of development, testing, and application of climate, watershed, reservoir, and supply system operation models, and database development and data analysis to support modeling, during the current FAD reporting period. While the Generalized Watershed Loading Function (GWLF) model remains available for use in all West of Hudson (WOH) watersheds, DEP is now moving to the use of the Soil and Water Assessment Tool (SWAT) model for these watersheds. DEP has completed testing and validation of SWAT for the Cannonsville watershed and is currently working on testing and validation for the remaining WOH watersheds. DEP applied SWAT to evaluate reductions in nutrient loads resulting from watershed protection programs in the Cannonsville watershed, with a focus on dissolved phosphorus (DP) loading. The model estimated the current sources of stream nutrient loads, assessed loading reductions from point and nonpoint sources achieved over the past 30 years, and simulated scenarios on the impact of various watershed management practices. An assessment on the potential impact of climate change using future climate scenarios was also made.

Comparison of model predictions for current (2010s) watershed conditions to predictions for 1990s watershed conditions, both using the same hydro-climatic conditions, shows that nonpoint source contributions of dissolved P have decreased by ~35% over this 30-year period. Agricultural activity is currently the largest anthropogenic source of dissolved phosphorus in the watershed, contributing about 42% of the mean annual loads. Currently point source dissolved phosphorus loads are less than 1% of total watershed load, a 98% reduction from the early 1990s and a result of upgrades to WWTPs.

During the FAD assessment period, DEP completed the development and testing of turbidity models for Cannonsville, Pepacton, and Neversink reservoirs. The model framework that was used for these reservoirs is fundamentally the same as the models previously validated for Ashokan, Schoharie, Kensico, and Rondout reservoirs. This model combines the two-dimensional CE-QUAL-W2 hydrothermal and transport model with a three size-class turbidity model. The setup, testing and performance of the model for Cannonsville is described in this report; the procedure and results for Pepacton and Neversink are similar. Rigorous testing was performed for 2011-2019 historic conditions, while additional testing was completed for 1987-2010. The accuracy of predictions of temperature and turbidity in the water column of the reservoir, and in the water supply diversion from the reservoir, were good and were comparable to that achieved in applications to other reservoirs.

DEP also completed an analysis to estimate the impact of climate change on the NYC water supply system. This analysis combined future climate forecasts for the watersheds with watershed and reservoir models and the Operations Support Tool. Current climate forecasts indicate consistently warmer and generally wetter conditions in the watersheds. Summarizing the system-wide forecasts, a 6% increase in inflow to both Catskill and Delaware system reservoirs is predicted when comparing future (2041-2060) to current (2001-2020) climate. Diversion from the Delaware System is predicted to increase by 9% in the future, while Catskill diversion will decrease by 3%. The return period of various levels of elevated turbidity in major tributaries to the WOH reservoirs is predicted to decrease moderately, consistent with the inflow forecasts.

The number of days per year when diversion turbidity from Ashokan and Rondout reservoirs exceeds certain high values is predicted to increase moderately. Average number of days when the water supply system is under watch, warning or emergency drought conditions remain generally unchanged for the future conditions. The number of days when addition of alum to the Catskill Aqueduct will be required is predicted to increase a small amount.

1. Introduction

1.1 Purpose of this Report

This report has been prepared to comply with Section 5.1 of the December 2017 FAD, which requires the City to submit a comprehensive report on watershed protection accomplishments and an assessment of water quality to the NYSDOH by March 31, 2026. The purpose of this report is to summarize the achievements of the programs that comprise the City's overall watershed protection program; to review water quality status and trends in the Catskill/Delaware basins; and, where possible, to demonstrate the link between program activities and changes in water quality.

The report is divided into two main sections: Chapter 2 provides brief summaries of the accomplishments of each of the watershed protection programs for the past five years; and Chapters 3, 4, 5, and 6 summarize water quality monitoring results with a goal of assessing current water quality and evaluating the effectiveness of some of those pro-grams. Chapter 7 summarizes model applications to evaluate the impact of climate change, assess the efficacy of watershed programs and guide operational decisions.

This document should be viewed as a companion to the regular reports DEP has produced detailing program progress and water quality over the past five years. For specific details about the implementation of watershed protection programs, refer to the annual reports prepared pursuant to the FAD for the years 2022 through 2024. DEP has prepared annual Watershed Water Quality Reports for the same period. DEP also produces dozens of quarterly, semi-annual and annual reports on FAD programs, publishes reports on special studies and develops an annual water quality statement, which gives detailed information about water quality. Finally, DEP's web site contains periodic updates on certain programs and other details. Reports and other information about the City's initiatives can be found at https://www1.nyc.gov/site/dep/about/filtration-avoidance-determination.page.

1.2 Water Supply System

The New York City Water Supply System consists of three surface water sources (the Croton, the Catskill and the Delaware) and a system of wells in Queens (the Jamaica System) (Figure 1.1). The three upstate water collection systems include 19 reservoirs and three controlled lakes with a total storage capacity of approximately 590 billion gallons. They were designed and built with various interconnections to increase flexibility to meet quality and quantity goals and to mitigate the impact of localized droughts and water quality impairments. The system supplies drinking water to almost half the population of the State of New York – approximately 8.5 million people in New York City and 1 million people in Westchester, Putnam, Orange and Ulster counties – plus the millions of commuters and tourists who visit New York City throughout the year. Overall in-City consumption in 2025 averaged 990 million

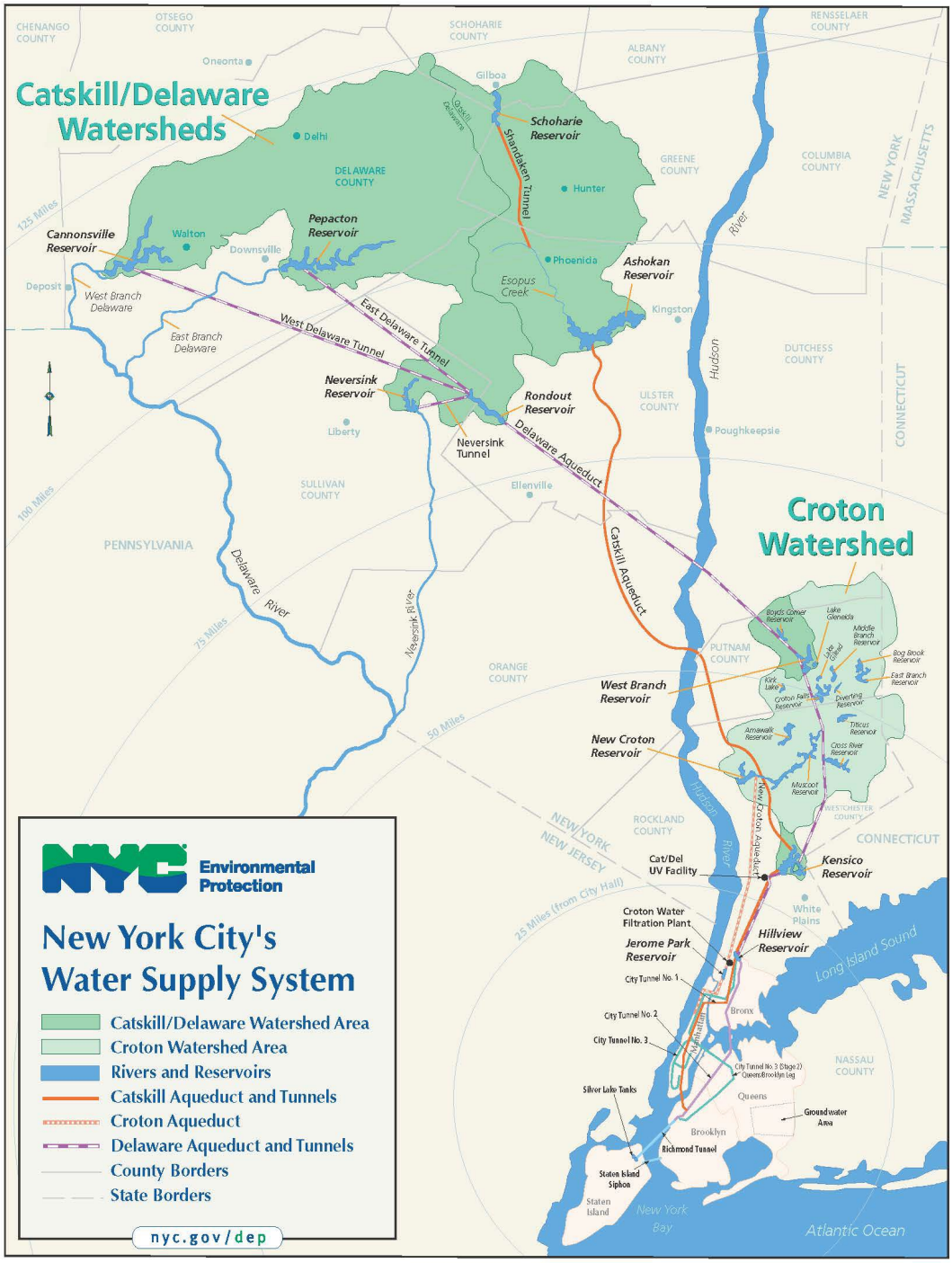


Figure 1.1 Map of New York City water supply system.

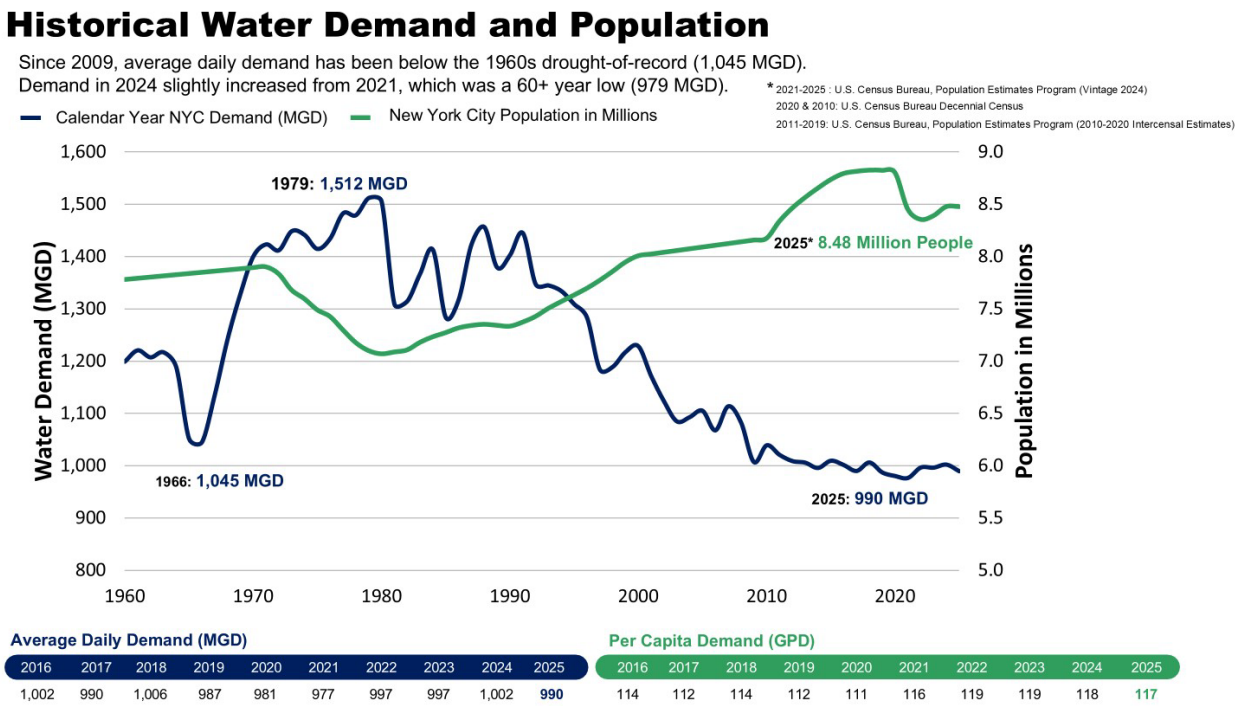


Figure 1.2 New York City consumption projection.

gallons a day. (Figure 1.2)

The Croton watershed is located entirely east of the Hudson River in Westchester, Putnam and Dutchess counties, with a small portion in Connecticut. The oldest of the three systems, parts of the Croton System have been in service for more than 175 years. The watershed covers approximately 375 square miles. Croton's 12 reservoirs and three controlled lakes are connected primarily via open channel streams and rivers, and ultimately drain to the New Croton Reservoir in Westchester County. Historically, approximately 10% of the City's average daily water demand has been supplied by the Croton, although in times of drought the Croton System may supply significantly more water.

The Catskill System consists of two reservoirs – Schoharie and Ashokan – located west of the Hudson River in Ulster, Schoharie, Delaware and Greene counties. The Catskill System was constructed in the early part of the 20th century, and Ashokan Reservoir went into service in 1915. Water leaves Schoharie Reservoir via the 18-mile-long Shandaken Tunnel, which empties into the Esopus Creek at Allaben and then travels 22 miles to the Ashokan Reservoir. Water leaves Ashokan via the 92-mile-long Catskill Aqueduct, which travels to Kensico Reservoir in Westchester County. The Catskill System supplies, on average, 40% of the City's daily water supply.

The Delaware System was constructed in the 1950s and 1960s, and is comprised of four reservoirs: Cannonsville, Pepacton, and Neversink in the Delaware River basin, and Rondout in

the Hudson River basin. The first three reservoirs supply Rondout; water then leaves Rondout and travels to West Branch Reservoir in Putnam County via the Rondout-West Branch Tunnel. Water from West Branch then flows through the Delaware Aqueduct to Kensico Reservoir. The Delaware System provides the remaining 50% of the City's daily demand. Because waters from the Catskill and Delaware watershed are commingled at Kensico Reservoir, they are frequently referred to as one system: the Catskill/Delaware System.

In the late 1980s, the City decided to apply for filtration avoidance for the Catskill/Delaware System under the terms of the SWTR. Since that time, DEP and its partner agencies and organizations have developed and deployed a comprehensive watershed monitoring and protection program designed to maintain and enhance the high quality of Catskill/Delaware water. This program has been recognized internationally as a model for watershed protection and has allowed the City to secure a series of waivers from the filtration requirements of the SWTR.

DEP is the City agency with primary responsibility for overseeing the operation, maintenance and management of the water supply infrastructure and the protection of the 1,969 square mile watershed. Within DEP, the Bureau of Water Supply (BWS) manages the upstate watershed and infrastructure and all drinking water quality monitoring in-City and upstate. BWS also operates the City's two main distribution reservoirs – Hillview and Jerome Park. The Bureau of Water and Sewer Operations is responsible for the drinking water distribution and sewage collection infrastructure. The Bureau of Engineering Design and Construction manages all large contracts for capital construction and maintenance of the water supply infrastructure. Other bureaus and units within DEP – including Legal Affairs, Environmental Planning and Analysis, Public Affairs and Communications, Customer Service, and budget, personnel and procurement staff – provide vital support services to ensure the smooth operation of the water supply. In addition, staff from the NYCDOHMH assist in certain drinking water programs and staff from the New York City Law Department provide legal support.

1.3 Regulatory Context

The Safe Drinking Water Act (SDWA) amendments of 1986 required the USEPA to develop criteria under which filtration would be required for public surface water supplies. In 1989, USEPA promulgated the SWTR, which requires all public water supply systems supplied by unfiltered surface water sources to either provide filtration or meet certain criteria. The filtration avoidance criteria are comprised of the following:

- Objective Water Quality Criteria – The water supply must meet certain levels for specified constituents including coliforms, turbidity and disinfection byproducts.
- Operational Criteria – A system must demonstrate compliance with certain disinfection requirements for inactivation of *Giardia* and viruses; maintain a minimum chlorine residual entering and throughout the distribution system; provide uninterrupted disinfection with redundancy; and undergo an annual on-

site inspection by the primacy agency to review the condition of disinfection equipment.

- Watershed Control Criteria – A system must establish and maintain an effective watershed control program to minimize the potential for contamination of source waters by *Giardia* and viruses.

1.4 Historical Context

The City first applied for a waiver for the Catskill/Delaware system from the filtration requirements of the SWTR in 1991. This first application was filed with NYSDOH because, at the time, the City and NYSDOH believed NYSDOH had primacy for all water supply systems in New York State. NYSDOH granted a one-year filtration waiver. Subsequently, it was determined that EPA had retained primacy for the SWTR for the Catskill/Delaware systems. In mid-1992, DEP submitted a 13-volume application to USEPA, describing in detail the City's plans for protecting the Catskill/Delaware supply. On January 19, 1993, USEPA issued a conditional determination granting filtration avoidance until December 31, 1993. The waiver incorporated many elements of the program the City had described in mid-1992, and was conditioned upon the City meeting 66 deadlines for implementing studies to identify potential pollution sources, developing programs to ensure long-term protection of the watershed, and addressing existing sources of contamination in the watershed. USEPA also imposed substantial reporting requirements on the City to monitor its progress.

DEP submitted a second application for continued avoidance to USEPA in September 1993. This application was based upon the knowledge gained by the City through initiation of its watershed studies and programs and laid out a long-term strategy for protecting water quality in the Catskill/ Delaware System. Again, USEPA determined that the City's program met the SWTR criteria for filtration avoidance, although they did express concerns about the program's ability to meet the criteria in the future. On December 30, 1993, USEPA issued a second conditional determination, containing 150 requirements related primarily to enhanced watershed protection and monitoring programs. USEPA also required the City proceed with conceptual design of a filtration facility for the Catskill/Delaware supply so no time would be lost should USEPA decide filtration was necessary in the future.

Two critical pieces of the watershed protection program that DEP described in September 1993, and that USEPA incorporated into the December 1993 determination, were implementation of a land acquisition program and promulgation of revised watershed regulations. DEP was unable to move forward with implementation of those key program elements primarily due to the objections of watershed communities over the potential impact those programs might have on the character and economic viability of their communities. It was against this backdrop that New York Governor George Pataki convened a group of stakeholders to try to come to an accord. The negotiations involved the City, the state, USEPA, representatives of the counties, towns and residents of the watershed, and representatives from

environmental groups. In November 1995, the parties reached an agreement in principle setting forth the framework of an agreement that would allow the City to advance its watershed protection program while protecting the economic viability of watershed communities. It took another 14 months to finalize the details of an agreement. In January 1997, the parties signed the Watershed Memorandum of Agreement (MOA). The MOA supplemented the City's existing watershed protection program with approximately $350 million in additional funding for economic and environmental partnership programs with upstate communities, including a water quality investment program and a regional economic development fund. The state issued a land acquisition permit, which was updated in 2010, to allow the City to purchase land in the watershed, and approved a revision to the City's Watershed Regulations governing certain aspects of new development in the watershed. The City also secured a five-year waiver from the filtration requirements for the Catskill/Delaware System.

In March 2006, the City submitted to USEPA a rigorous, science-based assessment of Catskill/Delaware water quality, followed in December 2006 by an enhanced, comprehensive long-term plan for watershed protection efforts. That long-term plan represented a significant enhancement to the City's watershed protection efforts and relied in part on the continued support and cooperation of the City's partners. The plan formed the basis of an updated FAD, issued by USEPA in July 2007. Significantly, the 2007 FAD was the first FAD to cover a full 10-year period, signaling the growing confidence of all parties that source water protection has become a sustainable alternative to filtration for the City's Catskill/Delaware supply.

Following issuance of the 2007 FAD, USEPA granted NYSDOH primary regulatory responsibility for the SWTR as it applies to the Catskill/Delaware supply. In March 2011, DEP issued another detailed assessment of program activity and water quality, which formed the basis of a revised long-term plan submitted to NYSDOH in December 2011. In late summer 2011, two significant storms swept through the region, devastating communities and significantly impacting water quality in portions of the New York City supply. In the wake of the storms, a large group of watershed stakeholders came together to discuss developing and enhancing certain programs to promote flood resiliency and minimize water supply impacts from future events. Following these discussion, NYSDOH issued a Revised 2007 FAD in May 2014.

In March 2016, DEP released the next five-year summary and assessment report, again confirming the high quality of the New York City supply. In December of that year, following extensive discussions with regulators and watershed stakeholders, DEP submitted a long-term plan, which included detailed program proposals for the period 2017-2027. Following additional review and stakeholder discussion, NYSDOH issued a new FAD in December 2017.

In 2018, the National Academies of Science, Engineering and Medicine (NASEM) convened an expert panel to evaluate New York City's source water protection program. This study follows a similar evaluation conducted by NASEM in the early 2000s after the MOA was signed. Over approximately two years, the panel engaged in a comprehensive process, which included eight meetings, dozens of presentations by DEP staff and watershed stakeholders,

several site visits in the watershed, countless information requests and hundreds of hours of discussion and drafting. Their final report was released in August 2020. The panel was able to synthesize an incredible amount of information about our complex program and watershed conditions, and produce a detailed analysis and discussion.

The report includes a strong endorsement of the work DEP and its partners have undertaken over many years, stating that the programs "have admirably supported water quality" with "strong indications" they will continue to effective in the future. However, the panel's charge was not simply to look at the accomplishments to date, but rather to make recommendations for adjustments to ensure the continued effectiveness of our investments. The report includes 63 major recommendations, ranging from straightforward and relatively modest program adjustments to out-of-the-box thinking. Many of the recommendations have been implemented and others are in various stages of evaluation and planning.

1.5 Report Details

This report primarily focuses on program activities undertaken since 2016 and continuing through the end of 2020. However, since most of the programs discussed were initiated more than 25 years ago, there is some discussion of program activities that fall before the term of the current FAD. Indeed, the City's watershed protection efforts are best evaluated in the context of the overall program that was initiated in the early 1990s. The significant accomplishments of the City and its partners have been made possible only by the sustained commitment to source water protection.

One of the primary purposes of this report is to evaluate quantitatively how effective the watershed programs have been since 1997 and will be over the long term. The City has taken a basin-by-basin approach, evaluating each reservoir in turn to assess the status and trends in water quality. The water quality analysis presented in this document is an extension of the analysis presented in the 2001, 2006, 2011, 2016 and 2021 assessments of DEP's FAD programs. Here DEP presents an analysis covering 32 years of data collection and program implementation. This data includes results collected through the end of 2024. Due to the time needed to process samples, and compile, review and verify data, it was not possible to incorporate any monitoring results from 2025. Long-term data is critical in the evaluation of programs that cover large geographical areas and are implemented over long periods, so analyses have become better as the data record becomes longer. The approach DEP has used is to evaluate water quality in terms of status, trends, and modeling. The status of waterbodies is based on three recent years of data (i.e., 2022 through 2024) and these are compared to regulatory benchmark values. The trends are based on 32 years of data (i.e., 1993 through 2024). Five important analytes were selected, including fecal coliforms, turbidity, phosphorus, conductivity and trophic status. Modeling was conducted to attribute program effects to programs on a watershed-wide basis. All analyses together provide a context to understand program effects.

2. Watershed Management Programs

2.1 Institutional Alliances

As embodied in the 1997 MOA and memorialized in dozens of DEP contracts during the past 30 years, a number of non-City entities contribute to the development, implementation, and evolution of DEP's Watershed Protection Program. Representatives from watershed communities, locally based contract partners, and environmental organizations all bring their own perspectives to watershed issues. DEP strives to balance these views with its public health mandate to provide safe, clean drinking water to more than nine million consumers, while complying with the City's complex budgetary and contracting framework, as well as numerous state and federal regulatory requirements.

DEP's Watershed Protection Program serves as a national and international model for how to reliably safeguard an unfiltered public water supply. Although science, engineering, planning, security, and financial investment are all indispensable components of a successful overall program, the active involvement of local stakeholders and affected constituents is also essential. The architects of the 1997 MOA recognized that DEP's delivery of targeted watershed programs depends on strong institutional alliances with local partners and a substantial "ownership interest" by watershed communities and residents in the shared long-term goal of stewarding the New York City water supply for future generations.

As affirmed by the NASEM in its 2020 Review of the New York City Watershed Protection Program, the MOA's structure continues to stand the test of time, providing a stable foundation for many watershed partnership programs established since 1997. In many ways, the City's ongoing commitment to cooperate with local partners toward mutually beneficial outcomes is one of the crowning achievements of the past three decades. This section provides a brief summary of key institutional alliances that help make the overall program a collaborative success.

2.1.1 Watershed Agricultural Council

The WAC was the first locally based partnership that DEP funded to administer and implement voluntary pollution prevention programs. WAC was incorporated in 1993, years before the MOA, to receive City funds and assist watershed farmers with the development of Whole Farm Plans and the implementation of BMPs that protect water quality. Since WAC's inception, DEP has served as a member of WAC's Board of Directors and all program committees. Other WAC board members include watershed farmers, forest landowners, and business representatives.

Today, DEP contracts with WAC to fund a portfolio of programs that address both agricultural and forestry sources of pollution. WAC's mission is to promote the economic viability of agriculture and forestry, the protection of water quality, and the conservation of working landscapes through strong local leadership and sustainable public-private partnerships.

WAC's core programs include the Watershed Agricultural Program, Forestry Program, Farm and Forest Conservation Easement (CE) Programs, and Economic Viability (EV) Program. WAC also manages a long-term Farm and Forest CE Stewardship Endowment Fund.

During the current FAD assessment period, WAC continued to evolve as an independent not-for-profit organization while balancing its role as a DEP contract partner responsible for the expenditure of City funds. In late 2020, WAC's executive director and board chair both resigned, resulting in a significant leadership transition and the need to improve WAC's financial accounting and internal governance. In 2021, the City's Department of Investigation (DOI) placed WAC under a monitorship agreement, while DEP subsequently hired an independent auditing firm and WAC hired a part-time consultant to better assess and ultimately resolve organizational weaknesses and financial deficiencies. DEP also hired an organizational consultant to assist WAC with recommended changes to by-laws, policies, board responsibilities and committee structure, and to conduct leadership training for WAC staff and board members. On May 30, 2025, the City's DOI released WAC from its monitorship early, while DEP committed $228 million to WAC over the next 10 years through two separate program contracts and a new operating contract that is modeled after DEP's arrangement with the Catskill Watershed Corporation.

2.1.2 Catskill Watershed Corporation

The Catskill Watershed Corporation (CWC) was created in 1997 to implement a diverse portfolio of WOH watershed programs as outlined in the MOA and funded by the City through a series of DEP contracts. As a not-for-profit local development corporation, CWC's dual mission is to preserve and strengthen the region's economy while administering watershed programs that protect the City's unfiltered water supply originating from the 39 towns and five counties that comprise the WOH watershed. CWC's current portfolio of programs address septic system remediation and maintenance, stormwater management, community wastewater management, flood hazard mitigation, local consultation, public education, workforce development, and economic development through the CWC-administered Catskill Fund for the Future.

With headquarters in Arkville, New York, CWC is comprised of more than two dozen local staff and governed by a 15-member Board of Directors, 12 of which are elected by the local watershed towns. Of the remaining three CWC Board seats, one is a New York State representative appointed by the Governor, one is a representative of the environmental community who lives in a watershed town and is also appointed by the Governor, and one is a representative of the City of New York (DEP) appointed by the Mayor.

During the current FAD assessment period, DEP continued to serve on CWC's Board of Directors while CWC continued to deliver a wide range of programs to the mutual benefit of watershed residents and downstate water consumers. In 2020, CWC completed construction of a new 35,000-square foot office building in Arkville that, pursuant to the 2017 FAD, provides shared office space for at least 40 DEP staff with a goal of improving communication,

collaboration, and coordination of programs. CWC and DEP both utilize this new facility for centralized meetings and events. In 2024, CWC hired its first Human Resources Director and geared up to launch a new DEP-funded Workforce Development Initiative in 2025.

2.1.3 Stream Management Program Partners

Since 1996, DEP has contracted with Soil and Water Conservation Districts (SWCDs) in Delaware, Greene, Ulster, and Sullivan counties, and with Cornell Cooperative Extension of Ulster County, to develop and implement the SMP within each WOH reservoir basin. Partnership is a core value of the SMP, and DEP recognizes that long-term success depends on a community-based approach with substantial involvement of streamside landowners, local officials, highway departments, code enforcement officers, and others. Within each basin, the SMP partners work closely with local advisory committees and flood commissions to guide program priorities while relying on basin-specific action plans to guide the implementation of projects and to educate and train a broad range of stakeholders.

In its 2020 FAD Expert Panel Report, the NASEM acknowledged and commended the SMP for developing long-term partnerships with multiple agencies, communities, scientists, and engineers to build an extensive Catskill Mountain stream and floodplain stewardship program that is focused on the overarching goal of protecting and restoring stream system stability and ecosystem integrity. Five years ago, DEP noted that new leadership at each of the five core SMP basin partner organizations could result in the loss of institutional knowledge despite a number of internal staff promotions. During the current FAD assessment period, the SMP continued to foster, strengthen, and coordinate a network of institutional alliances in support of stream restoration, riparian buffer protection, and flood hazard mitigation.

However, a growing wave of staff turnover within many of the SMP partner organizations is beginning to erode the engineering expertise of the SMP. Throughout the program's history, efforts focused on collecting scientific data and conducting geomorphic analysis of site conditions, utilizing natural channel design to restore stability at the reach scale and leading to system resiliency and water quality protection. More recently, efforts have shifted towards completing discrete projects for compliance with the FAD or to achieve community goals. It will be important for the SMP to train new staff in construction management and refocus on its scientific underpinning in the years ahead.

2.1.4 Environmental Organizations

Environmental organizations have always been vital to the success of DEP's Watershed Protection Program, including MOA signatories such as the Catskill Center, Hudson Riverkeeper, Natural Resources Defense Council, New York Public Interest Research Group, Open Space Institute, and Trust for Public Land. Many of these organizations provide an important perspective during stakeholder discussions and offer key policy suggestions that inform the continued evolution of DEP's Watershed Protection Program.

During the current FAD assessment period, DEP continued to contract with the Catskill Center to fund the Streamside Acquisition Program (SAP) that was initiated in 2015 as part of the City's broader Land Acquisition Program (LAP). The SAP is mandated by the 2017 FAD and authorized by the 2010 Water Supply Permit (WSP) issued by the NYSDEC. Recognizing that a successor permit would be needed to continue and/or expand the SAP after expiration of the 2010 WSP in December 2025, DEP spent the past several years negotiating with MOA signatories over the future of both the City's core LAP and the SAP; these negotiations included valuable input and perspectives from the Catskill Center, Hudson Riverkeeper, and Natural Resources Defense Council.

2.1.5 East of Hudson Partners

During the current FAD assessment period, DEP continued to work with various EOH partners including county governments, the locally administered EOHWC, and the regionally administered NEIWPCC (formerly called the New England Interstate Water Pollution Control Commission). Collectively, these entities support DEP's implementation of voluntary EOH watershed programs that address septic system repairs, community wastewater management solutions, and stormwater management projects.

Westchester and Putnam counties continued to administer City funding provided through the MOA's EOH Water Quality Investment Program while working closely with DEP through delegation agreements with their respective health departments to conduct and perform coordinated reviews and inspections of new, modified, and repaired septic systems. Historically, DEP contracted with the New York State Environmental Facilities Corporation (EFC) to administer the EOH Septic System Rehabilitation Reimbursement Program. Since 2022, DEP has successfully been implementing this program in-house.

The EOHWC, a local development corporation established in 2011, continued to assist watershed municipalities in Westchester, Putnam, and Dutchess counties with the installation of stormwater retrofit projects that meet the heightened State regulatory requirements for phosphorus reduction through Municipal Separate Storm Sewer System (MS4) permits. The EOHWC is governed by a board of directors comprised of town supervisors, village mayors, and county executives representing EOH watershed municipalities.

NEIWPCC is a regional entity that helps northeastern states to preserve and advance water quality initiatives. In 2017, DEP contracted with NEIWPCC to administer the EOH Community Wastewater Grants Program, a requirement of the 2017 FAD. In 2019, DEP entered a second contract with NEIWPCC to administer the WWTP Regulatory Upgrade and Capital Replacement Programs following EFC's decision to discontinue its role in these programs.

2.2 Land Acquisition

2.2.1 Program Overview

DEP's LAP permanently protects lands in the Catskill/Delaware watersheds through acquisition of conservation easements (CEs) and land in fee simple, both directly by the City and in partnership with the WAC (WAC Farm and Forest CE Programs), Catskill Center for Conservation and Development (CCCD, SAP), and local municipalities through the New York City-Funded Flood Buyout Program (NYCFFBO). For nearly three decades, the goal of the LAP has been to permanently protect sensitive lands to prevent water quality impacts associated with intense land uses and development of impervious surfaces. As such, the role of the LAP is not to improve water quality over existing conditions, but rather to ensure that future development will not appreciably impact water quality. The history of acquisitions during 28 years of activity offers a compelling story of land protection in a two thousand square-mile watershed, as assessed here.

Based on DEP's robust geospatial data, the entire Catskill/Delaware watershed comprises 1,048,660 acres (including reservoirs). When the LAP commenced in 1997, the City owned 3% of the land area in the Catskill/Delaware watershed, while an additional 21% was owned by New York State and other public entities for a total protected status of approximately 25%. Since 1997, LAP initiatives have resulted in 155,069 acres in fee simple or CEs being protected within

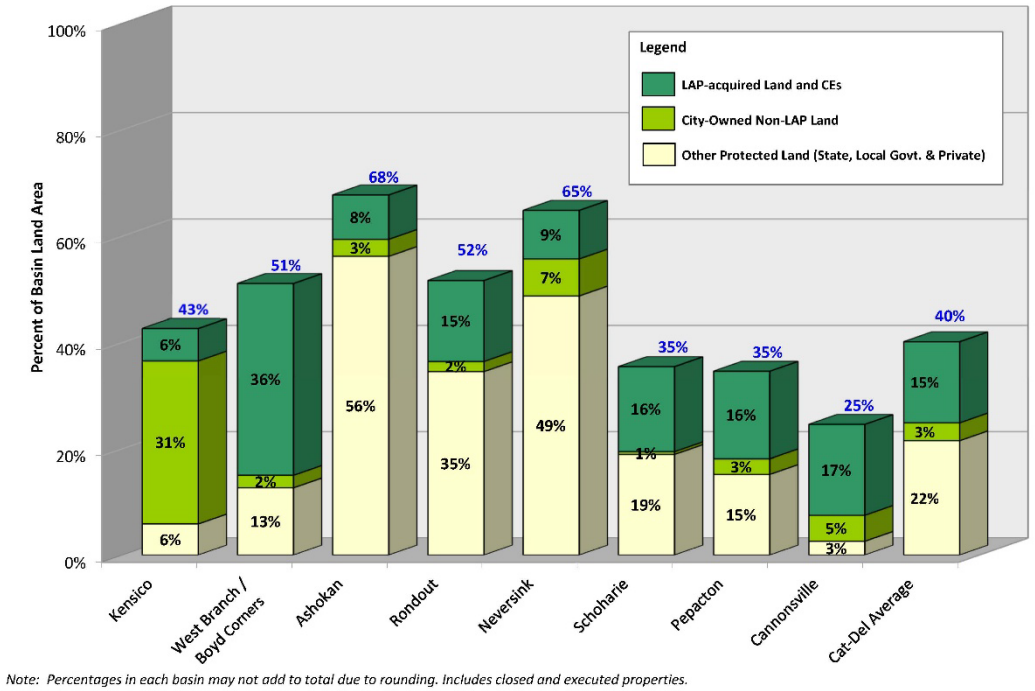


Figure 2.1 Protected lands by reservoir basin as a percentage of basin land area in the Catskill/Delaware watershed.

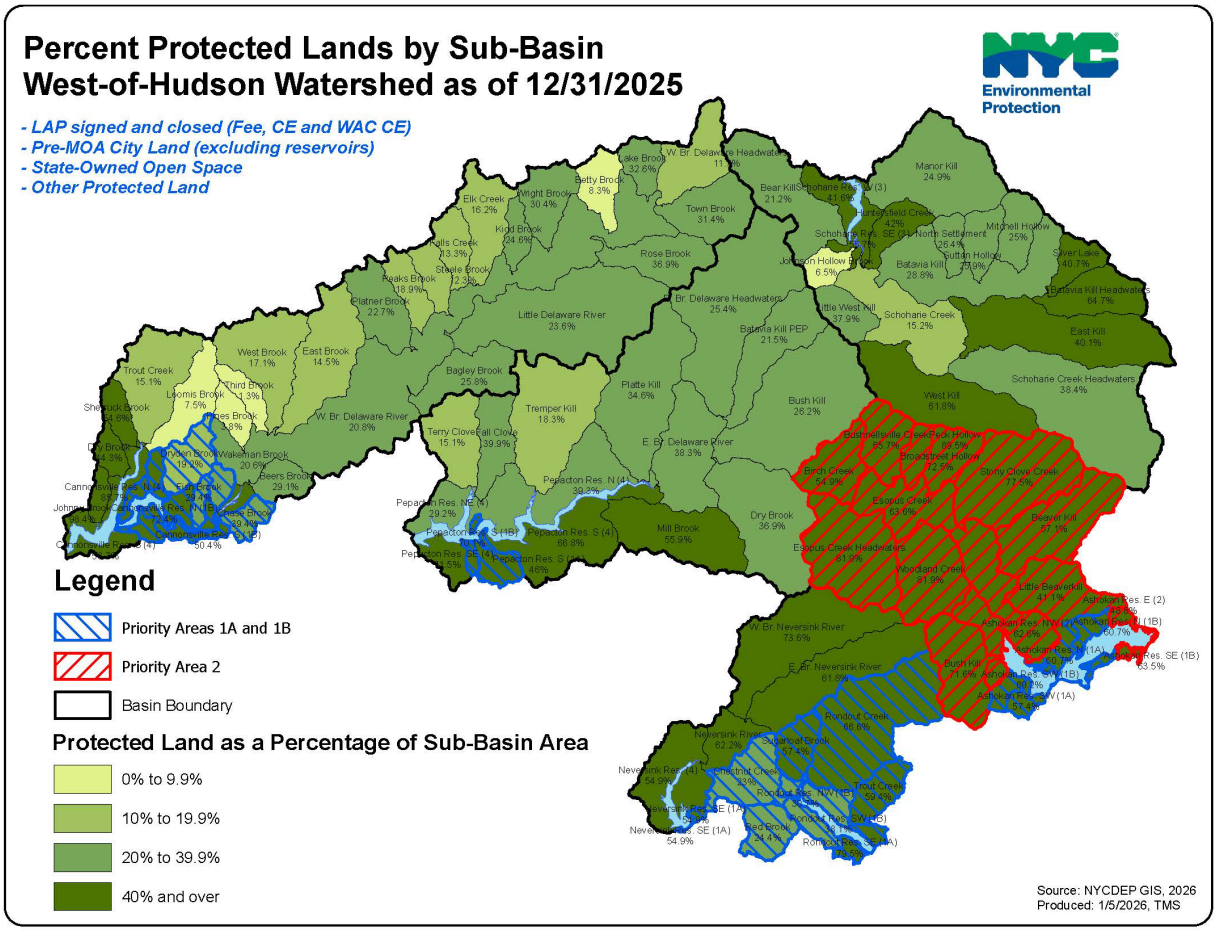


Figure 2.2 Percent protected lands by sub-basin for the WOH watershed.

the watershed, bringing DEP-owned or controlled land (including reservoirs) to 216,397 acres, or 21% of the watershed area. Including land protected by other government agencies and land trusts, 436,878 acres (40%) of the Catskill/Delaware watershed are now permanently protected. Figure 2.1 shows the percentage of land protected by basin, including land protected by the City, State and others as of December 31, 2025.

Figure 2.2 is a map showing the percentage of land protected by sub-basin, including land protected by the City, State and others in the WOH portion of the Catskill/Delaware watersheds.

As of December 31, 2025, DEP, including its partnership programs, has protected 216,397 acres. In all, properties protected under LAP initiatives have resulted in permanent protection of 630 miles of streams (one or both banks) and 39,992 acres of riparian buffers as shown in Table 2.1.

Table 2.1 Summary of riparian buffers (areas within 300-feet either side of a watercourse), length of streams, and floodplains within City-owned land and CEs in the Catskill/Delaware watersheds.

Type of City Ownership	% of Watershed Acres	Stream Length (miles)	% of Stream Miles	Riparian Buffer (acres)	% of Riparian Buffers	Flood-plains (acres)*	% of Flood-plains
City-owned (Pre-1997 & facilities)	5.8%	105	2.7%	6,878	2.7%	29,921	55.3%
LAP-acquired Fee	9.1%	385	10.1%	24,694	9.9%	2,072	3.8%
LAP-acquired CEs	2.5%	107	2.8%	6,701	2.7%	56	0.1%
SAP Fee Simple	0.0%	5	0.1%	223	0.1%	489	0.9%
NYCFFBO (City)	0.0%	1	0.0%	42	0.0%	1,376	2.5%
FEMA FBO (City)	0.0%	1	0.0%	41	0.0%	50	0.1%
WAC Farm CEs	2.8%	125	3.3%	7,749	3.1%	36	0.1%
WAC Forest CEs	0.3%	7	0.2%	542	0.2%	42	0.1%
Total	20.6%	735	19.2%	46,870	18.7%	34,042	62.9%

** "Floodplains" are defined as 100-year Floodplain, areas with a 1% annual chance of flooding, as extracted from published FEMA DFIRM data. Some Wetlands, Floodplains, and Riparian Buffers overlap with each other, so these acreages cannot be added together for a "total water feature" figure.*

2.2.2 Solicitation

The Revised 2017 FAD set a solicitation goal of 200,000 acres for the seven-year period 2018-2024 and required DEP to submit LAP solicitation plans biennially beginning October 2018. DEP previously reported that the FAD solicitation goal of 200,000 acres had been achieved in September 2024. Core LAP (the original program through which the City acquired fee simple lands and CEs as outlined in the 1997 MOA) solicited 103,022 acres and all partner programs solicited 100,064 acres, with applicable FAD acreage credits, for a combined total of 203,086 acres during 2018-2024.

Since 1997, DEP has solicited the owners of more than 481,000 acres in the watershed; re-solicitation of many of these properties has contributed significantly to acquisition gains. During the reporting period January 1, 2021 through December 31, 2025, Core LAP solicited

39,595 acres, the vast majority of which were re-solicitations. During this same period, partner programs were credited with soliciting 43,832 acres.

The current five-year FAD assessment period marks a time of programmatic refinement for LAP. The 2017 FAD required that DEP convene a NASEM Expert Panel to review and evaluate the City's watershed protection programs, including the LAP, and to make recommendations for improving certain programs. When the NASEM Expert Panel issued its final report in 2020, it recommended that the LAP's emphasis moving forward should be on the most valuable lands for water quality protection, with a particular focus on acquiring riparian lands on critical areas of tributary streams through the SAP and NYCFFBO. The NASEM Expert Panel also recommended that Core LAP reconsider its focus on acquiring larger parcels.

In response to these recommendations, DEP proposed additional modifications to Core LAP that were shared with watershed stakeholders in April 2021 and subsequently adopted to further refine Core LAP's selectivity of watershed properties in Priority Areas 2, 3 and 4. Specifically, DEP agreed to the following new criteria, which reduced available lands for Core LAP by more than 103,600 acres or 33%:

1. Increase surface water criteria (SWC) from 7% to 15% for parcels under 200 acres that are outside half-mile buffers around MOA-designated hamlet areas and adjoining City-owned lands;
2. Increase SWC from 15% to 20% for parcels under 200 acres that are outside half-mile buffers around MOA-designated hamlet areas and not adjoining City-owned lands; and
3. Increase SWC to 30% (from 7% or 15%) for parcels over 200 acres regardless of hamlet buffers and adjacency to City-owned land.

In accordance with the Revised 2017 FAD, in May 2023 DEP submitted its 2023-2033 Long-Term Land Acquisition Plan, which outlined the methods and strategies that DEP proposed to guide Core LAP and City-funded LAP partners to increase the percentage of permanently protected lands within specific WOH sub-basins and throughout the Catskill/Delaware watershed over the next ten years. At the time, DEP noted that due to uncertainties stemming from (a) stakeholder negotiations over the future of Core LAP and a potential expansion of the SAP, (b) the anticipated issuance of a new Water Supply Permit in 2025, and (c) the anticipated issuance of a new FAD in 2027, it was likely the 2023-2033 Long-Term Plan would need to be modified in the future.

In late 2024, in response to stakeholder negotiations, DEP committed to cease Core LAP acquisitions in Priority Areas 3 and 4, except in very limited cases as supported by a local municipality. The sub-basins where Core LAP may still acquire land in the WOH watershed, subject to individual parcels meeting eligibility requirements, are depicted in the red and blue hatched areas on Figure 2.2. In addition, DEP committed to not soliciting parcels in the expanded

Shokan Hamlet and identified adjacent parcels, removing an additional 835 acres from solicitation. These commitments have been incorporated into a Fourth Stakeholder Agreement.

2.2.3 Acquisition Activity

The LAP was much less active across all program areas during the five-year assessment period. Reduction in activity was due, in part, to the impacts of COVID-19 on the real estate market and program challenges that included budget drawdowns and pandemic-related program pauses. Across all acquisition programs, only 4,270 acres (72 contracts) were secured in signed purchase agreements for the current five-year assessment period compared with 16,357 acres (205 contracts) secured in the previous five-year period. Figure 2.3 shows the acres in executed contracts by year and program.

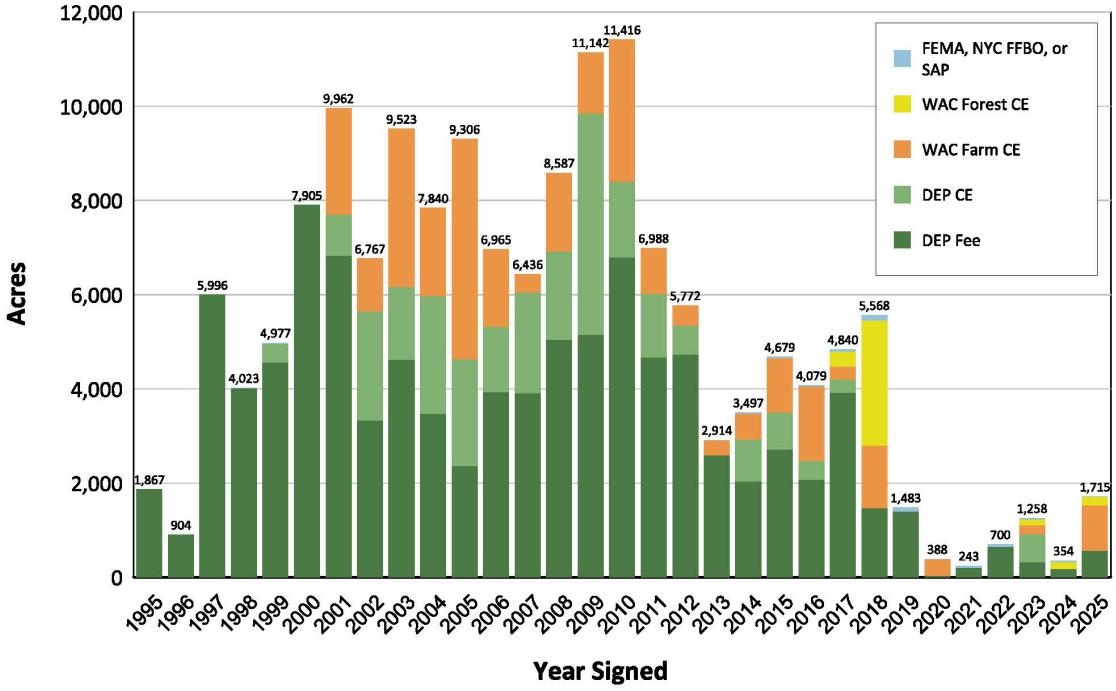


Figure 2.3 Acres in executed LAP contracts by year for the Catskill/Delaware watershed.

Situations arise in which a purchase contract must be rescinded due to a seller's inability or unwillingness to complete their obligations. Historically, problems that have resulted in rescissions included significant title defects, unresolvable encroachments, unsatisfied mortgages, and other such intractable issues. During the assessment period, rescissions also resulted from programmatic delays related to COVID-19. When a modestly sized project (flood buyout (FBO) or SAP) is rescinded, LAP's reported acres signed to contract do not change appreciably, but if a larger project is rescinded, then prior reported figures for acres signed to contract may create a noticeable difference between current and prior reports. During this reporting period, 1,112 acres were subject to rescinded contracts or otherwise went out of contract across all programs.

Core LAP

During the previous 5-year FAD assessment period (2016-2020), Core LAP executed 114 fee contracts (8,907 acres) and 3 CE contracts (685 acres). During the current assessment period (2021-2025), Core LAP executed only 32 fee contracts (1,919 acres) and one CE contract (586 acres). The purchase contracts executed in the current assessment period demonstrate greater emphasis on Priority Areas 1A, 1B and 2 than in the previous assessment period as reflected in Table 2.2.

Table 2.2 Summary of Core LAP fee contracts by Priority Area (PA) for both the prior and current FAD five-year assessment periods.

Period	PA 1A & 1B		PA 2		PA 3		PA 4	
	Contracts	Acres	Contracts	Acres	Contracts	Acres	Contracts	Acres
2016-2020	11	439	5	190	29	2,132	65	5,770
2021-2025	6	167	1	109	5	628	14	874

Although the number of Core LAP fee acquisitions was greatly reduced in the current assessment period, the percentage of SWC increased for projects advanced. Prior to 2020, properties acquired in fee simple by Core LAP averaged 28% SWC, while during the reporting period executed Core LAP fee projects have averaged over 47% SWC as set forth in Table 2.3.

Table 2.3 Surface Water Criteria (SWC) for executed Core LAP fee acquisition projects.

Year	Number of Contracts	Acres	SWC Acres	Avg. % SWC
2021	4	197	110	56%
2022	12	653	312	48%
2023	6	325	131	40%
2024	4	181	89	49%
2025	3	563	253	45%
Total:	29	1,919	895	47%

New York City-Funded Flood Buyout Program

This program allows for the acquisition of flood damaged or threatened properties with structures, after which the structures are removed and the properties are restored to a natural condition, thus mitigating the impacts of future floods. Properties may also qualify for the NYCFFBO if they are threatened by stream erosion, or if the land is needed for a flood hazard mitigation project, such as floodplain restoration or a new upsized bridge. The flood hazard mitigation goals of the NYCFFBO are managed locally, with properties to be acquired generally identified through the LFA process overseen by the SMP. To be considered for the NYCFFBO, a

town or village board must pass a resolution specifically endorsing acquisition of the property. Property-specific outreach is managed by outreach coordinators chosen by the municipalities, not the City, and the CWC manages the demolition of improvements after closings.

To date, 61 unique properties (183 acres) have been approved via municipal resolution for acquisition through the NYCFFBO, including projects in the LFA, Erosion Hazard, Inundation, and Stream Project categories. DEP has ordered appraisals on 53 of those 61 properties. Six of the properties with resolutions were not appraised due to lack of landowner interest, sale to another party, condemnation by the State for highway purposes, or lack of interest by DEP. For the 53 properties appraised, 39 contracts have been executed (74% of projects appraised) and 32 have closed (60%). Two contracts have been rescinded; one property was subsequently acquired by the CWC on behalf of the Town of Walton, and the other remains in private ownership. For the 32 closed contracts through the NYCFFBO, 19 have been acquired by local municipalities (59%) and 13 by the City (41%).

In total during the FAD assessment period, DEP ordered 17 original appraisals on NYCFFBO projects and signed contracts for 15 projects. In addition, four accepted offers, including three on municipal properties, are currently outstanding.

Since 2020, local municipalities have shown increased interest in ownership of properties acquired under the NYCFFBO. During the current FAD assessment period, 18 municipal resolutions were passed and 14 of those resolutions called for ownership by the local municipality. Twelve of the 15 projects (80%) closed within the reporting period were acquired by local municipalities. Table 2.4 shows details of acquisitions and ownership under the NYCFFBO. For the five active contracts yet to close, three will be acquired by local municipalities (60%) and two will be acquired by the City (40%).

Table 2.4 Summary of closed NYCFFBO contracts and final ownership.

	City-owned		Municipally-owned		Totals	
Period	Contracts	Acres	Contracts	Acres	Contracts	Acres
2014-2020	10	36	7	4	17	40
2021	1	4	4	3	5	7
2022	0	0	0	0	0	0
2023	1	4	3	13	4	17
2024	1	3	4	3	5	6
2025	0	0	1	1	1	1
Total	13	47	19	24	32	71

Overall, the NYCFFBO has proven to be an important tool that allows communities to carefully and proactively plan for flood hazard mitigation projects outside the stressful periods that immediately follow flood emergencies and between storm events, when a Federal

Emergency Management Agency (FEMA) program is not available to assist communities and landowners. DEP has worked with local municipalities to find creative contracting solutions under the NYCFFBO to allow those seeking to relocate critical community infrastructure out of floodplains to retain ownership of existing municipal lands.

During the assessment period, DEP received seven inquiries from WOH watershed communities related to using the NYCFFBO as a vehicle to assist with the potential relocation of critical community infrastructure. Several of these requests include the potential for relocation on Core LAP-acquired lands as provided for in the Revised 2017 FAD (referred to as "Swaps"). Core LAP-acquired lands are encumbered with a CE to NYSDEC which restricts development, therefore DEP and the communities have requested, but have not yet received, guidance from NYSDEC on how to address the NYSDEC CE restrictions. In the Fourth Stakeholder Agreement, DEP agreed to continue to collaborate with the WOH watershed communities and DEC to facilitate Swaps.

In December 2024, the first three CEs and accompanying baseline documentation for NYCFFBO properties acquired by municipalities were submitted to NYSDEC for review and filing. DEP is working with municipalities to complete baseline packages for CEs on the remaining 16 municipally owned properties.

Streamside Acquisition Program

Since 2015, DEP has funded the pilot SAP in the Schoharie Basin through a contract with the CCCD. During the current FAD five-year assessment period, DEP extended the contract with CCCD until December 2027 and increased the overall contract budget from $8 million to $13.4 million.

During this reporting period, 24 SAP projects were appraised, 16 projects were signed to contract (excluding two that were signed and later rescinded), and 17 projects consisting of 123 acres were closed. Since program inception, the SAP has closed on 38 contracts totaling 295 acres. Table 2.5 provides a summary of all SAP purchase contracts executed during the reporting period.

Starting in 2023, and continuing through June 2025 when DEP paused stakeholder negotiations, CCCD participated in stakeholder discussions on the development of a WOH watershed-wide Collaborative Streamside Acquisition Program (CSAP). At DEP's request deriving from the status of stakeholder negotiations at the time, CCCD paused solicitation in Priority Areas 3 and 4 (the entirety of the SAP pilot area) from fall 2024 until December 2025, when DEP provided CCCD with updated guidance for limited solicitation moving forward.

Table 2.5 Summary of executed SAP projects with SWC for the five-year period 2021-2025.

Year	Contracts	Acres	SWC Acres	Avg. % SWC
2021	4	42	35	84%
2022	4	34	29	87%
2023	4	17	14	84%
2024	3	30	20	68%
2025	1	3	3	84%
Totals	16	126	101	80%

In February 2025, the City registered a fourth amendment to the original SAP contract allowing CCCD to perform certain tasks related to the potential modification and expansion of the current SAP into a proposed CSAP. In December 2025, DEP and watershed communities executed a Fourth Stakeholder Agreement, which confirmed the City's intention to develop, fund and implement a new CSAP in the WOH watershed, with Delaware County communities retaining the option to participate. The Fourth Stakeholder Agreement allows the pilot SAP to continue acquiring properties on a scaled-back basis within the Schoharie Basin (except the Delaware County portion), but only if the local municipality approves the acquisition. CCCD continues to engage in discussions with local municipalities and Greene County Soil and Water Conservation District (GCSWCD) on how the pilot SAP might support community goals.

Watershed Agricultural Council Farm and Forest Easement Programs

DEP funds the Farm and Forest CE Programs through contracts with the WAC. To date, DEP has committed $149.7 million to WAC's acquisition and stewardship of farm and forest CEs. This total includes $85.5 million in prior contract commitments for the acquisition of farm and forest CEs, $43 million for the WAC CE Stewardship Endowment Fund, and $21.1 million in current contracts that registered in February 2025 to fulfill the Revised 2017 FAD funding obligations for both WAC CE programs. The Revised 2017 FAD requires DEP to provide $11 million to support the WAC Agricultural Easement Program and $8 million to support the WAC Forest Conservation Easement Program. To ensure adequate funding to continue both programs through the remainder of the FAD, NYSDOH approved in June 2024 a request to combine these two amounts into one $19 million fund for WAC to utilize for both Agricultural and Forest Conservation Easement Programs. This combined fund has allowed WAC sufficient funding to continue to administer and implement the programs, while also giving WAC greater flexibility to acquire CEs on the most compelling properties at any given time, regardless of whether they are agricultural or forest properties.

During the assessment period DEP, in consultation with WAC, convened a working group to explore the suitability of including pre-emptive purchase rights (PPR) within WAC

CEs. The findings of the workgroup concluded that WAC's CE program could potentially adopt a PPR component by modifying existing guidelines and model deed provisions. Should WAC proceed with implementing a PPR component with alternative funding, DEP committed to funding WAC staff time to implement the PPR component as well as using staff time as a match for any grant opportunities.

Between January 1, 2021, and December 31, 2025, WAC executed five contracts (1,126 acres) and closed on three contracts (538 acres) under the Farm CE Program (Figure 2.4). Since initiation, WAC has purchased 159 farm easements totaling 28,424 acres. It should be noted that during the assessment period two Agricultural CEs were reduced by a total of roughly 32 acres by local eminent domain proceedings in support of community driven projects relating to wastewater management and utility infrastructure. As of December 31, 2025, three executed contracts (971 acres) have not yet closed.

Figure 2.4 Huntersfield Christian Training Center - Farm Conservation Easement acquired by WAC in 2024 in the Town of Prattsville.

Between January 1, 2021, and December 31, 2025, WAC executed and closed on three contracts (446 acres) under the Forest CE Program. Since initiation, WAC has purchased 12 forest easements totaling 3,428 acres.

Table 2.6 summarizes all WAC CE Program accomplishments since 1997, in comparison to each year covered by the current FAD assessment period (2021-2025). Through 2022, there was a significant slowdown in program activities due to various challenges, since resolved, including COVID-19 and an organizational restructuring of WAC's internal leadership. More recently, program activity has begun to increase.

Table 2.6 Summary of executed contracts for the WAC Farm and Forest CE Programs.

	Farm CEs		Forest CEs		Total WAC CEs	
Period	Contracts	Acres	Contracts	Acres	Contracts	Acres
1997-2020	157	28,229	9	2,982	167	31,211
2021	0	0	0	0	0	0
2022	0	0	0	0	0	0
2023	2	195	1	128	3	323
2024	0	0	1	142	1	143
2025	3	971	1	176	4	1,147
Total	162	29,395	12	3,428	175	32,823

2.2.4 Water Withdrawal Permit

As required by the 2017 FAD, DEP submitted an application to NYSDEC in June 2022 for a ten-year Water Withdrawal Permit (WWP) to succeed the 2010 Water Supply Permit (WSP). DEP's application was updated in December 2024 with additional supporting documents required by NYSDEC. In November 2025, NYSDEC issued a Notice of Complete Application along with a draft four-year renewal of the City's 2010 WSP containing myriad conditions which were unrelated to the City's application or inconsistent with stakeholder negotiations. In December 2025, after a 30-day public comment period, NYSDEC formally issued a four-year renewal of the City's 2010 WSP that extends all prior authorizations for the LAP, including the pilot SAP, NYCFFBO, and WAC CE Programs, through December 24, 2029.

2.2.5 Transfer of CEs to NYS

In accordance with Paragraph 82 of the 1997 MOA, the City is required to grant a CE to the State of New York on all properties acquired by the City in fee simple as part of the LAP. DEP bundles multiple acquisition projects into combined easements by geographic regions within each county to facilitate stewardship by NYSDEC of individual CEs. DEP works closely with NYSDEC and the NYS Attorney General's Office on this process.

To date, DEP has conveyed a total of 83 CEs to NYSDEC, covering 1,093 fee simple properties acquired by Core LAP totaling 72,834 acres. Eighty-two of the recorded CEs

encumber lands within the Catskill/Delaware watershed covering 1,077 properties and 71,653 acres. DEP continues to participate in discussions with NYSDEC and watershed stakeholders regarding CE modifications that will allow for certain land uses compatible with water quality protection. Until these modifications are finalized and approved by NYSDEC, DEP has deferred the conveyance of additional CEs on Core LAP fee lands.

2.3 Land Management

DEP continues to focus on the management and stewardship of City-owned water supply lands and CEs, while supporting and promoting beneficial uses of City-owned lands, such as recreation, agriculture (through the issuance of agricultural licenses), and other regional and community needs (through the issuance of Revocable Land Use Permits).

2.3.1 Fee Simple Lands and Conservation Easements

As of December 31, 2025, DEP managed 181,763 acres of City-owned water supply lands and reservoirs in nine counties north of New York City; this includes 175,052 acres of fee simple lands within the watershed, which are largely comprised of pre-MOA lands, reservoirs, and newer fee simple properties acquired through the LAP. The average sized parcel acquired by the LAP was 43 acres. The largest contiguous assemblage of City-owned lands acquired by the LAP is 2,922 acres. As the City acquires new, smaller properties under the Flood Buyout Program and Streamside Acquisition Program, these lands are often isolated from other City-owned parcels and typically involve active neighbors; both factors contribute to property management challenges.

Fee Land Property Inspections

DEP inspects all City-owned water supply lands pursuant to its Fee Land Monitoring Policy. All City-owned lands are posted with appropriate signage, and all properties receive a comprehensive boundary inspection at least once every five years. These inspections include traversing all property boundary lines to ensure proper survey monumentation and maintenance of boundary lines over the long term. DEP records all property inspections and site visits, including encroachments, in its Watershed Lands Information System (WaLIS) database.

Annually, DEP prioritizes ground inspections of properties into two categories (“High” and “Standard”) based on location, number of adjacent properties, uses conducted on the property, and history of trespass or encroachments. “High Priority” properties generally have active recreational use, a history of encroachments or trespass, multiple adjacent landowners, or an active DEP permit/project. “Standard Priority” properties are those where minimal or no trespass or encroachments have been observed, or road frontage and/or public use are limited. DEP performs “Focused Inspections” on all High Priority properties, while “Site Visits” are conducted on Standard Priority properties. Focused Inspections are significantly more involved than Site Visits. DEP may change a property’s inspection priority at any time depending on the circumstances, such as the discovery of an encroachment.

Fee Land Encroachments

DEP strives to cure encroachments when they are discovered on City-owned lands. Fee land encroachments are typically identified during monitoring. Once an encroachment is identified and categorized as low, standard or high, DEP internally determines whether the encroachment can be managed as an administrative action or needs to be addressed via a criminal citation or as a violation under NYS Environmental Conservation Law. Low and standard level encroachments typically include mowing, trash, debris and the presence of minor or temporary structures; high level encroachments typically involve permanent structures and often require remediation or restoration of affected lands. Most encroachments are managed by DEP as administrative actions.

Between January 1, 2021, and December 31, 2025, DEP identified a total of 325 new encroachments on City-owned lands (Table 2.7), 309 of which were categorized as low or standard. During the same period, DEP successfully cured 122 encroachments. Encroachment resolution remains an ongoing activity, and it is important to note that encroachments identified in one year may not get resolved within the same year.

Table 2.7 Number and type of encroachments identified, and number cured, during 2021-2025.

Year	2021	2022	2023	2024	2025	Total
Low	6	21	66	20	3	116
Standard	28	38	54	32	41	193
High	4	9	1	2	0	16
Total	38	68	121	54	44	325
Cured	6	32	24	32	28	122

Conservation Easements

As of December 31, 2025, the City held 178 CEs on private properties totaling 26,665 acres throughout the Catskill, Delaware, and Croton watersheds. To ensure the conservation purposes of these CEs are maintained, DEP monitors each CE property twice a year, comprised of one ground inspection and one aerial inspection. Digital photographs of possible violations are taken during spring aerial monitoring conducted by the DEP police via helicopter; any potential violations identified via aerial monitoring are followed up with post-flight field inspections. The entire portfolio of CE properties can be monitored in three to four days by aerial monitoring. Ground monitoring generally occurs in the summer and fall, with larger, individual CEs often taking several days to complete.

Landowner outreach is a critical component of CE stewardship. As such, DEP continually engages CE landowners to educate them about the terms and conditions of their deed of CE, particularly as it relates to any upcoming plans or proposed activities on their CE encumbered properties. While certain activities are prohibited under the terms of the CE, other

activities may require notice to, or approval by DEP. During the reporting period, DEP received and reviewed an average of 10-12 activity requests annually that required DEP approval; the most common activities included timber harvests, stream work, utility installation, agricultural activities, and the installation of accessory structures. DEP approval typically includes conditions or requirements, including the implementation of BMPs, to ensure the proposed activity will not negatively affect water quality or the conservation purposes of the easement. Once DEP approves a CE activity, the approval is usually valid for two to five years, depending on the extent of the activity. DEP monitors these approved activities to ensure compliance with the terms and conditions of the approval.

In addition to activity requests, CE grantors are required to notify DEP of any sale or transfer of their CE encumbered properties to new owners. During the reporting period, an average of five DEP CE encumbered properties were either sold or transferred annually; once DEP learns of an encumbered property being conveyed, DEP engages the new property owners to ensure they are familiar with the terms and conditions of the CE deed.

Despite education and outreach efforts, minor technical violations may occur when a landowner does not understand the terms and conditions of the CE. During the reporting period, DEP identified an average of two technical violations per year. Working with CE grantors, DEP was generally able to resolve these violations within a year. No major violations occurred during the reporting period.

2.3.2 Watershed Recreation

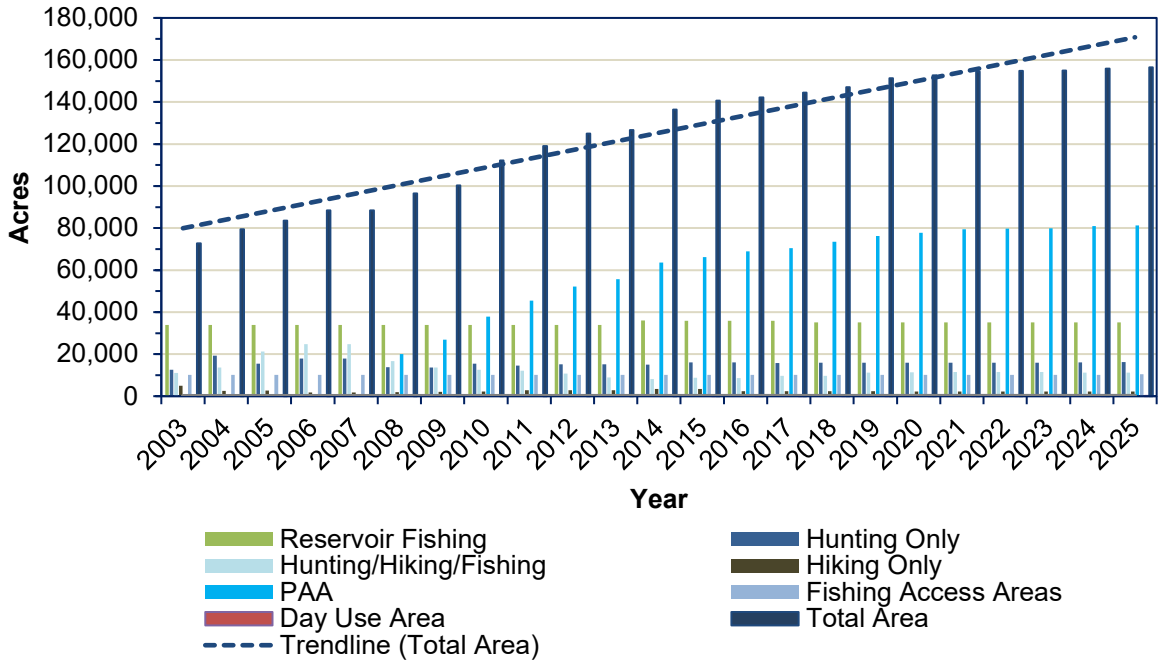
DEP administers recreational activities on City-owned lands pursuant to Chapter 17, Title 16 of the Rules of the City of New York, the "Rules for the Recreational Use of New York City Water Supply Lands and Waters". Over the past five years, DEP continued to support and enhance low-impact recreational uses of City-owned watershed lands and waters across 19 reservoirs, two controlled lakes, and thousands of acres of land. DEP remains committed to expanding recreational access where compatible, improving recreational infrastructure, and collaborating with watershed partners on recreational projects that support and/or improve access to City-owned watershed lands in a manner consistent with long-term water quality protection.

Recreational Lands Access and Acreage Expansion

As of December 31, 2025, DEP managed a total of 156,616 acres of watershed lands and reservoirs open for recreational use. This included 81,305 acres of Public Access Areas (PAAs), 29,670 acres of Access Permit Areas (APAs), 135 acres of Day Use Areas (DUAs), 35,086 acres of reservoirs, and 10,419 acres of pre-MOA reservoir shoreline (Figure 2.5). PAAs allow hunting, hiking, fishing, and trapping without a DEP access permit, while APAs require a valid access permit for activities such as fishing and hunting, as well as hiking in select areas. DUAs allow for activities such as walking and picnicking without a permit and are typically located

adjacent to reservoirs. During the reporting period, DEP converted several APA properties to PAAs to expand permit-free recreational opportunities.

Figure 2.5 Acreage and categories of City-owned lands and reservoirs opened for public recreation since 2003.



Boundary and Acreage Mapping Adjustments

In 2025, DEP updated the mapping of reservoir recreation boundaries after finding an internal GIS data discrepancy. As part of this mapping update, several small areas of land that had been previously classified as reservoir acreage were reclassified as City-owned land and incorporated into the recreational access inventory. Likewise, a limited number of areas that were formerly reported as land were reclassified as reservoir water, based on improved spatial data. These adjustments resulted in minor changes to previously reported acreages for PAAs, APAs, reservoir acreage, and pre-MOA shoreline. The acreage presented in Figure 2.5 for the five-year period includes these corrected 2025 GIS boundary updates.

Boating Access and Reservoir Recreation

DEP continued to support the use of fishing boats on water supply reservoirs throughout the five-year reporting period. Individuals are permitted to use fishing boats on City-owned reservoirs pursuant to DEP's Recreation Rules after registering their vessels and obtaining a DEP boat tag. All boats are required to be steam cleaned before storage and must remain on their assigned reservoir within designated boat storage areas once a tag is issued. Boat owners are required to renew their registrations every four years.

Between 2021 and 2025, DEP issued a total of 2,662 new fishing boat tags and processed 15,940 boat tag renewals, reflecting steady participation in reservoir-based fishing across the watershed. In 2025, DEP issued 479 new fishing boat tags and renewed 3,398 expiring tags. As of December 31, 2025, DEP maintained a permitted fishing boat inventory of 15,568 boats stored across the Catskill, Delaware, and Croton reservoir systems. DEP limits the number of allowable boats per reservoir.

DEP's recreational boating program, administered in partnership with the CWC allows for seasonal use of kayaks or canoes on Cannonsville, Pepacton, Neversink, and Schoharie reservoirs. The recreational boating season runs between May 1 and October 31. During the reporting period, a total of 6,460 recreational boaters participated in this program, including 2,608 users who registered privately owned canoes and kayaks that remained stored at designated areas along reservoirs during each season. Additionally, 3,852 day-use visitors rented recreational boats from certified local vendors. Since the program started in 2019, nearly 20,000 recreational users have utilized the program for paddling on City reservoirs.

DEP continues to issue access permits that allow access to recreational lands on City-owned lands immediately adjacent to reservoirs, designated as APAs. During the reporting period, DEP issued 40,066 new access permits and processed 93,299 renewals. Access permits allow individuals to engage in hunting, fishing, boating, and hiking on APA designated lands near the reservoirs.

Rail Trails, Hiking Trails, and Other Public Uses

DEP continues to coordinate with Ulster County and other partner organizations to manage and enhance recreational trail opportunities throughout the watershed. During the reporting period, the Ashokan Rail Trail (ART) in Ulster County remained one of the most heavily used recreational assets on City-owned lands, with annual visitation ranging between roughly 140,000 and 170,000 users per year. DEP monitored recreational use of the ART through trail counters installed at each of the three trailheads and worked closely with the Woodstock Land Conservancy and Ulster County volunteer stewards to enforce trail rules and educate recreational users during peak use periods.

Additionally, DEP advanced several significant trail projects that enhanced public access over the five-year reporting period. In partnership with the Hunter Area Trail Coalition, DEP continued work on the Hunter Branch Rail Trail, completing a new section and pedestrian bridge while advancing an ADA-accessible segment. DEP also supported the ongoing use of 17 designated hiking trails on City-owned watershed lands totaling approximately 67 miles, while an additional 4.4 miles of trails are in development, including the Morris Hill Trail in Arkville and the Huntersfield Creek Trail extension in Prattsville, which will connect the popular Pratt Rock Trail to the Waterfall Loop Trail.

During the reporting period, DEP collaborated on a major regional ecotourism project with Delaware County and the Friends of the Bramley Mountain Fire Tower by permitting the

reconstruction and reopening of the historic Bramley Mountain Fire Tower on City-owned lands in Delhi. Since the tower's opening in 2025, there has been a significant increase in the number of hikers using the Bramley Mountain Trail, with counters installed near both trailheads recording 5,719 visitors for the period January 1, 2025, to November 1, 2025. Between June 1, 2025, and August 31, 2025, these trail counters recorded 2,217 hikers, a substantial increase compared to the 844 hikers recorded over the same time period in 2024.

Guide Permits

Throughout the five-year reporting period, commercial guide activity remained a consistent and growing component of DEP's recreational program. DEP issues guide permits only to active, NYS state-licensed guides, who are allowed to bring clients onto City-owned lands and reservoirs for hunting, fishing, hiking, and other low-impact recreational uses. At the beginning of the reporting period, there were 47 active guide permits; by the close of the period, the number had increased to 57 active permits. Guides continue to play an important role in promoting stewardship and enhancing public use of recreational lands and waters, particularly during peak fishing and hunting seasons. The gradual increase in commercial guide participation reflected broader trends in outdoor recreation and reinforced the value of commercial recreation professionals who promote good stewardship practices and safe use of watershed lands to the benefit of local economies.

Letters of Permission Program

DEP continued to provide expanded recreational opportunities for organized, low-impact recreational users of City-owned lands through the implementation of its Letter of Permission (LOP) program, which began in 2022. This program provides authorization for schools, community groups, conservation organizations, youth programs, and research partners to conduct activities that are otherwise not open to the general public under DEPs Recreation Rules, but are allowed with written permission by DEP, as long as the activities are compatible with water quality protection and serve a public purpose.

During 2022-2023, DEP issued nine LOPs each year for group educational outings, youth hunting programs, natural resource investigations, and structured hiking activities. In 2024, DEP issued 10 LOPs, supporting a range of activities that included environmental education, field-based learning, and community recreation events. In 2025, DEP issued eight LOPs. Over the five-year period, DEP issued a total of 36 LOPs to support enhanced recreational activities and events on City-owned watershed lands.

Deer Management and Hunting Access

DEP continues to support regulated hunting as a longstanding recreational activity and an important deer management tool on City-owned watershed lands, consistent with DEP's Recreation Rules. During the reporting period, public hunting access remained available on most PAA and APA lands during NYS regulated hunting seasons, thereby allowing NYS licensed

hunters to help DEP manage deer populations across the watershed in support of long-term forest health and ecological resilience.

DEP participated in the NYS Deer Management Assistance Program (DMAP) throughout the five-year assessment period to address localized concerns related to deer abundance and forest impacts. Between 2021 and 2025, DEP implemented DMAP on 12 to 16 City-owned properties annually, with the program expanding from 12 enrolled parcels during 2021–2023 to 16 parcels in both 2024 and 2025. Over the five-year reporting period, DEP issued a total of 2,343 DMAP tags, resulting in 367 documented harvests of antlerless deer.

DEP also supported community-based hunting and educational programs during the reporting period, including group hunting activities authorized through the LOP program. These efforts contributed to hunter recruitment and retention, strengthened community partnerships, and maintained public engagement related to responsible wildlife management on watershed lands.

2.3.3 Land Use Permits and Agricultural Licenses

Land Use Permits

Pursuant to Chapter 17, Title 15 of the Rules of the City of New York, the "Rules for the Issuance of Revocable Land Use Permits for the Occupation or Use of City Property", DEP issues five-year revocable land use permits (LUPs) to qualified entities, where the proposed use is compatible with DEP's land management priorities and no appropriate alternative exists. Terms and conditions of individual LUPs are intended to ensure protection of water quality as well as City-owned property, assets, and infrastructure. As of December 31, 2025, DEP managed 1,204 active LUPs (Table 2.8). During the five-year reporting period, DEP issued an average of 26 new LUPs per year while renewing an average of 213 LUPs per year, and amending an average of four LUPs per year

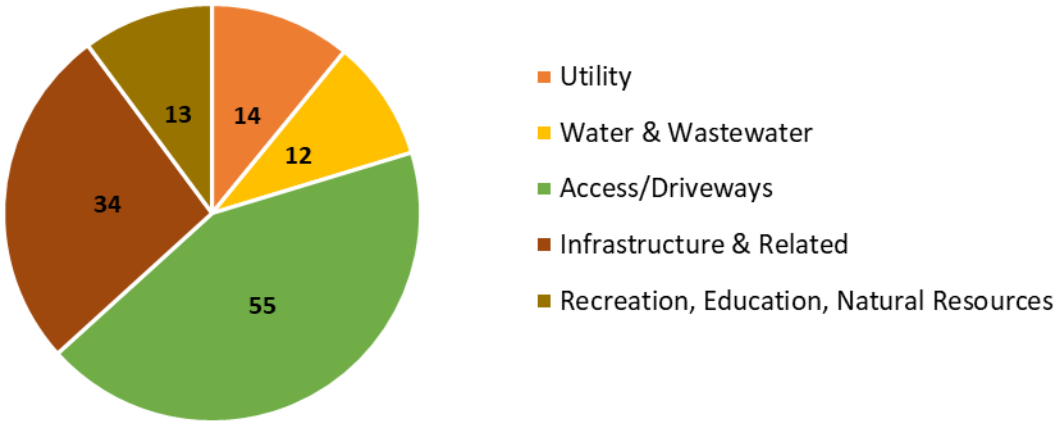
Table 2.8 Number of new land use permits issued and renewals/amendments of existing permits during 2021-2025.

Year	2021	2022	2023	2024	2025
New Permits	29	27	35	22	15
Permit Renewals	720	61	72	143	69
Amended Permits	7	3	5	3	4
Total	756	91	112	168	88

Although LUPs can only be issued for no more than a five-year period, they may be renewed as long as the permittee remains compliant with the LUP terms and conditions. Most LUPs with utility companies are processed in batches, leading to spikes in renewals, as seen in 2021. The most common purposes of new LUPs during the reporting period were for residential and commercial driveway access, municipal infrastructure projects, and utilities (Figure 2.6).

As of December 31, 2025, utility companies made up the largest number of active LUPs, with 739 active utility permits maintained for gas, electric and telecommunications infrastructure, followed by LUPs maintained by municipalities for critical municipal infrastructure projects, which totaled 249 (Figure 2.7). As of December 31, 2025, there were 48 active LUPs for recreational purposes, such as trail maintenance and kiosks, spanning several non-profit groups as well as state and local governments.

Figure 2.6 Total number of new LUPs issued between 2021 and 2025 by purpose.



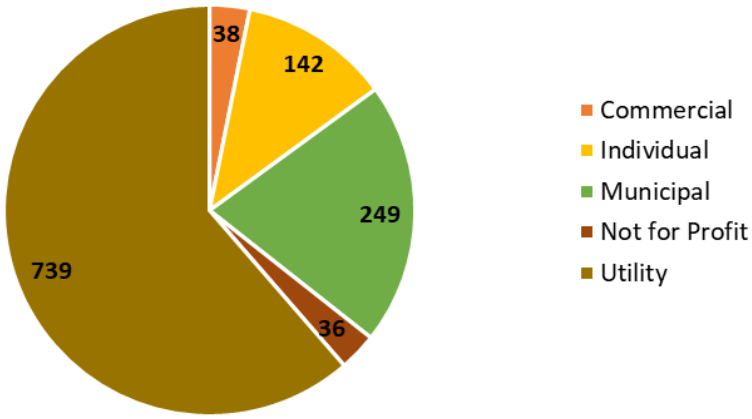


Figure 2.7 Total number of active LUPs (1,204) by Permittee Class.

Agricultural Uses

DEP continues to allow for a range of agricultural uses and activities on certain City-owned properties by awarding agricultural licenses to watershed farmers through a competitive bidding process. As of December 31, 2025, DEP managed 124 active agricultural licenses covering 2,933 acres of City land. Table 2.9 depicts the number of new licenses awarded by year, as well as active licenses renewed, during the five-year reporting period.

Table 2.9 Summary of Agricultural License activity during 2021-2025.

Year	2021	2022	2023	2024	2025	Total
New Licenses	2	4	0	2	4	12
Renewals	31	17	20	11	33	112
Total Active Licenses	140	135	131	127	124	n/a

Agricultural licenses are issued for five-year terms and may be renewed for an additional five-years upon completion of the renewal process by the licensee. For some new licenses, awards are made in one calendar year, but the license may not be executed until the following year. For example, DEP competitively awarded seven new licenses at the end of 2025, but those licenses will not be executed until 2026. Due to staffing shortages, DEP did not issue any new agricultural licenses in 2023.

The most common agricultural use on City land is the harvesting of hay, but other common uses include the planting and harvesting of row crops, and the pasturing of livestock. Figure 2.8 shows the total number of active agricultural licenses by year and by use.

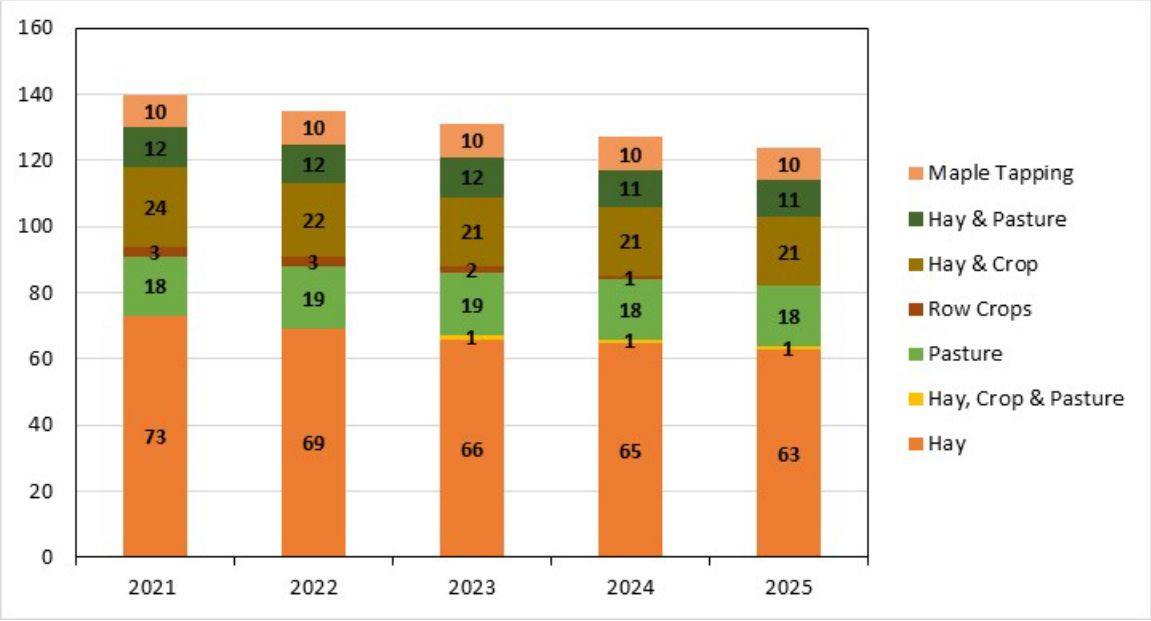


Figure 2.8 Total number of active agricultural licenses by year and by use.

Most farmers with agricultural licenses are enrolled in the WAP and use BMPs adapted for use on City-owned lands. Over the years, in collaboration with the WAC, DEP has allowed for the implementation of certain BMPs on City lands, including application of nutrients pursuant to a nutrient management plan, planting of cover crops, and the installation of fencing and watering systems to support rotational grazing of livestock. Licensees are required to follow the terms and conditions of the license, which requires a minimum 35-foot riparian buffer along watercourses to protect water quality. DEP remains committed to maintaining historic agricultural lands and keeping those lands available for the benefit of the agricultural community and local economies.

2.4 Watershed Agricultural Program

2.4.1 Introduction

The WAP reduces the risk of agricultural pollution through the development of Whole Farm Plans (WFPs) and the implementation of BMPs, along with the establishment of riparian buffers through the federal Conservation Reserve Enhancement Program (CREP). The WAP is funded by DEP and administered by the WAC in partnership with Delaware County Soil and Water Conservation District (DCSWCD) and Cornell Cooperative Extension of Delaware County (CCEDC), along with technical support from the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA). In 2025, federal-level changes resulted in NRCS withdrawing its dedicated WAP staff and the associated responsibilities were transitioned to WAC.

During this assessment period, WAC experienced two primary programmatic challenges. The first involved financial and contract management issues, compounded by turnover among key WAC personnel and the simultaneous reassignment of a new DEP program management team. These challenges led the DOI to place WAC under a Monitor Agreement. In response, WAC, in coordination with DEP, implemented measures to improve financial and contract management, strengthen staffing, and enhance program oversight. As a result of these corrective actions and the adoption of new policies and procedures, DOI granted WAC early release from the Monitor Agreement, concluding that WAC had met all requirements and could fulfill its obligations independently. This renewed partnership between DEP and WAC led to the successful negotiation and registration of three new contracts: A ten-year $167,000,000 Operating Contract, a five-year $53,900,000 Agricultural, Forestry and EV Program Contract, and a three-year $7,317,753 Watershed Farm and Forest Conservation Easement Program Contract.

The second programmatic challenge concerned the administration of the BMP “Backlog List.” During 2016 strategic planning, DEP and WAC identified a $31 million backlog of BMPs with existing WFPs pending implementation. The 2017 FAD officially formalized this list. Although the list initially comprised 1,410 BMPs, WAC and DEP later expanded it to account for 1,606 Component BMPs.

As required by the 2017 FAD, DEP tasked WAP with designing, encumbering, and scheduling at least 50% of all priority BMPs (Categories I-VI) identified as of January 1, 2017 for implementation within a two-year window, as well as implementing 60% New and 70% Repair and Replacement (R&R) Backlog BMPs by the end of 2022. While intended to create a sustainable implementation strategy, several challenges hindered meeting this deliverable, including temporary funding cessation, staff turnover, and the COVID-19 pandemic.

The Revised 2017 FAD included the requirement to implement new priority BMPs on active participating farms with WFPs, with the dual goals of reducing the existing backlog of new priority BMPs and limiting the potential backlog for newly identified BMPs. DEP tasked WAC with designing, allocating project funding, and scheduling for implementation within a 3-year timeframe at least 50% of all BMPs within pollutant categories I-VI that were identified in the January 1, 2017 Backlog List, with a final implementation deadline of June 30, 2023. This goal was aimed towards implementing all viable BMPs if and until alternative recommendations for BMP implementation metrics (to be informed by the June 30, 2024 metrics report) were approved by NYSDOH.

By June 30, 2023, the WAP satisfied the Revised 2017 FAD BMP requirements to design, fund, and schedule 50% of both New and R&R BMPs from the 2017 Backlog List by implementing 55.3% of New and 80.1% of R&R Backlog List BMPs. Although the program met these deliverables, it became clear during the assessment period that there were unintended consequences of focusing the program on the Backlog List. DEP expressed concern that the program's emphasis on design outpaced its implementation capacity, creating a secondary backlog of pending BMPs that contradicted the FAD goal of increasing implementation and further delayed effective resource management. Reliance on a fixed, multi-year backlog list also stalled new farm enrollments and prevented BMPs from re-prioritization to meet changing agricultural needs and water quality concerns. Shifting farm operations and participant status drove high deletion rates of planned BMPs, demonstrating how quickly farm changes can make a fixed implementation list obsolete. Overall, the Backlog List functioned more as an administrative tracker of workload and funding than a direct measure of water quality or economic impact. By focusing strictly on completion rates and a static 2017 Backlog list, the program struggled to account for regulatory or emerging environmental challenges, ultimately creating an inequitable system that prioritized participant timing over real-time resource concerns.

The 2024 WAP Metrics Assessment, which formally closed out the Backlog List, recommended that WAC transition from fixed, multi-year implementation lists to an agile annual or bi-annual prioritization model, allowing for greater flexibility and responsiveness to evolving needs and conditions. The report also set a three-year timeframe for the implementation of all BMPs that had completed designs as of June 30, 2023 per the Revised 2017 FAD deliverable, which consists of 574 BMPs, of which all viable ones are to be implemented by June 30, 2027. While not a Revised 2017 FAD deliverable, the implementation of this “BMP Implementation

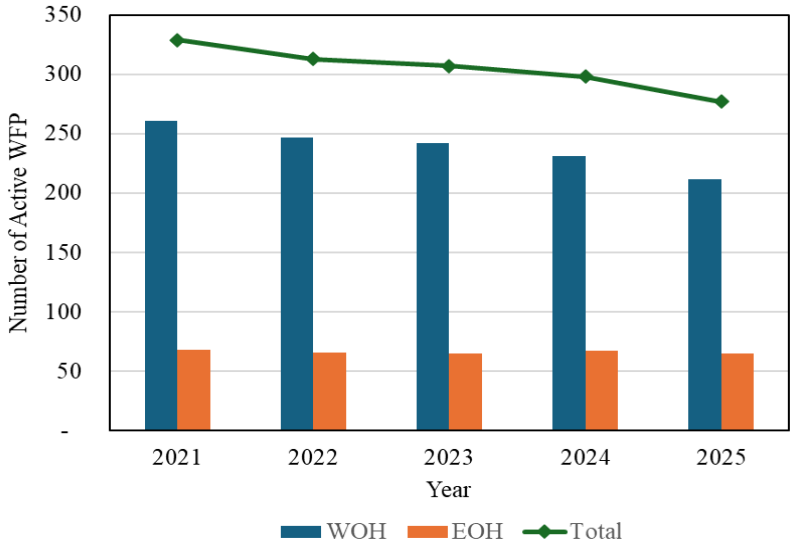
List" is included in WAC's current Agricultural, Forestry, and EV Program Contract with DEP. The WAP Metrics Assessment also recommended that WAC ensure BMPs only advance to the design phase if they can realistically be implemented within three years.

During the 2023 through 2025 period, WAC, in coordination with DEP, conducted a comprehensive reconciliation and verification of program data, resulting in refinement to cumulative BMP implementation reporting, as reflected in this five-year assessment.

2.4.2 Whole Farm Planning

Whole Farm Planning is a holistic approach to farm management used to identify and prioritize environmental issues on a farm without compromising its business. Through careful structural planning, the program identifies and addresses potential risks to the water supply to reduce or avoid the transport of agricultural runoff. The WAP has solidified its role as a key steward of water quality through the development of a cumulative total of 480 Whole Farm Plans (WFPs) since the program began in 1992 with the first 10 pilot farms. This cumulative total represents years of sustained outreach and partnership, consisting of 396 plans in the WOH watershed and 84 in the EOH watershed. At the end of 2025, 277 WFPs remained active; 212 WOH and 65 EOH. The total number of WFPs decreased by 19% over this assessment period, with a peak of 329 in 2021 (Figure 2.9). This assessment period saw 44 inactive WOH farms retired, 14 moved to inactive-ineligible status, and six new WFPs added. Currently, WAP monitors 16 active WOH farms under an ineligible status due to maintaining fewer than five animal units. WAC anticipates developing two new WFPs within the next 12 months.

Figure 2.9 Number of active WFPs, both EOH and WOH, from the years 2021 through 2025.



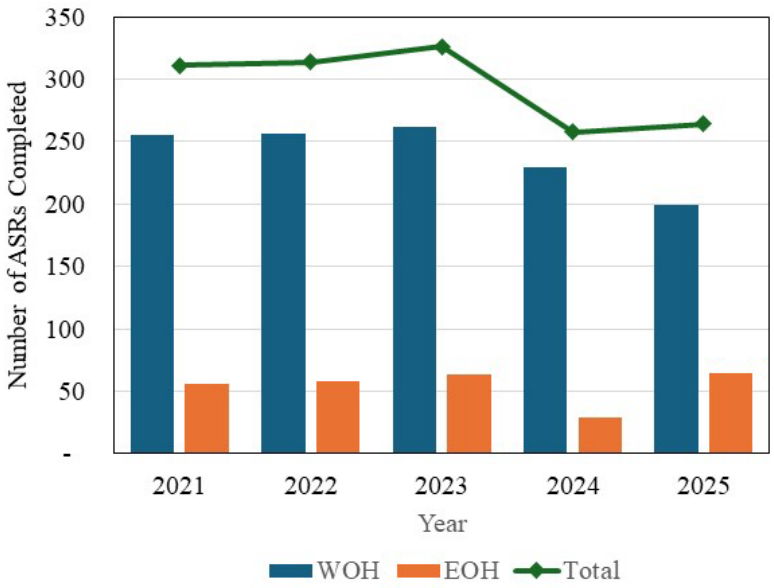


Figure 2.10 The number of ASRs conducted EOH and WOH for the years 2021 to 2025.

Oversight is required to ensure WFPs are being followed correctly. This happens during Annual Status Reviews (ASRs), where WAP staff conduct an annual evaluation of BMP functionality and effectiveness. Discussions between WAP staff and farm owners are used to evaluate the plan's performance and identify operational changes that may impact future goals. This process includes inspecting existing BMPs for durability, ensuring adherence to operation and maintenance agreements through routine repairs, and scheduling any outstanding BMPs. Ultimately, the ARS measures landowner satisfaction while assessing the plan's overall impact on the efficiency of the farm's operations. During this assessment period, WAC has completed 1,473 ASRs, with 1,201 conducted WOH and 272 EOH. The EOH team saw a slight decline in the number of ASRs completed in 2024 due to staff vacancies but rebounded above 90% in 2025 with 100% of the ASRs completed (). In this assessment period, the WAP achieved a 94% annual average completion rate for WOH farms, consistently outperforming the FAD requirement of 90%. WFP design is an iterative process, with 344 plan revisions (286 WOH and 58 EOH) completed over the past five years to maintain alignment between environmental strategies and changing farm operations.

2.4.3 Best Management Practices Implementation

Best Management Practices are conservation practices meant to prevent or reduce the amount of pollution generated by nonpoint sources (in this case, agriculture) to protect and enhance water quality (Figure 2.11). Many of the BMPs used in the WAP are standard practices established by the USDA NRCS. The WAC also develops and implements its own innovative BMPs based on scientific research and field experience. For watershed farms, the implementation of BMPs remains the WAP's most significant investment. During this

assessment period, 1,113 BMPs were implemented, 1045 WOH and 68 EOH, representing a five-year investment total of $17,655,579. The total includes 720 structural BMPs (572 WOH and 49 EOH) and 181 R&R BMPs WOH at a cost of $3,474,744 (Figure 2.12). Collectively, these efforts account for a cumulative program total of 8,906 implemented BMPs (8,069 WOH and 837 EOH), representing a total investment of $80,371,745, including $72,469,459 for WOH and $7,902,286 for EOH. In 2026, the WAP anticipates implementing an additional 200 BMPs WOH at an estimated cost of $6,000,000 and 38 BMPs EOH at a cost of $888,556. During the assessment period, EOH implemented 29 no-cost management BMPs.

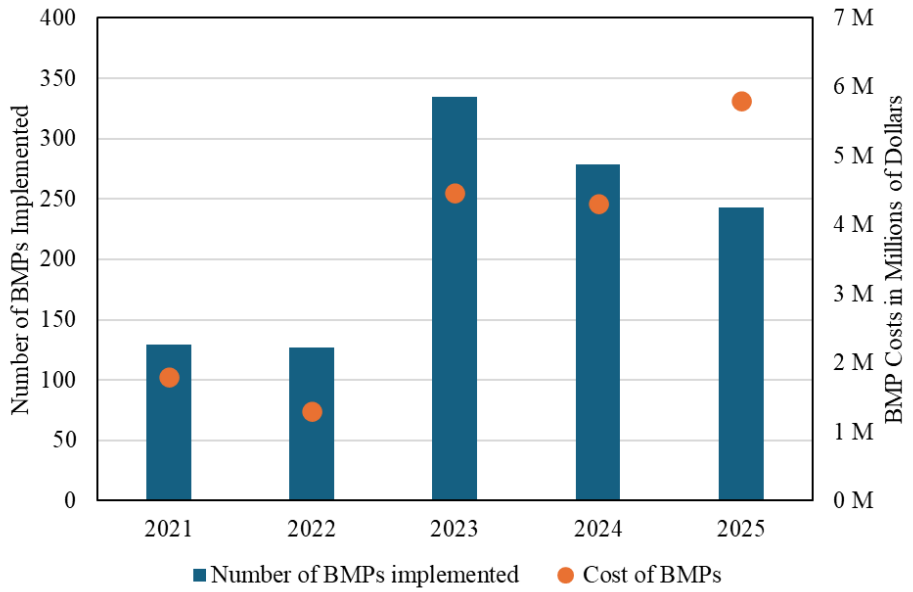


Figure 2.11 The number of BMPs implemented by EOH and WOH with the associated implementation costs in millions of dollars for the years 2021 to 2025.

The FAD Metric Assessment Report (DEP 2024) identified the need to update program reporting to more fully reflect the full suite of BMPs offered through the WAP. In response, beginning in 2025, WAP enhanced its reporting to include Agronomic BMPs implemented on an annual basis. These non-structural, management-based practices are integral to the effective implementation of WFPs, translating conservation goals into everyday farming decisions that improve soil health, optimize nutrient use, and help reduce the source, timing, and transport of pollutants. Agronomic BMPs are categorized using NRCS Practice Codes and include practices such as Prescribed Grazing, Crop Rotation, Cover Cropping, and Precision Feed Management. In 2025, the WAP implemented 42 Agronomic BMPs at a total cost of $192,794.

During this assessment period, WAC's Watershed Investigation and Repair Crew (WIRC) continued to focus on performing, managing, and leading field activities, including OSHA-compliant investigations, emergency repairs on BMPs alongside participants, and education on proper BMP operation and maintenance. This includes work on drainage systems,

access roads, and animal watering systems. When no viable contractors are available, WIRC may implement structural BMPs itself, often at a lower cost. During this assessment period, WIRC implemented a total of 89 BMPs in the WOH watershed. Those BMPs totaled over $250,000 in cost estimates. While actual WIRC costs to implement these 89 BMPs were not fully tracked, the FAD Metrics Assessment found WIRC has continued to achieve notable cost savings for its BMP implementation, which, on average, from 2018 through 2023, achieved more than 30% in cost savings compared to the original BMP cost estimate.

Following the closeout of the 2017 Backlog List in 2024, a total of 574 designs had been completed as of June 30, 2023, as documented in the 2024 FAD Metrics Assessment. Under WAC's current contract with DEP, all viable BMPs associated with these designs are required to be implemented by June 30, 2027. Although implementation of these BMPs is not a specific FAD deliverable, tracking their status remains important, as they represent the remaining commitments carried forward from the 2017 Backlog List. In 2025, the WAP successfully implemented 60 BMPs on the BMP Implementation List, at a cost of $4,275,050. Eight BMPs were classified as non-viable due to feasibility constraints, while 63 BMPs were placed on a hold status for future consideration. BMPs designated as "on hold" are in the final stages of design but cannot progress due to external factors. These factors typically involve changes in participant status or farm operation.

Figure 2.12 A new barnyard BMP installed by WAC to decrease manure runoff built on the Marsiglio beef Farm, Delaware County, NY.

2.4.4 Nutrient Management Plans and Nutrient Management Credit Program

A Nutrient Management Plan (NMP) maps out where, when, and how much manure can be spread on a farm with minimal risk of phosphorus and pathogens entering a water supply (Figure 2.13). By adhering to an appropriate manure-spreading schedule, high-risk practices can be eliminated. For the assessment period, on average, the WAP maintained current NMPs on 91% of active farms requiring one. The WAP developed or updated an average of 60 NMPs every year on active WOH and EOH farms. At the end of 2025, 201 (196 WOH, 5 EOH) active farms had current NMPs, and 125 active farms were participating in the Nutrient Management Credit (NMC) Program, which represents a 6% decrease from the total of 132 farms receiving credits at the end of the previous assessment period in 2020. The NMC Program provides financial incentives to participants who adhere to their NMPs. To be eligible for the NMC Program, participating farms must be active WAP participants with at least 25 Animal Units and must manage at least 50 tons of manure.

Figure 2.13 Kari Sheridan and Dan Deysenroth, WAC staff, collecting plant samples to test them for phosphorus uptake as part of a cover crop and NMP assessment.

2.4.5 Precision Feed Management Program

The WAP Precision Feed Management (PFM) program is designed to engage farmers in a recurring process of planning, implementing, and monitoring the largest source of nutrients on the farm: feed nutrients. The goals of PFM are to improve animal productivity, improve profitability, and to reduce nutrient accumulation on the farm (Figure 2.14). In 2025, the PFM

program had 51 active participants with six new or revised plans completed that year. The diversity of WOH watershed agriculture is reflected in the distribution of active dairy and beef participants with 29 dairy farms (18 in Cannonsville, seven in Pepacton, and four in Schoharie) and 22 beef farms (14 in Cannonsville, five in Pepacton, two in Schoharie, and one in Rondout).

Over the five-year assessment period, the PFM Program monitored an average of 2,045 lactating dairy cows annually, tracking the amount of phosphorus in the feed ("fed phosphorus") as a percent of animal requirements. Benchmarking on dairy farms is dynamic, with herds shifting between phosphorus scenarios year to year based on milk and crop production, forage quality, and nutritional strategies. Over the five-year assessment period, 48% of managed cows had benchmarks persistently within phosphorus guidelines, were not overfeeding phosphorus, and therefore were not targeted for phosphorus reductions. Throughout the same period, 26% of cows were above the phosphorus guidelines. During the same five-year timeframe, 15% of cows that were not within phosphorus rationing guidelines at the beginning of the year achieved targeted reductions to meet the guidelines by year-end. Approximately 11% of cows over the assessment period began the year within phosphorus guidelines but exceeded phosphorus requirements throughout the year. Yearly fluctuations in cows' phosphorus levels are natural responses to dairy farming and feeding under volatile conditions, even when all attempts are made to reduce the phosphorus fed. Despite these fluctuations, for the assessment period, PFM monitoring reduced the total annual phosphorus excretion pool by 15.7% for all monitored cows. The PFM program continues to measure, monitor, and implement changes contributing to a decrease in phosphorus fed.

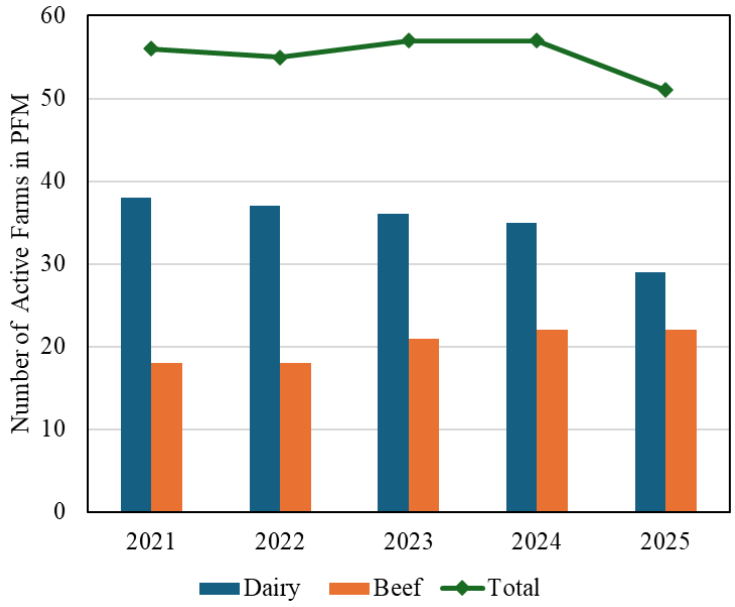


Figure 2.14 The total number of dairy and beef farms in the PFM program for the years 2021 to 2025.

2.4.6 Conservation Reserve Enhancement Program

The CREP is a voluntary DEP and USDA partnership administered by WAP that provides financial incentives for producers to retire environmentally sensitive land from active farming by creating a riparian buffer along stream corridors. In exchange for establishing permanent conservation riparian buffers with covers like grasses and trees to prevent erosion and filter water, the Farm Service Agency (FSA) and DEP provide participants with annual rental payments and cost-share assistance. During the assessment period, the WAP enrolled 12 new contracts (53.12 acres) in CREP, while re-enrolling 120 expiring contracts (217 acres). A total of 9 expiring contracts were not re-enrolled by the landowners. As of the close of this assessment period, 130 landowners had enrolled 1,306 acres of riparian buffers.

In 2020, a USDA review of CREP contracts revealed an annual overpayment across 172 contracts (totaling 1,687.4 acres), which resulted in those participants either accepting reduced future payments, appealing the decision, or terminating their CREP contract without penalty. This issue created two primary challenges for the WAP during this assessment period. First, with CREP no longer in effect on certain parcels, some producers began to graze within previously excluded areas. As a solution to mitigate any potential environmental degradation, the WAP implemented access control BMPs within the WFP to limit animal access potential to water courses. Secondly, the issue has eroded participant trust, resulting in some farmers permanently withdrawing from future CREP participation.

2.4.7 Farmer Education Program

The WAP's Farmer Education Program is led by CCEDC in coordination with WAC. Educational and economic support initiatives maintained stable engagement throughout the assessment period by delivering 183 farmer education events reaching 5,818 total attendees, 2,343 (40%) of whom were watershed farmers. Events included conferences, workshops, hands-on farm demonstrations, and tours, which focused on all aspects of farm production and environmental management. Popular events included the annual Catskill Regional Agricultural Conference, pesticide application trainings, and multiple farm tours and workshops covering topics such as livestock production and pasture management. Events were held in a variety of locations within the watershed and open to all farmers regardless of their participation in the WAP.

2.4.8 Economic Viability Program

The EV Program supports the economic viability of farms, agribusinesses, and the wood products industry in the NYC Watershed region through upstate/downstate marketing efforts, the Pure Catskills branding campaign, and other initiatives such as the Micro Grants Reimbursement Program, the Business Planning Program, and the Farm and Forests in Transition Reimbursement Program. The EV Program reaches approximately 50,000 people annually via the Pure Catskills guide and engages the public through various e-newsletters and events. During the assessment period, WAC sponsored 1,659 events, including the Taste of the Catskills in

Delhi, NY and Cauliflower Festival in Margaretville, NY. At the end of 2025, there were 324 Pure Catskill members. The number of annual members remained stable over the assessment period, with a maximum of 364 in 2023 and a low of 311 in 2021.

During this assessment period, WAC awarded one Business Planning grant for $2,000 and 12 Farms & Forests in Transition grants for $50,415. The Micro Grants Reimbursement Program emerged as the most popular initiative during this period, resulting in 55 grants awarded for a total of $199,982. The Marketing and Greenhouse and/or Raised Bed Expansions were the most commonly applied for grant categories.

In 2023, NYC released its five-year climate action plan entitled PlaNYC, which, for the first time, included initiatives related to the NYC watershed. One such initiative created an incentive program to support farmers in the NYC watershed who expand agricultural production of fruits and vegetables. To fulfill this initiative, DEP collaborated with WAC to create a new Micro Grants category. In 2023, WAC successfully piloted the Fruit and Vegetable Expansion Microgrant. This grant provides up to $5,000 in reimbursements for greenhouses, raised beds, water access expansion, and qualified farm structures. A total of $51,624 in microgrants were awarded to 11 farms during this pilot. Following positive participant feedback, permanently added the category to the EV Program to continue supporting agricultural expansion in the watershed.

2.5 Watershed Forestry Program

2.5.1 Introduction

Since 1997, the WAC Forestry Program and DEP have partnered with the USFS to promote and support well-managed working forests as a beneficial land use for watershed protection and economic viability. The WAC Forestry Program combines core DEP contract funds with USFS grant funding to support the development of forest management plans, the implementation of forest stewardship activities through the Management Assistance Program (MAP), the implementation of BMPs on active timber harvest projects, professional training for loggers and foresters, and educational programs for landowners and school-based audiences.

2.5.2 Forest Stewardship Planning

During the assessment period, the WAC Forestry Program continued to incentivize NYS's 480-a Forest Tax Law (480-a) participation by funding the development of 132 forest management plans, which cover 20,199 acres of forest. Ten of these plans resulted in the new enrollment of 1,246 acres in 480-a, while the remaining 122 plans (18,953 acres) represented re-enrolled properties. A total of 61,786 acres (58,953 WOH, 2,833 EOH) is estimated to be enrolled in 480-a through forest management plans funded by WAC. To be eligible for 480-a, landowners must have at least 50 acres of forest, limit subdivision, restrict development, and commit to a rolling 10-year forest management schedule that is enforceable by NYSDEC. The 2021 FAD Summary and Assessment Report identified challenges in accurately quantifying the

number of active 480-a acres receiving WAC funded forest management plans due to limitations in NYSDEC reporting. In 2025, WAC and NYSDEC met to discuss opportunities to strengthen coordination related to the 480-a program and to identify pathways for improving data sharing in future reporting periods.

Since 2015, WAC has maintained MyWoodlot.com, an interactive website that educates landowners through modules to help them develop customized stewardship goals, informed conservation practices, and personalized forest management plans (Figure 2.15). There are currently 535 MyWoodlot profiles, of which 224 profiles were added during this assessment period; a 41% increase over the last five years. Additionally, 1,409 new blogs and stories were added to the site. In 2025, engagement continued to increase with 25,843 unique visitors to the website.

As required by the Revised 2017 FAD, a 2024 assessment evaluated MyWoodlot's effectiveness in identifying landowners' needs and interests while providing the knowledge necessary for informed conservation decisions (DEP 2024b). The assessment found MyWoodlot continues to serve as a cost-effective, interactive tool for forest owners to access conservation information and professional guidance at no cost. Despite attracting tens of thousands of annual visitors, MyWoodlot has only 535 registered profiles, representing a small fraction of the site's total traffic. To address this low participation rate, the report recommended that WAC should introduce registration incentives and better integrate the site with other programs, such as the Economic Viability Micro Grants Program and Forest Conservation Easement Program. To improve program assessment, the report recommended that WAC implement methods to track "conversions", instances where users transition from passive browsing to active participation in MAP or other WAC programs. A review of the 2020 Conservation Awareness Index (CAI) Survey suggested MyWoodlot users possess higher conservation knowledge. However, it remains unclear whether the website fosters this awareness or primarily attracts already-informed owners. To further evaluate this, DEP recommended that WAC supplement the 2025 CAI Survey with a focused, repeatable survey of website users to provide specific feedback and measurably track improvements in stewardship behavior.

2.5.3 Management Assistance Program

The MAP provides cost-share incentives for forest landowners to implement stewardship projects, such as invasive species control, timber stand improvement, and other BMPs. The Revised 2017 FAD set a goal of completing at least 60 MAP projects annually. During the assessment period, WAC only missed this goal once, in 2023. As with many FAD programs, MAP participation is voluntary. While setting a firm target is important, DEP finds no fault when this goal is narrowly missed, especially given WAC's strong efforts, which resulted in an all-time program high of 115 projects completed in 2024.

Figure 2.15 Jason Humbolt and Heather Hilson, from WAC, at the Delhi, NY Farmers Market showcasing the MyWoodlot.com display.

The MAP provided funding for 418 projects over the assessment period, which included 79 timber stand improvements, 107 wildlife improvements, 34 invasive plant control projects, 37 tree plantings, one riparian improvement, and 160 landowner site visits, marking a cumulative program total of 1,162 projects covering 7,812 acres to date. Timber stand and wildlife projects accounted for 66 percent of the cumulative number of projects. Many of the stewardship practices supported through MAP are communicated to other watershed landowners via MyWoodlot.com with the goal of providing education and encouragement among peer landowners to implement these practices themselves. During this assessment period, WAC staff began focusing outreach efforts on local farmers' markets where they can better attract and directly interact with unengaged forest landowners. These personal interactions have contributed to the steady increase in MAP Site Visits. During these visits, WAC foresters meet one-on-one with forest landowners on their property to discuss a wide variety of stewardship practices and provide education on WAC's existing suite of programs that the landowner may be interested in. While not specifically tracked by WAC, many of these site visits can lead to landowners participating in MAP and other WAC programs.

In 2025, in consultation with the WAC, DEP assessed the effectiveness of the MAP in supporting the implementation of forest management plans as required by the Revised 2017 FAD (DEP 2024c). The report recommended optimizing the MAP in support of 480-a enrollment and water quality, recommending that the program prioritize funding for timber stand improvement, invasive species control when required by 480-a plans, and riparian tree plantings, while evaluating adding a new component of boundary line marking for 480-a. Other recommendations

included limiting wildlife improvements to first-time participants, eliminating alternative inspection techniques, and focusing marketing on landowners with at least 50 acres to increase 480-a participation, increasing the leverage of MyWoodlot.com for improved outreach and data collection, the development of mechanisms to track site visit conversion rates, and future consideration on how best to utilize the CAI to more accurately measure the impact of MAP on forest stewardship.

2.5.4 Best Management Practice Program

Among WAC's Forestry Program components, the BMP Program delivers the most direct water quality protection benefits by providing financial and technical assistance to loggers, foresters, and landowners who implement BMPs during active timber harvests. These practices include erosion control measures, stream crossing facilitation, and the distribution of free materials such as geotextile road fabric, silt fencing with stakes, grass seed/hay, and spill kits. During this assessment period, the WAC Forestry Program supported the completion of 211 erosion control BMP projects and 73 stream crossings on active timber sites, supported by 37 portable bridge loans and 158 free samples of BMP technology, such as geotextile road fabric and rubber belt water deflectors. In January 2025, WAC, in coordination with DEP, revised its BMP Program funding rates to better reflect the actual cost of implementation. The logging community has responded positively to these changes, leading to increased participation in the program.

2.5.5 Croton Trees for Tribs

Trees For Tributaries is a stream-side planting program first developed in 2007 by NYSDEC's Hudson River Estuary Program, then expanded to create the Croton Chapter of Trees for Tribs, which is administered by the WAC Forestry Program. Trees for Tribs offers free trees and shrubs for the planting of stream-side forests and is available to landowners in the Croton Watershed. The program utilizes a community-based approach where participants receive in-field education, and technical and installation assistance from WAC. To better support this program, WAC leverages its Watershed Forestry Field Trips Program by educating students on the NYC Watershed and providing them hands-on training on how to plant trees in riparian areas, further enhancing classroom learning. During the assessment period, the WAC Forestry Program implemented 88 Trees for Tribs projects, resulting in the planting of 1,302 trees and shrubs across 8,208 linear feet of riparian area. Compared to the prior assessment period (2016–2020), this represents a 151% increase in the number of projects and a 129% increase in treated riparian linear feet. These increases reflect the program's transition from a primarily landowner-driven riparian reforestation initiative to a broader program with an expanded educational focus.

2.5.6 Forestry Education and Training

The WAC Forestry Program continued to focus efforts on landowner and professional education through partnerships with Cornell Cooperative Extension of Greene and Columbia Counties (CCEGC) and Cornell University's Master Forest Owners (MFO) Program. These

collaborations facilitate dozens of annual workshops and woods walks, reaching thousands of participants. During this assessment period, WAC organized and implemented 106 landowner workshops attended by 2,493 participants while MFOs conducted 377 site visits to assist local landowners. At the end of 2025, there were 50 MFOs available to help landowners, an increase of 30% from the beginning of this assessment period.

In collaboration with the NYS Trained Logger Certification Program and CCECG, WAC sponsored 52 logger training sessions, attended by 607 participants over the assessment period. At the end of 2025, 85 loggers working in the Catskill/Lower Hudson region were Trained Logger Certified (TLC). The annual total of TLC loggers ranged from 31 to 88 during the assessment period.

The WAC Forestry Program implements the Urban/Rural Education Initiative program (UREI). This program provides school-based education through several key initiatives, including the Watershed Forestry Institute for Teachers (WFIT), Watershed Forestry Field Trips Program, and the Green Connections Program. The WFIT is a professional development program that equips educators to teach forest watershed science. The Watershed Forestry Field Trips Program is a competitive grant-funded educational initiative for 4th-12th-grade students and educators in NYC and its watershed regions. It provides firsthand, hands-on experiences to study how forests, water, and people interact, with a special focus on how healthy, managed forests protect drinking water quality. The Green Connections Program facilitates year-long partnerships between NYC and upstate schools, pairing urban and rural students for collaborative watershed studies and joint field trips that highlight their shared reliance on forest stewardship for clean water. These programs demonstrate how managed forests act as natural filtration systems for the City's drinking water, while also fostering social and educational links to the watershed.

The COVID-19 pandemic impacted the UREI program throughout the first half of this assessment period. During that time, WAC successfully transitioned to virtual options for many of these initiatives, including virtual bus tours to ensure these educational programs continued. In total, the Watershed Forestry Field Trips Program hosted 121 in-person bus tours and 62 virtual tours, educating 9,356 participants from both NYC and the watershed about the links between forests and water quality. One hundred and fifteen teachers attended one of the five annual WFIT programs, and the Green Connections Program engaged 1,244 students throughout the assessment period.

2.5.7 Model Forest Program

The WAC Forestry Program operates four model forests; The Lennox Model Forest in Delhi, NY, the Frost Valley YMCA Model Forest in Claryville, NY, the Siuslaw Model Forest in Acra, NY, and the Clearpool Model Forest in Carmel, NY. Model forests are intended to be living classrooms where various BMPs, silvicultural practices, and water quality protection topics can be displayed to the public. These model forests also serve as research sites for scientists to investigate the relationship between forest management and water quality. During

this assessment period, the four model forests hosted 312 educational events, attended by 15,187 participants; 9,053 at Clear Pool, 1,006 at Lennox, 743 at Frost Valley, and 4,385 at Siuslaw. Impacts from the COVID-19 pandemic resulted in lower participation in 2021, but the program has since recovered.

2.5.8 Conservation Awareness Index

The CAI estimates landowner preparedness to make informed conservation decisions about their forest lands regarding harvesting timber, paying taxes, and planning generational transfers, and is modeled after the Consumer Confidence Index. The CAI estimates landowner knowledge, awareness, and experience with conservation options, which can help identify gaps to better target the education and outreach efforts of the WAC Forestry Program. Since 2015, WAC conducts a CAI survey every five years that includes four subject areas that represent conservation decisions that landowners may encounter: property tax reduction programs, conservation easements, timber harvesting, and estate planning.

Although completed in the prior assessment period, only preliminary 2020 CAI survey results were available for inclusion in the 2021 FAD Summary and Assessment. Final data showed the average CAI total score of 16.5 in 2020, a slight increase over the 2015 average of 15.8. These figures suggest that landowner conservation awareness remained relatively stable during this period, though 480-a section scores increased in 2020. Across the subject areas, planning and timber harvesting earned the highest CAI scores, while 480-a and conservation easements scored lowest. Conclusions from the 2020 CAI survey suggested that WAC evaluate how to facilitate more peer-to-peer interactions among landowners to both increase conservation awareness and empower them to share firsthand experiences regarding property taxes, legacy planning, and sustainable forest management.

During this assessment period, WAC implemented several of the 2020 conclusions, including a blog collection called ‘The Big Decisions’, which focuses on important choices landowners make regarding the future of their forests. These ‘big decisions’ can include dealing with forest taxes, a timber harvest, or succession planning (deciding the future owner and land use). The WAC Forestry Program also increased its support of the Catskills-Hudson Valley Women Owning Woods (WOW) chapter. At the end of 2025, the WOW Facebook group has 318 members, and seven workshops were held during the assessment period and attended by 92 people.

In 2025, WAC conducted its third five-year CAI survey, which once again involved mailing surveys to 3,000 watershed landowners with over 10 acres of watershed forests. Previous response rates were 35% (921 respondents) in 2015 and 31% (793 respondents) in 2020 (DEP 2021). The WAC is currently analyzing the survey results and will issue findings by December 31, 2026, the required Revised 2017 FAD deadline.

2.6 Stream Management Program

2.6.1 Introduction

DEP established the SMP to protect and restore stream stability and ecosystems. The stream channel and riparian corridor together sequester sediments and nutrients which can contribute to the degradation of water quality. DEP and its partners at Greene, Ulster, Delaware, and Sullivan SWCDs and CCEUC apply state-of-the-science river and floodplain management principles to implement programs and projects, working with stakeholders whose individual actions are fundamentally important to stream stability and riparian integrity.

The SMP process begins with stream feature inventories (SFIs) of current conditions which are used to develop stream management plans. Recommendations in the plans result in program-prioritized Water Quality Stream Projects (WQSPs) and SMIP projects, which are further prioritized by SMP partners. Projects include geomorphic channel restoration, stream bank and hillslope stabilization, flood hazard mitigation, and riparian plantings. The stream management plan recommendations also inform an extensive and integrated program of education, outreach, and training to support the SMP's mission. The NASEM commended this approach to stream management in 2020 in its multi-year expert panel review.

The current assessment period was characterized by primarily average stream flows with isolated flood flows, and the emergence from the COVID-19 pandemic. Landowner support for projects, permitting, partner staff turnover, and a need for enhanced professional development to better align partner staff capacity and expertise to support program work constrained project implementation during this period. Despite this, SMP completed 104 stream projects, restoring stability or riparian buffer to nearly 10.6 miles of stream (including CSBI projects reported in Section 2.7), at a total cost of $17,516,379.

With a robust flood hazard mitigation program comprised of the SMP partners and the CWC, the SMP completed five Local Flood Analyses (LFAs) in this reporting period laying a strong foundation for achieving flood resilience and water quality protection. Finally, DEP negotiated and registered all five SMP partner contracts for new five-year terms totaling $86.7 million through 2030 and continued the ten-year Esopus Creek Watershed Turbidity/Suspended Sediment Study to inform future projects and enhanced program evaluation.

2.6.2 Water Quality Stream Projects

Water Quality Stream Projects (WQSPs) prioritize improvements in water quality above other project objectives. The Revised 2017 FAD emphasized the importance of WQSPs relative to other project categories. The 2017 FAD directed SMP and its partners to review, at the reservoir basin scale, water quality status and trends, identify priority pollutants, and utilize past SFIs and independent studies to evaluate the potential for WQSPs to improve water quality.

During this assessment period, 10 WQSPs were designed and constructed, treating 2.1 miles of unstable stream through full channel restoration or streambank stabilization at a cost of

$11,479,341. Two projects (West Branch Neversink at Clothes Pool and West Kill Above Wolff Road) were also repaired at a cost of $242,104. The Revised 2017 FAD requires that 24 WQSPs are designed and completed by December 31, 2027, with a minimum of three in the Stony Clove basin and at least eight in the Ashokan watershed. To date, DEP has nominated, and NYSDOH approved, 24 WQSPs which have a principal benefit of water quality protection or improvement. In June of 2023, NYSDOH approved the withdrawal of one WQSP, the Hillslope Stabilization at Bull Run, located in the Pepacton watershed, due to concerns over constructability. During this assessment period 10 WQSPs have been completed (Table 2.10), including three in the Stony Clove Basin and five in the Ashokan watershed. In total, 14 of 24 FAD-required WQSPs have been completed, including three in the Stony Clove basin and six in the Ashokan watershed. Nine WQSPs are currently in design phase, including two in the Ashokan watershed. To meet the Revised 2017 FAD deliverable for WQSPs, one additional project will need to be nominated, and 10 projects will need to be designed and constructed by the end of 2027. In 2026, DEP anticipates one additional WQSP nomination will be made in the Neversink watershed. Completion of 10 projects over the remaining two years represents an ambitious schedule that will require SMP partners to concentrate efforts on design, procurement, and construction and will depend heavily on favorable summer construction conditions. Based on recent implementation rates and the complexity of remaining projects, achieving this level of delivery within the available timeframe may be challenging.

Table 2.10 Completed Water Quality Stream Projects.

Basin	Project	Year Completed	Project Length (ft.)	Total Cost
Ashokan				
	Warner Creek 1	2021	540	$373,342
	Warner Creek 2	2021	560	$373,342
	Stony Clove Above Jansen Road	2022	1,600	$2,049,055
	Panther Kill Stream Restoration	2022	450	$501,628
	Elk Bushkill Stream Restoration	2023	1,300	$1,129,900
Rondout/ Neversink				
	East Branch of the Neversink River at Ladleton	2022	1,360	$1,008,920
Schoharie				
	Batavia Kill at Red Falls P1	2021	1,606	$1,563,319
	Batavia Kill at Red Falls P2	2022	830	$1,169,798
	West Kill above Wolff Road	2023	750	$754,753
	Batavia Kill at Red Falls P3	2024	1,650	$2,555,284
Total			10,646	$11,479,341

An iterative design and review process is a critical component of the SMP project development workflow. The SMP has been using hydrologic and hydraulic modeling (HEC-RAS) as a standard engineering practice in most projects for many years, modeling a range of flows and design alternatives, in both existing and proposed conditions. HEC-RAS is routinely used to evaluate channel and floodplain velocity, shear stress, and energy in choosing treatment practices and to avoid an increase in water surface elevations of the 100-year flow, as required by local floodplain ordinances and associated permits. To better understand hydrologic conditions, designers have also increased the use of two-dimensional (2D) hydraulic modeling for WQSPs. The SMP has provided training opportunities for program staff in these modeling techniques.

During the reporting period, Unmanned Aerial Systems (UAS), or drones, continued to be used for assessment and survey increasing the precision, accuracy, and efficiency of topographic mapping. DEP has provided funding to partners for the purchase of drones, training and the required Federal Aviation Administration (FAA) licensing of staff.

The following are two examples of WQSPs constructed during the assessment period that were identified through SFIs and prioritized for water quality protection to achieve turbidity reduction.

Stony Clove above Jansen Road (Ashokan Basin)

Located in the Town of Hunter, this WQSP included two primary areas of erosion including a large rotational failure of glacio-lacustrine sediment in a high terrace located above one of the eroding streambanks (Figure 2.16). The UCSWCD used high resolution topographic mapping and two rounds of SFI mapping to document that this reach had sustained erosional connectivity with glacial sediment that measurably contributed to turbidity production in Stony Clove Creek. A high-risk flood hazard private home located at the top of the actively mass-wasting terrace was purchased and removed through the NYCFBO Program in 2021, after which the site continued to degrade with a new large rotational failure.

The UCSWCD constructed this WQSP in 2022 at a cost of $2,049,055. Project objectives were to disconnect the channel from the glacial sediment sources and restore channel stability through realignment and re-dimensioning, increasing erosion resistance through in-stream and floodplain grade control structures and streambank protection with rock revetment, bioengineering, and natural vegetative restoration measures. Installed practices included hillslope, bank and floodplain grading and reconnection, constructed riffle grade controls, root wads, fascine and live stone revetment bank treatments, and revegetation with native trees, shrubs, and seeds.

Figure 2.16 Stony Clove above Jansen Road project showing pre-construction conditions (top) and post-construction.

Batavia Kill at Red Falls (Schoharie Basin)

The GCSWCD has made substantial progress on the multistage, multiyear restoration of the Batavia Kill at Red Falls. Each phase of this restoration aims to reduce suspended sediment loads caused by excessive bank and bed erosion, as well as mass bank failures. Geomorphic and water quality monitoring data identified this reach as the largest contributor of turbidity and suspended sediment within the Batavia Kill watershed. The Red Falls site remains one of the largest and most complex sites undertaken by the SMP. To date, Projects One through Three have restored 4,086 feet of stream and adjacent floodplain.

Project One was completed in 2021 and included 1,606 feet of stream and floodplain reconnection and restoration, along with the construction of a staging area and an access road. Project Two, completed in 2022, addressed the channel above a natural pinch point which separates the projects. This phase included 830 linear feet of stream and floodplain restoration and hillslope stabilization. Channel restoration involved installing boulder riffles, log keyways, and live stone revetment, alongside extensive floodplain restoration, partial reclamation of the access road, restoration of the dewatering channel, and site revegetation (Figure 2.17). Project Three construction began in 2023 but faced significant rain delays and was successfully completed in 2024. Project Three covered 1,650 feet of stream and adjacent floodplain restoration. It required the construction of a new pumped dewatering bypass, the establishment of streambed grade controls using boulder riffles and rock vanes, streambank stabilization via root wad and log revetment, and floodplain grading and revegetation (Figure 2.18).

Project Four is scheduled for construction in 2026 through 2027 and represents the final phase of the Red Fall Restoration (Figure 2.19). The work aims to stabilize the remaining unstable and deeply entrenched section of the stream, which is a persistent source of turbidity due to active geotechnical hillslope failures and bed degradation. Scour and erosion control measures will be installed along a private bridge, where the channel will be returned to its historic grade.

Additional grade control and bank and hillslope stabilization measures will be installed upstream of the bridge, completing the final 1,400 feet of the Red Falls Restoration. Project Four will also include revegetation of the entire work area and the restoration of staging and access roads. Upon completion, the Red Falls Restoration will have established channel stability and addressed chronic suspended sediment and turbidity along more than a mile of the lower Batavia Kill.

Figure 2.17 Batavia Kill at Red Falls Project Two before (February 2016) and after (August 2025) photos.

Figure 2.18 Batavia Kill at Red Falls Project Three after construction (October 2025).

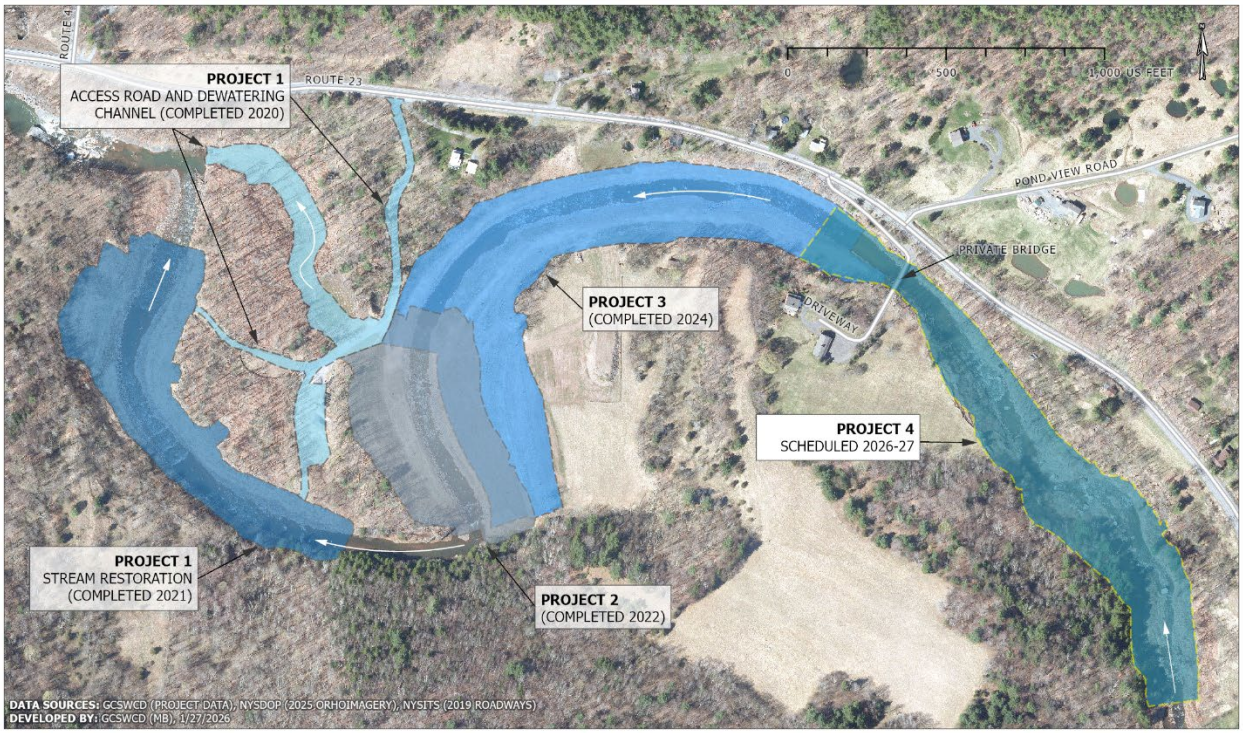


Figure 2.19 The four phases of the Batavia Kill at Red Falls stream restoration.

2.6.3 Implementing Stream Management Plans

DEP works in close partnership with SMP partners to develop and oversee a comprehensive, basin-scale stream management program, for which SMP partners are responsible implementing, including stream assessment and monitoring; project selection, design, and construction; LFA support; and stakeholder education and technical training.

Stream Feature Inventories

SFIs are data collection efforts in mapping stream condition and stability. The SFI process identifies localized or reach-scale instability that threatens water quality and/or infrastructure and ultimately leads to recommendations for management. SWCD technicians prioritize collecting GPS data for stream features of concern for management so further assessment can be conducted where needed. Stream feature data that are collected include, but are not limited to, erosion, invasive species, fine sediment sources, proposed planting sites, depositional features, and headcuts. Between 2021 and 2025, SFIs were completed on 14 streams across the WOH watershed, covering 57.3 miles of stream. These numbers are down from the previous assessment period, covering approximately half as many streams and one third as many miles. This decrease is due to having previously assessed many of the major tributaries throughout the watershed and SWCDs shifting their attention to smaller tributaries of concern. As the program evolves, a shift towards selecting tributaries for SFIs that reveal management concerns will keep the data collection efforts relevant to program goals. Digital assessments such as geomorphic change detection can point assessment teams towards areas for field verification and water quality monitoring data may indicate shifting turbidity trends where available. These assessment efforts are supported with DEP-funded interns from State University of New York (SUNY) Ulster, Student Conservation Association-AmeriCorps, and the SWCDs.

Stream Management Implementation Program

Successful watershed protection efforts depend upon coordination with municipalities and other local entities. Throughout this assessment period, the SMP partners met with their advisory councils and working groups to implement recommendations made in stream management plans, track program progress and set priorities via annual action plans, as well as administer the SMIP. Stream management plans and annual action plans can be found at catskillstreams.org/stream-management-program.

Community-driven projects are administered by SMP partners through the application-based SMIP. Table 2.11 summarizes the total number and category of SMIP awards made during the assessment period. Since its inception in 2009, 357 SMIP grants have been awarded, of which 84 percent have been completed, nine percent are currently in process and seven percent withdrawn. LFA recommended flood hazard mitigation projects are tracked separately from SMIP projects and are reported in Section 2.6.6. SMIP project descriptions and funding levels, by basin, can be found at catskillstreams.org/smip.

SMIP continued to be a source of support for numerous community-driven projects which were evenly divided between education and outreach, planning and research, and highway infrastructure projects. The number of SMIP awards was lower in this assessment period (63) compared to the 2015 (156) and 2020 (115) assessment periods. This was largely attributed to a reduction in education and outreach, recreation, and habitat awards due to the COVID-19 pandemic. Highway and infrastructure remained a popular category among local stakeholders, however, future SMP partner efforts should continue to emphasize projects that directly advance water quality protection and flood reduction, rather than infrastructure projects with maintenance goals, which provide more limited benefits in these areas.

Table 2.11 SMIP category summary by basin, 2021-2025.

SMIP Category	Schoharie	Ashokan	Delaware	Neversink/ Rondout	Total
Education and Outreach	6	1	0	10	17
Recreation and Habitat	3	0	0	0	3
Highway/Infrastructure	9	2	5	2	18
Streambank Stabilization	2	0	5	0	7
Planning and Research	4	12	0	2	18
Total	24	15	10	14	63

Summary of SMP Stream Project Delivery

In addition to implementing SMIP-funded stream projects, the SMP partners continued to identify and oversee the full suite of construction-related stream projects undertaken by the program. Table 2.12 summarizes all the projects completed during the assessment period including WQSPs, LFA-recommended flood hazard mitigation projects, and SMIP projects. CSBI projects are reported in Section 2.7. Excluding CSBI, 34 projects were completed that treated a total of 3.3 miles of stream. This is a notable decrease compared to previous assessment periods where 47 projects treating 5 miles of stream were completed between 2016 through 2020 and 79 projects treating 15.7 miles of stream were completed between 2011 through 2015, which included tropical storm Irene recovery and repairs.

For most projects, the SMP partners continued to coordinate design and construction contracts; provide or coordinate landowner agreements; apply for local, state and federal permits; and facilitate construction supervision and post-construction monitoring. DEP provided engineering review, construction inspection, and professional engineering support through engineering consultants to support the partners. The reduction in projects for this reporting period can largely be attributed to the COVID-19 pandemic, partner staff turnover, and a need for enhanced professional development to better align partner staff capacity and expertise to support design and construction program work. Figure 2.20 depicts the locations of completed stream projects by funding category.

Table 2.12 WQSP, SMIP and LFA projects competed 2021-2025.

Basin	Project Category	Total Projects Completed	Project Length (ft.)	DEP Cost
Ashokan				
	WQSP	5	4,450	$4,427,267
	SMIP	4	277	$905,245
	LFA Recommended (FHM)	1	0	$299,495
Delaware				
	WQSP	0	0	$0
	SMIP	8	1,695	$599,273
	LFA Recommended (FHM)	2	1,720	$1,500,892
	Contract	2	1,090	$244,300
Rondout/Neversink				
	WQSP	1	1,360	$1,008,920
	SMIP	1	83	284,893
	LFA Recommended (FHM)	0	0	$0
	Contract	1	900	$335,432
Schoharie				
	WQSP	4	4,836	$6,043,154
	SMIP	4	1,076	$1,129,073
	LFA Recommended (FHM)	1	115	$388,338
Total		34	17,602	$17,166,282

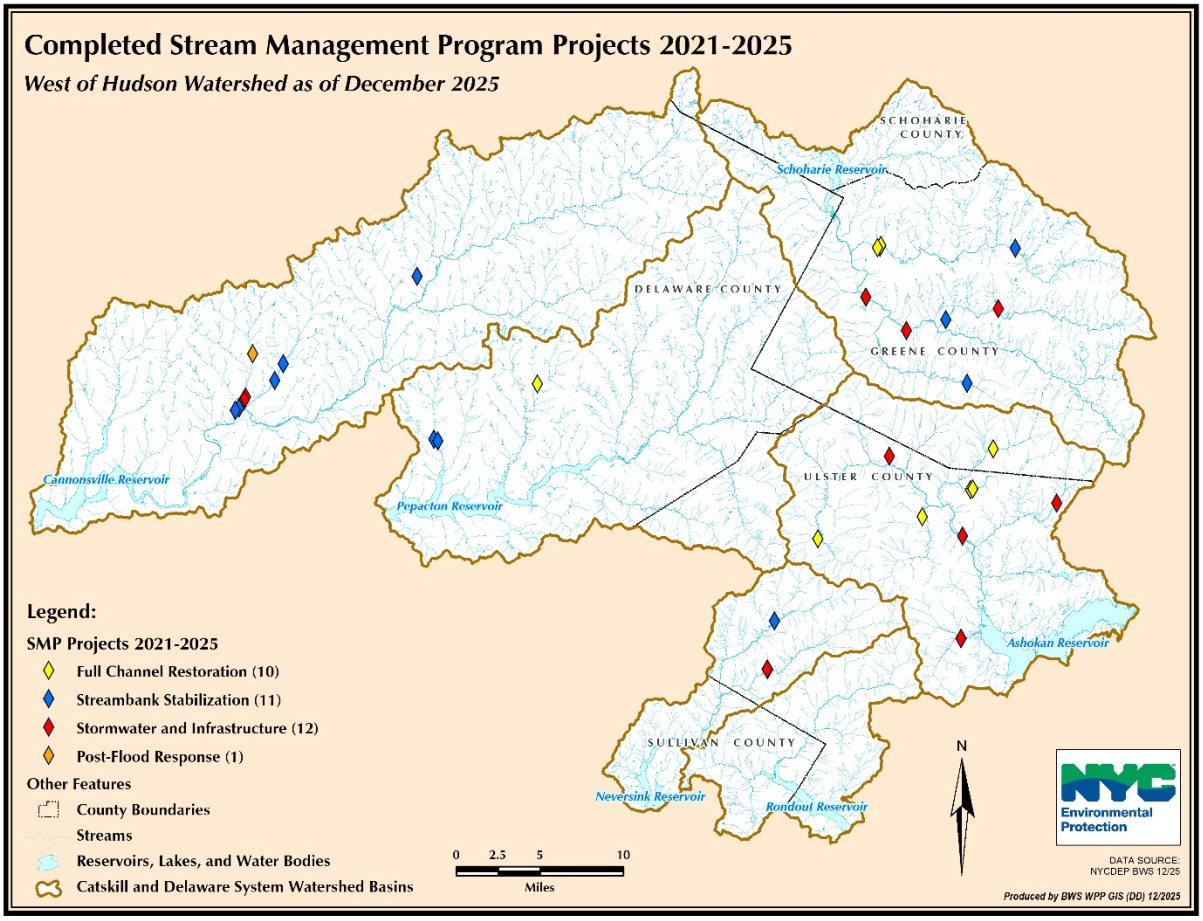


Figure 2.20 Completed SMP Projects by funding category, 2021-2025.

2.6.4 Education, Outreach and Training

Education remains a cornerstone of the SMP, which delivers and sponsors a broad range of outreach through trainings, workshops, presentations, youth engagement, and community programming. Through education and outreach, the SMP engages with streamside landowners, local officials, highway departments, flood response professionals, and the scientific community. During the current FAD assessment period, programming adapted to COVID-19-related constraints and expanded to include hybrid remote meeting and webinar formats. The SMP has continued to offer an extensive annual suite of educational programs coordinated by a long-standing engagement with State University of New York (SUNY) Ulster who provides a fulltime Stream Management Training Program Coordinator to the SMP. Highlights during this assessment period include:

Conferences and Gatherings: Partners regularly participated and hosted forums to share research, project outcomes, and best practices.

- Catskill Environmental Research and Monitoring Conference (2023, 2025)
- Schoharie Watershed Summit (multiple years)
- Ashokan Watershed Conference (annual)
- Catskill Science Collaborative
- Watershed Wednesdays Webinar Series
- Greene County, Delaware County, and Ulster County Fairs
- Mountain Top Earth Day, Olive Day, and Community Earth Day Celebrations
- Upper Delaware River Rendezvous

Training: Partners delivered training and professional development opportunities for municipal officials and watershed stakeholders with topics on flood resilience, regulatory compliance and project implementation.

- Certified Floodplain Manager exam preparation courses
- Floodplain Administrator Basic Training
- DEC Erosion and Sediment Control Trainings
- Post-Flood Emergency Stream Intervention Trainings
- Stream Mechanics and Fluvial Geomorphology Trainings
- National Flood Insurance Program flood map and map change
- Multi-Objective Stream Crossing Assessment Protocol Training

Community Outreach: Partners focused on increasing community awareness of stream processes, flood risk, and local watershed projects.

- Working with Streams' Natural Processes Workshops
- FEMA Virtual Flood Preparedness Tabletop Exercises
- Local Flood Analysis public meetings and flood commission briefings
- Bridge replacement and flood remediation project open houses
- Get to Know Your Stream Management Program public presentations
- Riparian buffer walks, watershed walks, stream walks, and forest walks
- Volunteer tree planting events with Trout Unlimited, Boy Scouts, Girl Scouts, and community members

- Interpretive events, including Riparian Rhapsody (Arm of the Sea Theater)
- Waterwheel Exhibition at the Time and the Valleys Museum
- Radio Woodstock and Radio Catskills interviews

Youth Education:

- Watershed Detectives Afterschool Program
- Watershed Scientist in Residence
- Stream Watch Program (including summer recreation programs)
- First, Third, Fourth, and Fifth Grade Watershed and Stream Ecology Programs
- Camp H_2O and other summer learning programs
- Macroinvertebrate studies at local schools
- Catskill Youth Climate Summit participation
- Environmental Awareness Days and BioBlitz events
- National Association of Conservation Districts poster contests
- Youth riparian planting projects with schools and youth organizations

The SMP continues to maintain catskillstreams.org which features a newly created municipal officials training entitled 'Stream Process 101' as well as links to annual reports, information on program areas, and basin contacts. 'Stream Process 101' is a self-paced training that introduces core stream process concepts and floodplain management considerations for municipal officials. Ongoing DEP contracts with SUNY Delhi and SUNY Ulster have provided invaluable experience to student interns who contribute to key work in the watershed. SUNY Delhi interns conduct vegetation monitoring at CSBI sites in the Schoharie and Delaware basins while learning about the crucial work of enhancing riparian buffers. SUNY Ulster interns in the Watershed Conservation Corps have assisted SWCD technicians in completing SFIs, project monitoring, and bank erosion monitoring on tributaries across the WOH watershed. Overall, the SMP delivered comprehensive and coordinated education programs that promoted informed stewardship throughout this assessment period.

2.6.5 Stream Studies

DEP formalized its commitment to science-informed and adaptive stream management through the establishment of the Stream Studies program in 2016 to evaluate and inform SMP's effectiveness in both protecting and improving water quality through enhanced research, assessment, and monitoring. For the assessment period, the primary focus has been completing years five through nine of the 10-year upper Esopus watershed suspended-sediment/turbidity monitoring study.

Esopus Creek Watershed Turbidity/Suspended Sediment Study

DEP and the United States Geologic Survey (USGS) continued to advance the 10-year suspended sediment/turbidity source and reduction monitoring research project initiated in autumn 2016 (DEP, 2017). DEP is collaborating with USGS and others to answer the following New York City water supply resource management questions:

- What are the primary tributary sub-basin sources and causal factors influencing turbidity delivered to the Ashokan Reservoir?
- Can stream management practices reduce stream turbidity and suspended sediment delivered to the Ashokan Reservoir?

The study sets out to answer these questions by achieving the following objectives:

- Characterize, monitor, and map turbidity source conditions in the upper Esopus Creek watershed (above the Ashokan Reservoir).
- Measure and monitor turbidity and sediment flux (sediment concentration and streamflow) to rank Esopus contributing tributaries and analyze spatial and temporal variations.
- Quantitatively characterize turbidity source dynamics that can be used to identify, rank and prioritize stream turbidity reduction projects (STRP), which are a WQSP category, using the Stony Clove Creek sub-basin as an experimental watershed.
- Evaluate STRP efficacy in the Stony Clove Creek sub-basin across a range of scales.

The study design uses a geomorphic connectivity framework model that relies on a multi-scalar continuous streamflow and turbidity monitoring network, geomorphic investigations into the fine sediment (silt-clay) supplies and geomorphic controls that generate turbidity production and implementing STRP to disrupt the turbidity production process (DEP, 2022).

USGS operates 29 turbidity monitoring stations for this study, 14 of which also monitor streamflow and sediment flux (DEP, 2024). The Broadstreet Hollow Creek turbidity monitoring station was converted from just monitoring turbidity to a streamflow and sediment flux monitoring station in August 2022. The Stony Clove Creek sub-basin continues to have 20 of the 29 study monitoring stations for turbidity source dynamics and STRP evaluation. In addition to the monitoring stations funded directly by DEP through a DEP-USGS cooperative agreement, the Ashokan Watershed Stream Management Program (AWSMP) SMIP grants fund additional temporary turbidity and sediment flux USGS monitoring stations in the Woodland Creek and Broadstreet Hollow watersheds to help inform independent STRP efficacy evaluations at the reach to sub-basin scale. The SMIP grant-funded monitoring results will be incorporated into the Esopus Creek watershed turbidity/suspended sediment monitoring study.

DEP and research collaborators from USGS and the University of Vermont continued to use an expanding variety of methods to investigate turbidity source sediment conditions to help

account for spatial and temporal variations in turbidity production at the reach to sub-basin (tributary) scale. This includes using SFI methods to map turbidity sources across the Esopus basin, particularly in the Stony Clove (2018-2024), Broadstreet Hollow (2023) and Woodland Creek (2025) sub-basins. DEP continued work with a contracted engineering consultant to implement the channel reach monitoring component through the "bank erosion monitoring study" (BEMS), which concluded in fall 2025. The BEMS includes use of ground-based survey and drone-based remote sensing methods to get repeat high resolution bare earth models for geomorphic change detection in reaches that are demonstrated to function as zones of elevated turbidity production, also known as hotspots. These BEMS sites serve as candidate STRP sites that are advanced to STRP implementation based on geomorphic and turbidity monitoring results.

In 2024, USGS added new turbidity source sediment investigations led by their experts in geophysical surveys to map subsurface occurrences of glacial legacy sediment, develop sediment budgets for Stony Clove and Woodland Valley sub-basins, and map potential future turbidity production zones in the Stony Clove and Woodland Valley sub-basins. With this hydrologic, water quality, geomorphologic, geologic, and existing/future STRP data, USGS, DEP and other researchers have access to sufficient data to achieve and exceed the research objectives. The final report, prepared by DEP, presenting the study findings will be submitted by November 30, 2027 as required by the Revised 2017 FAD.

The relative ranking of Esopus Creek tributaries for the nine monitoring years through 2025 still finds that Stony Clove Creek, Woodland Creek, Beaver Kill, Broadstreet Hollow, and Birch Creek were among the highest proportional turbidity tributary sources on an annual basis and for the average over the first nine years (DEP, 2022; DEP, 2024). Stony Clove Creek produces less turbidity than before the initial STRP implementation period between 2012 to 2016. The December 25, 2020 flood disturbed Stony Clove sub-basin fluvial geomorphology yielding an increased access to turbidity source sediment that resumed high turbidity productive conditions for at least the first half of 2021. Following 2021, Stony Clove has trended back to not being consistently the highest turbidity producer in the upper Esopus Creek. These results provide further indication of the benefit of removing turbidity production hotspot reaches from the sub-basin (DEP, 2024).

In the conceptual process model that informs this research, STRP function as turbidity source sediment "dysconnectivity" experiments in the study. Using the monitoring network, USGS and DEP can evaluate the impact of STRP from reach-scale out to reservoir watershed-scale reduction. Five additional STRP were constructed in the upper Esopus Creek watershed between 2021 and 2023 (DEP, 2024). Three of the STRP were selected as part of the study based on water quality and geomorphic monitoring data presented in the 2019 STRP Nomination Report (DEP, 2019b). The three sites were previous Stony Clove sub-basin BEMS sites that had an impact on reach-scale turbidity production. These hotspot production reaches were

disconnected from the geologic sources of fine sediment and have resulted in improved water quality in Stony Clove Creek (DEP, 2024).

Hydrology has been largely non-disruptive during the study period, except for the December 25, 2020 flood, which was a 4% annual exceedance probability (AEP) flood (or a 25-year flood) in the Stony Clove watershed and an approximately 10% AEP (10 to 11-year flood) for the Esopus Creek at Coldbrook. This relative absence of repeat high magnitude-low frequency runoff events resulted in prolonged periods of geomorphic recovery conditions. The relative lack of big floods distributed across the study area constrains the study findings regarding the driving force of hydrology on turbidity production.

Fortunately, the 4% AEP event occurred in the Stony Clove watershed where the study focused on intensive turbidity and sediment flux monitoring, geomorphic assessment and monitoring, and eight constructed STRP prior to the flood and three after the flood. This flood occurrence allows for analysis of big flood impacts on turbidity production in an STRP-treated sub-basin. Published study results presented at the 2023 Sedimentation and Hydrology Modeling Conference in St Louis, Missouri, and updated in 2024 for the last biennial status report, find that the collective Stony Clove STRP continues to measurably reduce turbidity production at the sub-basin scale, up to a range of a bankfull streamflow (around a 1.5- to 2-year flood).

Ongoing research is examining the potential to increase turbidity change detection resolution for higher flows. The preliminary research results continue to find that strategically disconnecting the channel from silt- and clay-enriched glacial lake sediment through STRP can measurably reduce turbidity at the sub-basin scale for bankfull scale floods, reduce the scale and duration of post-flood turbidity production following big floods, and increase fluvial system resiliency response to flood disturbances (Wang et al., 2021; DEP, 2022; DEP, 2024; Siemion et al., 2023; DEP, 2024). This reduction in the overall loading of suspended sediment to the reservoir provides a temporal buffer for reservoir water quality recovery between closely spaced flood events, like the floods in 2010 and 2011. This reduction in chronic loading can help with reservoir water quality recovery, thus reducing the impact of the next big flood on the reservoir water.

2.6.6 Flood Hazard Mitigation

During the assessment period, DEP and its partners have made significant progress implementing each of the four complementary components comprising the Local Flood Hazard Mitigation Program (LFHMP). These components include: an LFA process to determine flooding hazards; dedicated funding through the SMP to address LFA-recommendations; dedicated funding at the CWC Local Flood Hazard Mitigation Implementation Program (LFHMIP) to support the protection of residential and commercial properties; and a NYCFFBO, with dedicated funding through DEP's LAP. The LFHMP's goal is to protect water quality and secure a sustainable future for watershed communities by reducing areas of inundation and minimizing floodwater contact with residential and commercial pollutants. Pursuant to the

Revised 2017 FAD, DEP completed comprehensive evaluations of the LFHMP in 2020 and 2023. DEP also submitted an evaluation of the NYCFFBO in 2019. These reports can be found at www.catskillstreams.org.

The key recommendations from the 2023 LFHMP evaluation included increasing the number of active Flood Advisory Committees (FACs) in municipalities; better incorporating climate-informed science data into planning and design; working with the CWC to reduce the time from closing on a NYCFFBO property to its demolition; and considering LFA studies as "living documents" so they can be updated by the municipality and approved by partners as needed.

Over the last two years, DEP and partners have actively worked on implementing these recommendations. The number of active FACs has increased from two to five, including one that is multi-jurisdictional. Two newly completed LFAs (Lanesville, Margaretville) have incorporated climate change/future flow data into the recommendations included in the reports, and two additional communities, Pine Hill, and Phoenicia, have revised LFAs to ensure these data will be considered in project design. To address new flood hazard mitigation needs, the towns of Olive (West Shokan) and Denning (Sundown) have already or are currently revising previously completed LFAs. Lastly, for the five NYCFFBO demolitions since 2023, the post-closing to demolition/site restoration timeline has been reduced to 491 days, compared to an average of 602 days previously.

Local Flood Analyses and Recommended Projects

The cornerstone of the LFHMP is the LFA, a community-led engineering study using updated floodplain maps and associated hydraulic models to identify areas at risk for inundation in the WOH watershed population centers and to evaluate mitigation scenarios for those areas (Figure 2.21). Since 2021, five LFAs have been completed covering nine population centers at a cost of $505,343. One of the most significant accomplishments of the SMP during this assessment period was the revision of the decade-old LFA Program Rules in 2024 to allow for LFAs to be revised and to support LFAs in newly eligible subsequent study areas.

Since LFHMP initiation, the SMP has funded the completion of 27 LFAs covering 45 population centers at a total cost of $2.22 million. Three additional LFAs are underway, covering four population centers (Chichester, Shokan, West Shokan revision, and Trout Creek).

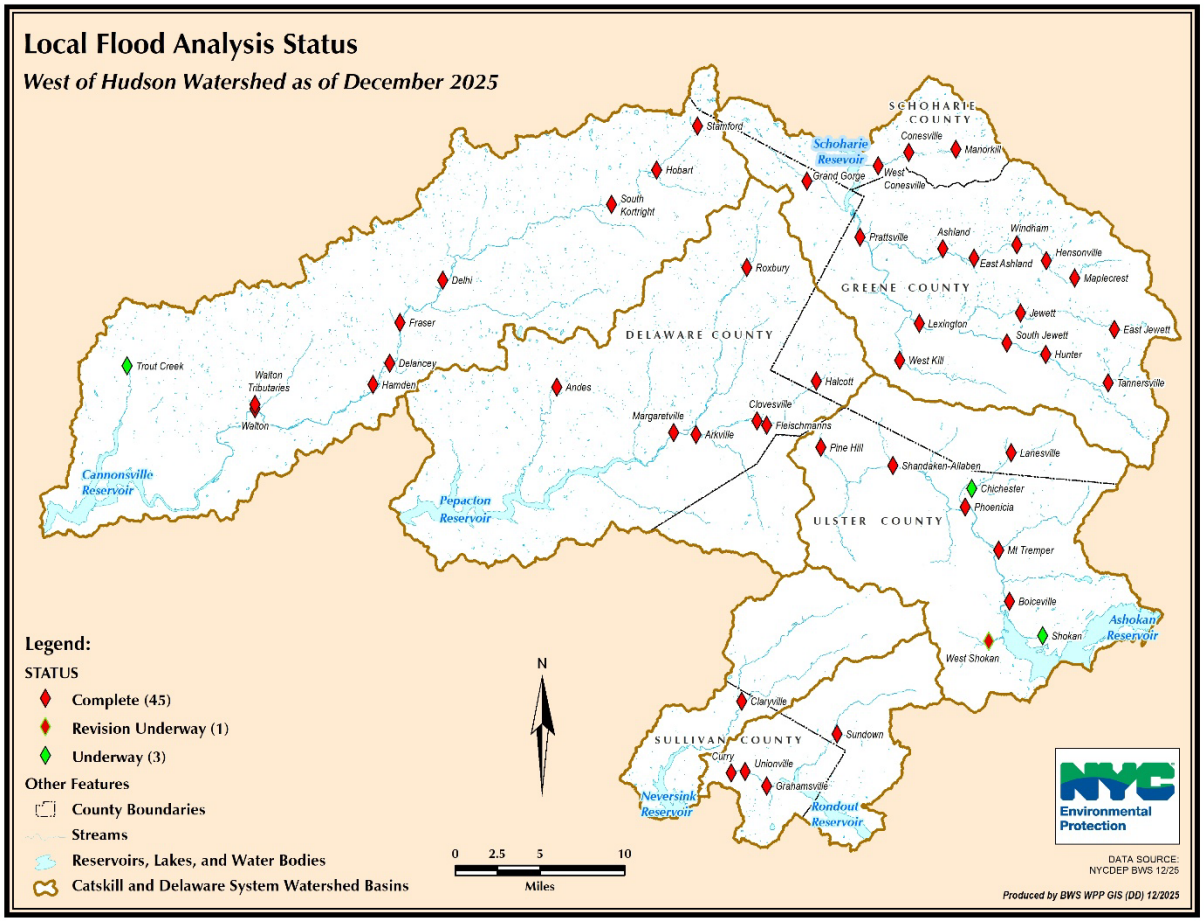


Figure 2.21 Location and status of LFAs completed as of December 2025.

All municipalities undertaking an LFA have adopted or accepted them; all completed LFAs are available at www.catskillstreams.org. Although LFAs for most large population centers are complete, many will need to be revised to include climate informed science and new or "best available" data that may have been generated during the design of LFA-recommended projects. One prior LFA (West Shokan) is currently being revised with an expanded study area and scope, the first revision of this scale.

Through their LFAs, local flood commissions have identified over 200 flood hazard mitigation projects. Of particular importance among these are infrastructure upgrades, floodplain restoration, streambank stabilization, property protection (elevation and floodproofing), and buyout and relocation projects. Of these, the SMP funds the design and construction of projects including floodplain restoration, infrastructure modification and replacement, streambank stabilization, and channel modification. The list of SMP grants supporting the design or construction of LFA-recommended projects during the assessment period is summarized in Table 2.13.

Table 2.13 SMP grants supporting the design or construction of LFA-recommended projects during the assessment period.

Basin	LFA Project Name	Award Type	Award Amount	Status
Pepacton				
	Andes Central School Floodplain Restoration and Streambank Stabilization	Design	$97,001	Complete
	Andes Central School Floodplain Restoration and Streambank Stabilization	Construction	$400,000	Complete
	Vega Mtn Road Culvert Replacement	Design	$400,000	Design
	Elk Creek Road Stabilization	Construction	$300,000	Complete
Cannonsville				
	South Street Bridge Replacement	Construction	$550,000	Design
	South Street Bridge Replacement	Design	$42,500	Design
	Maple Ave Bridge Replacement	Design	$20,000	Complete
	Buntline Drive Culvert Replacement	Construction	$500,000	Design
	Buntline Drive Culvert Replacement	Design	$48,500	Design
	Delhi Price Chopper Berm Removal	Design	$160,000	Design
Schoharie				
	County Route 23C Culvert Replacement	Construction	$500,000	Complete
	County Route 23C Culvert Replacement	Design	$77,000	Complete
	Pangman Road Floodplain Restoration (initial design)	Design	$35,000	Complete
	Pangman Road Floodplain Restoration (advanced design)	Design	$121,990	Complete
	Pangman Road Floodplain Restoration	Construction	$1,135,571	Complete
Ashokan				
	Burgher Road Culvert Replacement	Construction Insp.	$84,740	Complete
	Phoenicia Bridge Street Bridge Replacement	Design	$150,000	Complete
	Phoenicia Bridge Street Bridge Replacement (additional modeling)	Design	$64,040	Design
	Bonnie View and Station Rd Flood Conveyance	Design	$233,190	Design
	Total		$4,919,532	

CWC Local Flood Hazard Mitigation Implementation Program

The CWC LFHMIP supports a wide range of flood hazard mitigation efforts. During the current assessment period, DEP entered into a $15 million dollar successor contract with CWC to continue supporting the implementation of LFA recommendations and related flood hazard mitigation projects. CWC's major accomplishments during this period included the completion of 25 feasibility studies, eight designs, and six elevations under the property protection program; nine awards to municipalities relating to the future relocation of critical facilities; and managing

the demolition of dozens of structures and site restoration on 21 properties acquired through the NYCFFBO. Significant funding from the CWC's LFHMIP contributed to the relocation of the Boiceville fire station, the construction of the Andes Central School Streambank and Floodplain Enhancement project, and the Railroad Avenue Stabilization project in Tannersville. CWC's grants for the assessment period are summarized in Table 2.14.

Table 2.14 Summary of CWC LFHMIP grants and funding allocations during the assessment period.

Type of Project	No. of Grants Awarded	No. of Grants Completed	Total Funding Allocated
Property Protection	40	33	$1,981,550
Relocation	8	6	$538,388
Pollution Prevention	12	12	$142,585
Infrastructure	6	4	$2,317,344
Stream-Related	7	7	$3,007,562
NYCFFBO Demolitions	17	15	$1,852,306
Stream Debris Removal	1	1	$1,250
Total	91	78	$9,840,985

In addition to the property protection studies and designs noted above, and similar projects related to planning for relocation of critical facilities, the CWC professional engineering services contractor provided the capacity for technical assessments for potential flood buyout properties, preparation of safe work and demolition plans for NYCFFBO property acquisitions, and the subsequent demolition coordination and oversight through site restoration.

New York City-Funded Flood Buyout Program

Pursuant to the Revised 2017 FAD, DEP has committed an additional $15 million to the NYCFFBO. Given that most acquisitions are linked directly or indirectly to LFA recommendations, both the SMP and CWC continued to assist municipalities with future-use planning of these flood-prone properties, with CWC overseeing the post-closing removal of structures on these properties.

During the assessment period, there was an observed increase in interest on the part of local municipalities for taking ownership of the buyout parcels instead of the City; DEP supports this apparent trend. Additionally, there has been increasing interest from municipalities in using the NYCFFBO as a vehicle to relocate critical facilities from floodplains. While only one relocation has been completed to date, there are six others in-process that have or will utilize the NYCFFBO, coupled with CWC's LFHMIP relocation assistance.

2.7 Riparian Buffer Protection Program

DEP continues to protect and manage riparian buffers as an essential component of an effective overall watershed protection program. To this end, many of DEP's watershed programs, partnerships, and research initiatives actively address the protection, management, and restoration of riparian buffers in the watershed. Publicly-owned buffers are protected and/or managed through DEP's LAP and Land Management programs, and private buffers are offered management through SMP's Catskill Streams Buffer Initiative (CSBI). DEP and its partners at Greene, Ulster, Delaware, and Sullivan SWCDs have made incremental progress on the Riparian Buffer Protection Program during the 2021-2025 assessment period.

2.7.1 Acquisition and Management of Riparian Buffers on DEP or Controlled Lands

Through the LAP, DEP secures permanent protection for sensitive riparian buffers. Riparian buffers, often including wetlands and floodplains, are usually considered to have a higher water quality protective value than upland areas due to their proximity to streams. Preventing inappropriate development of these areas is a priority for DEP. In its 2020 FAD Expert Panel Review Report, the NASEM suggested that DEP place more emphasis on acquiring riparian lands on critical areas of tributary streams through the NYCFFBO and the SAP managed by the CCCD in the Schoharie basin. During this assessment period, the NYCFFBO acquired 31 acres while the SAP acquired 123 acres. Although the relative combined acreage acquired through SAP and NYCFFBO may seem minimal compared to broader LAP accomplishments, properties acquired under NYCFFBO and SAP contained an average of 97% and 76% surface water criteria, respectively. Overall, through all program elements including DEP's core LAP, the NYCFFBO, the WAC Farm and Forest Conservation Easement Programs, and SAP, LAP extended permanent protection to an additional 24 miles of stream and 1,526 acres of riparian buffer during the assessment period.

In addition, through DEP's increased selectivity of LAP parcels based on greater percentage of surface water features during the past several years, the average surface water criteria on properties in the 20-100-acre range acquired by the City has increased from roughly 34% prior to 2021 to over 55% within the assessment period. Table 2.1 provides a summary of riparian buffers (areas within 300-feet either side of a watercourse), length of streams, and floodplains within City-owned land and conservation easements in the Catskill/Delaware watersheds. DEP considers riparian buffer impacts when reviewing requests from outside parties regarding land use activities and projects on DEP lands. DEP also protects streams and wetlands with a 35-foot buffer requirement around lands leased for agricultural use. See Land Management chapter for more details on DEP's land management activities.

2.7.2 Catskill Streams Buffer Initiative

The CSBI continued implementing riparian buffer protection and enhancement as a component of the SMP throughout this assessment period. CSBI focuses on mapping riparian vegetation to plan riparian buffer establishment; removing invasive species; constructing,

monitoring and maintaining riparian restoration projects; and conducting extensive education and outreach. CSBI was initiated in 2009 and was expanded in 2016 with the establishment of a pilot program to include the federal CREP which would be administered under the WAP by the WAC and DCSWCD. This pilot was designed to incentivize non-agricultural landowner participation in the CSBI program with lease payments and enhanced planting options. DEP now tracks and reports projects as base CSBI and CREP/CSBI projects. This assessment period included the final evaluation of the CREP/CSBI Pilot Program as detailed further in this section.

Native Plant Materials

Central to DEP's overall stream management mission is a commitment to maintaining and restoring forested riparian buffers. To that end, one of the unique aspects of the CSBI is the production of native plant stock for CSBI projects. The SMP partners continued coordination of contracts to provide local native seed collection, propagation and grow out with 16,663 seedlings delivered by the Greenbelt Native Plant Center, located in Staten Island, NY, during the assessment period. However, in 2024, Greenbelt informed the SMP that they were no longer able to continue with the seedling grow out and the last order from them was picked up in September 2024. Starting in 2025, the SWCD CSBI programs were offered the opportunity to partner and utilize the GCSWCD Plant Materials Center (PMC) to grow out plant materials. DEP has provided funding in support of the Greene County PMC expansion which included green houses, irrigation, fencing, soil mixing pads and staffing to provide these resources to all SMP partners for their CSBI projects. The PMC sits on 12.3 acres of GCSWCD-owned land in Windham, NY and has a dedicated staff to manage up to 24,000 trees and shrubs to support the CSBI.

Implementation, Monitoring, and Maintenance

CSBI coordinators at partnering SWCDs implement the program by recruiting landowners, conducting field assessments to determine project eligibility, analyzing historical information, and addressing landowner concerns. When landowner interests align with eligibility criteria, Riparian Corridor Management Plans (RCMPs) are created. RCMPs include a range of recommendations from BMPs landowners can implement themselves to more substantial planting projects that require SWCD assistance. A total of 91 RCMPs were completed during this assessment period.

During this assessment period, the CSBI and CREP/CSBI programs together completed 69 projects over 7.3 stream miles and 106 acres (Table 2.15). As detailed in Table 2.15, a large portion of the length and acreage was accounted for by eight CREP/CSBI projects. CSBI was originally envisioned to fill a perceived riparian buffer programming gap for non-agricultural landowners ineligible for CREP. These nonagricultural buffers, often termed backyard buffers, tend to be numerous, but smaller in size. CREP/CSBI projects tend to be on larger properties that have current or past agricultural land uses. CSBI activity has gradually declined as the pool of eligible properties has decreased (Table 2.16); however, the addition of CREP/CSBI and the ongoing maintenance of existing projects have partially offset this reduction in workload. CSBI

projects represent a diversity of riparian restoration techniques including plant installation and bioengineering practices.

Table 2.15 CSBI progress during the assessment period.

Program	No. of Projects	Length (mi.)	Acres Planted
CSBI	61	4.5	29.5
CREP-CSBI	8	2.8	76.5
Total	69	7.3	106

Table 2.16 CSBI and CREP/CSBI progress in the last three FAD Assessment periods.

FAD Period	CSBI	CREP/ CSBI	Total Projects	Length CSBI (mi.)	Length CREP (mi.)	Acres CSBI	Acres CREP
2011-2015	132	0	132	10.0	0	60.0	0
2016-2020	68	4	72	5.4	1.5	42.9	19.6
2021-2025	61	8	69	4.5	2.8	29.5	76.5
Totals	261	12	273	19.9	4.3	132.4	96.1

Figure 2.22 illustrates the approximate locations for all CSBI projects completed during this assessment period as well as since the inception of CSBI in 2009. Since 2009, the CSBI program has completed 317 projects over 29.5 stream miles and 266 acres. Gaps in the forested riparian buffer were revegetated through installation of over 31,434 trees and shrubs during the assessment period, and more than 128,000 to date.

Site preparation and protective measures are designed to optimize survival of plantings, improve growth rates, and reduce the need for project maintenance. Prior to planting, often for several years, invasive species are removed to the extent possible. At planting, deer fencing, tree tubes, weed mats, beaver deterrents, and herbicides are used to reduce herbivory and competition. Following planting, monitoring is completed and tracked by the SMP partners and used to identify maintenance needs and adjust future species selection. DEP provides program interns through a partnership with SUNY Ulster, SUNY Delhi, and Student Conservation Association-AmeriCorps for both monitoring and maintenance of CSBI projects. Throughout this assessment period, 310 CSBI projects were monitored and 139 projects received maintenance including adding plants, reseeding, fertilizing, and fixing tree protection tubes.

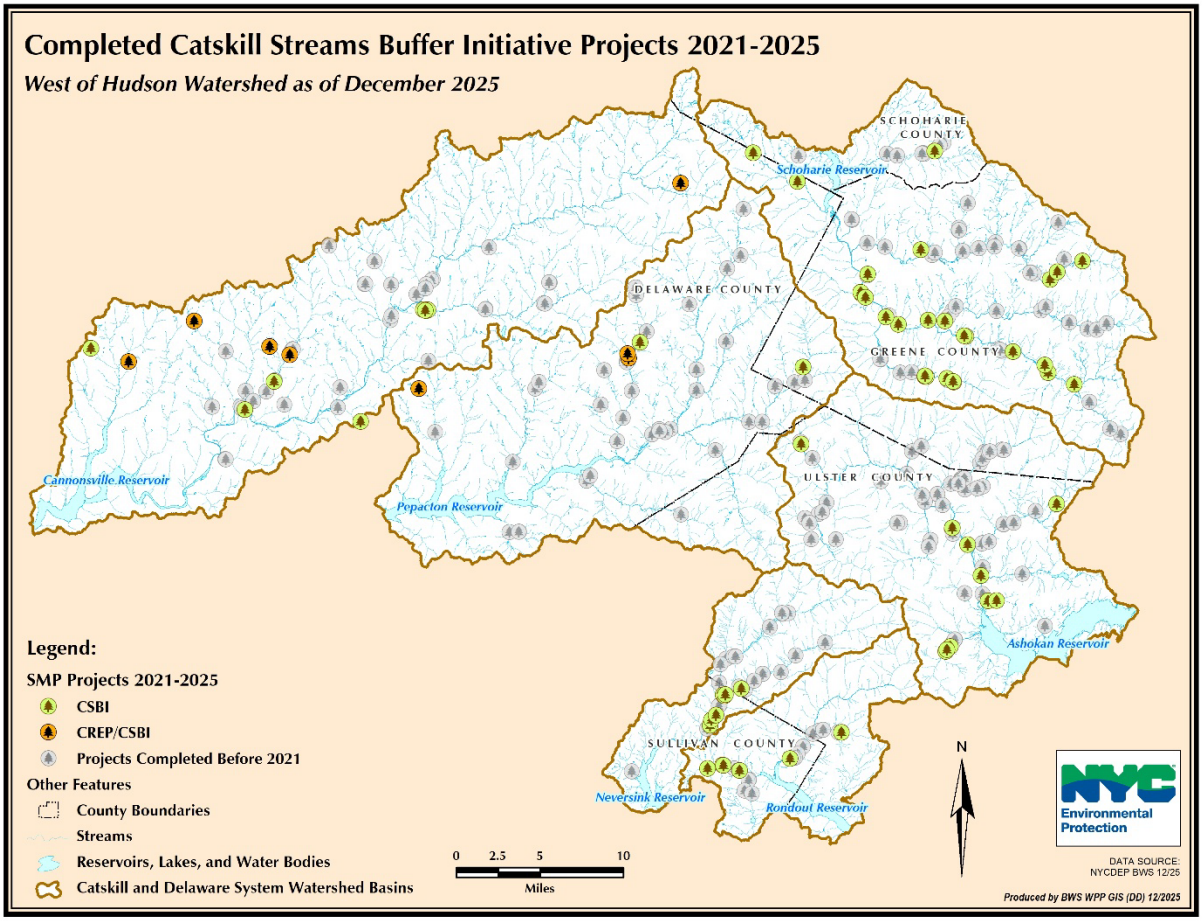


Figure 2.22 Project locations for all CSBI projects during this reporting period and to date since 2009.

One example of a typical CSBI project completed during this assessment period is the riparian buffer restoration along an unnamed tributary to the Upper Rondout Creek within the Rondout watershed (Figure 2.23). The project was completed in 2021 and encompassed 552 linear feet of streambank and covered approximately 0.6 acres (26,130 square feet) on a residential property in Grahamsville, NY. The property exhibited visible bank erosion along the toe of the streamside edge, making it a high priority for riparian vegetation protection. The restoration aimed to address the landowner's priorities of reducing streambank erosion, improving pollinator conditions, and supporting native biodiversity with the installation of 300 native plants. Riparian plantings such as this can stabilize streambanks with root systems, reducing erosion, and filtering runoff to protect water quality. Forested buffers also protect aquatic ecosystems by shading water to lower temperatures, providing habitat for wildlife.

Figure 2.23 CSBI project in Grahamsville, NY designed and planted by SCSWCD in 2021.

CREP/CSBI Pilot Program

The 2017 FAD required the DEP to establish a partnership between the CSBI and the federal CREP administered by USDA. This pilot program officially began in 2017 and originally was intended to occur over a two-year period. In the 2019 evaluation, a two-year extension was approved to allow for additional projects to be completed resulting in more data being available to facilitate a thorough review of the established evaluation metrics. In 2021, a second evaluation report recommended an additional four-year extension through November 2025, due to the COVID-19 pandemic delaying project implementation. The final evaluation was submitted to NYSDOH on November 31, 2025, as required by the Revised 2017 FAD. This final evaluation provided a comprehensive review of the pilot program over an eight-year time frame and included recommendations made in consultation with the WAC and DCSWCD who jointly administered the CREP/CSBI Pilot Program.

Through the term of the pilot program, 12 CREP/CSBI riparian planting projects were completed in Delaware County on 4.7 miles of stream and 96.8 acres. Of the 96.8 acres planted, 52.3 acres were enrolled into CSBI and the remaining 44.5 acres were enrolled into CREP. Although only 12 of the total 318 riparian buffer projects completed since CSBI started in 2009 were through CREP/CSBI, these projects accounted for 37% of the total program acres and 16% of the total program stream lengths planted (Table 2.17). Combining the two programs allows for

larger buffer widths and planting densities, promotes the use of larger plants, facilitates maintenance through CSBI, and provides financial incentives to landowners through CREP to entice participation. The pilot achieved a noteworthy increase in riparian buffers while providing federal funds to offset the installation cost to DEP and provide landowners with additional financial incentives to participate. However, the evaluation found that the number of annual projects completed was much lower than originally projected but still substantially contributed to meeting the Revised 2017 FAD CSBI deliverable of revegetating a minimum of 10 streambank miles throughout the WOH watershed.

Table 2.17 CSBI base program and CREP/CSBI pilot program projects completed through 2025.

	All Projects (2009-2025)	CSBI Projects (2009-2025)	CREP/CSBI Projects (2017-2025)
Number of projects	312	300	12
Stream length (miles)	29.5	24.8 (84%)	4.7 (16%)
Area (acres)	264.5	167.7 (63%)	96.8 (37%)

The 2025 report concluded that the CSBI program will continue to offer CREP as an option for landowners with eligible fallow agricultural lands. The CSBI program is a positive complement to CREP as it allows for larger buffer widths, increased planting densities, a mechanism to address instability of stream banks, increased maintenance, and invasive species mitigation efforts.

While this pilot focused on Delaware County, CREP/CSBI was offered throughout the WOH watershed, but no projects were completed outside of Delaware County. Greene, Sullivan and Ulster County SWCDs reported that federal contracting requirements coupled with modest landowner incentive payments on smaller parcels were insufficient to compel landowners to enroll into CREP. These counties lack the large fallow agricultural lands that are present in Delaware County, making it more financially lucrative for landowners in Delaware County to sign up for the CREP program. Nonetheless, CREP will continue to be made available as a component of CSBI throughout the entire WOH watershed.

Finally, DEP recommended that future CREP/CSBI riparian plantings further target priority sub-basins where pollutant filter strips have greater value to water quality protection and to further examine and better understand potential unintended environmental and health effects of the widespread uses of herbicides on riparian planting project sites.

The Carr CREP/CSBI project, located in Walton, NY along Kerr's Creek in the Beers Brook sub-basin of the Cannonsville watershed is one example from the pilot. Beers Brook sub-basin was identified as the second highest priority of the 24 sub-basins analyzed in the pilot. Prioritization of sub-basins is based on the relative amount of non-forest lands, the proportion of agricultural buffer land, soil loss and erosion potential, the number of upstream animal units,

and, lastly, planting potential within 100 feet of a watercourse. In 2025, 6.2 acres were planted at this site with 809 trees and shrubs, with four acres enrolled into CREP and the remaining 2.2 acres into the CSBI program (Figure 2.24). The landowner was then able to leverage this riparian planting to meet acreage requirements to enroll into NYS's 480-a Forest Tax Law, which provides additional financial incentives to encourage sustainable stewardship of forested lands.

Watershed Agriculture Program and Watershed Forestry Program

Please refer to Sections 2.4 and 2.5 of this report for information about the riparian buffer protection efforts of the Watershed Agriculture and Forestry programs.

Figure 2.24 Riparian restoration through the CREP/CSBI program at the Carr property, designed and planted by DCSWCD in 2025.

2.8 Waterfowl Management Program

2.8.1 Introduction

The management of waterbird populations at Kensico Reservoir is essential to meet the requirements of USEPA's SWTR and the City's FAD. DEP's Waterfowl Management Program (WMP) was established to research the relationship between wildlife, particularly waterbirds that inhabit the reservoirs (geese, gulls, cormorants, swans, ducks, and other duck-like birds), and fecal coliform bacteria concentrations in surface water prior to disinfection. Following several years of waterbird population monitoring, DEP identified birds as a significant source of fecal coliform bacteria in Kensico Reservoir. In addition, migratory waterbirds utilize DEP reservoirs as temporary staging areas and wintering grounds significantly contribute to increases in fecal coliform loadings during autumn and winter, primarily from direct fecal deposition. These

waterbirds generally roost nocturnally and occasionally forage and loaf diurnally on the reservoirs, although most of the feeding activity occurs off reservoir in surrounding watershed property. Previous DEP annual summary reports (DEP 1993 – 2025) have documented that fecal coliform increases have occurred concurrently with increases in waterbird populations and significant precipitation events in water samples collected near roosting locations at several reservoirs.

In response, DEP implemented standard waterbird management techniques approved by USDA, Animal and Plant Inspection Service, Wildlife Services, NYSDEC and United States Fish and Wildlife Service (USFWS) to reduce or eliminate the waterbird populations inhabiting the reservoir system. In combination with these standard dispersal and deterrence techniques, an additional measure is used to manage local breeding populations of Canada geese (*Branta canadensis*) and mute swans (*Cygnus olor*): identification of nesting locations and subsequent depredation of eggs and nests, covered under a USFWS registration and NYSDEC permit respectively.

Since the implementation of the combined dispersal and deterrence measures, there has been a dramatic reduction in both roosting waterbird populations and fecal coliform levels, which has helped DEP maintain high quality water in compliance with SWTR. While developed for Kensico Reservoir in 1992, the WMP was expanded to include five additional reservoirs (West Branch, Rondout, Ashokan, Croton Falls, and Cross River) for waterbird management on an as needed basis. In addition, DEP has implemented an enhanced wildlife management program which includes waterbirds, terrestrial birds, and mammals at Hillview Reservoir to further protect the water supply.

Implementation of the WMP is described in the sections that follow. The water quality results of the program are described in Chapter 4, in the discussion of each reservoir basin in which the program was implemented.

2.8.2 Waterbird Census

DEP and its contractor conducted surveys to track the number of waterbirds on the reservoirs throughout the year because of the well-established relationship between elevated waterbird counts and increased levels of fecal coliform bacteria in raw water samples. Currently, reservoir waterbird surveys are conducted throughout the calendar year at Kensico and Hillview reservoirs and for part of the year at West Branch Reservoir. Additional surveys are conducted on an as needed basis at reservoirs that are sources or possible sources to Kensico, including Croton Falls, Cross River, Rondout, and Ashokan. Under a Water Quality Monitoring Plan for Croton Falls and Cross River Pump Station Operations Plan, DEP is required to conduct waterbird surveys during pumping operations. As needed waterbird censuses were conducted at Croton Falls and Cross River reservoirs in 2021, 2023, and 2024, during periods of pump station testing and operations. Mammal trapping is conducted year-round at Hillview Reservoir and as

needed at other reservoirs. The frequency of surveys varies based on the reservoir and time of year (Table 2.18).

Waterbird Mitigation

The current program at Kensico Reservoir and as needed reservoirs listed in Table 2.18 employs motorboat, Biondo airboats, pyrotechnics, propane cannons, and physical chasing techniques with occasional deployment of remote-control motorboats. Lethal removals of ducks with the DEP Police Special Operations Unit and through a USDA, Wildlife Services Cooperative Service Agreement, are conducted on an as needed basis at Hillview Reservoir. Additional wildlife mitigation measures have been instituted at Hillview including trapping and removal of mammals along the reservoir perimeter; nest and egg depredation of nesting mallard ducks (*Anas platyrhynchos*), and swallows; and daily wildlife sanitary surveys. Overhead bird deterrent wires were maintained over the reservoir surface and additional wires, and netting have been installed along the reservoir dividing wall and water influent and effluent facilities to prevent terrestrial bird species from nesting and roosting. The waterbird dispersal program at Kensico is conducted between August 1 and March 31 of each year, while the Hillview program is performed daily year-round.

Table 2.18 Reservoir wildlife monitoring and mitigation, 2021-2025.

Reservoir	Time period	Activities
Kensico Reservoir		
Monitoring:	Daily August 1 to March 31 and weekly April 1 to July 31, annually.	Motorboats and shoreline.
Dispersal:	August 1 – March 31, annually.	Motorboats, pyrotechnics, and Biondo airboats
Deterrence/ Prevention:	As needed building inspections. August to March baitfish collections. Weekly wildlife excrement surveys.	Bird deterrent netting on intake building, baitfish collection, and wildlife excrement sanitary surveys.
Depredation:	April to June Canada goose and mute swan nest/egg, annually. April to June Canada goose removals, as needed. April to July swallow nest/egg removals, as needed.	Nest and egg for Canada geese, mute swans, and swallows. Canada goose removals via Westchester County Airport contract.
West Branch Reservoir		
Monitoring:	Biweekly August 1 to April 15, annually.	Shoreline.
Dispersal:	As needed August 1 to April	None required during this

Reservoir	Time period	Activities
	15, annually.	reporting period
Deterrence/ Prevention:	As needed.	Bird deterrent netting on intake.
Depredation:	April to June, annually.	Nest and egg for Canada geese and mute swans.
Rondout Reservoir		
Monitoring:	As needed. Conducted in 2024. Two special investigations in 2022, one in 2024, and one in 2025.	Shoreline.
Dispersal:	As needed, August 1 to April 15, annually.	None required during this period.
Deterrence/ Prevention:	As needed. Conducted in 2024.	Sanitary survey around intake.
Depredation:	April – June, annually.	Nest and egg for Canada geese and mute swans.
Ashokan Reservoir		
Monitoring:	As needed. Conducted in 2022 and 2024. One special investigation in 2022.	Shoreline.
Dispersal:	As needed, August 1 to April 15, annually.	None required during this reporting period.
Deterrence/ Prevention:	As needed. Conducted in 2022.	Sanitary survey and mammal trapping.
Depredation:	April – June, annually.	Nest and egg for Canada geese and mute swans.
Croton Falls Reservoir		
Monitoring:	As needed. Conducted in 2021, 2023, and 2024.	Shoreline and motorboat.
Dispersal:	As needed, August 1 to April 15. Conducted in 2023 and 2024.	Motorboats and pyrotechnics.
Deterrence/ Prevention:	As needed.	None required during this reporting period.
Depredation:	April – June, annually.	Nest and egg for Canada geese and mute swans.
Cross River Reservoir		
Monitoring:	As needed, August 1 to April 15. Conducted in 2021, 2023, and 2024.	Shoreline.
Dispersal:	As needed, August 1 to April 15, annually.	None required during this period.
Deterrence/ Prevention:	As needed.	None required during this reporting period.
Depredation:	April – June, annually.	Nest and egg for Canada geese and mute swans

Reservoir	Time period	Activities
Hillview Reservoir		
Monitoring:	Daily, year-round.	Shoreline and reservoir dividing wall.
Dispersal:	Daily, year-round.	Pyrotechnics, propane cannons, physical chasing.
Deterrence/ Prevention:	Daily, year-round.	Wildlife sanitary surveys, overhead, railing and facility bird deterrent wires.
Depredation:	April–August, nest and egg, annually. Waterbirds year-round as needed. Mammal trapping year-round.	Nest and egg for swallows and mallards. Waterbird removals under USFWS Depredation Permit. Mammal trapping.

Beginning daily at 8 a.m. and continuing until approximately 1.5 hours past sunset, bird dispersal activities were conducted reservoir-wide a Kensico and Hillview, targeting all species except those designated as endangered or threatened by USFWS and NYSDEC (

Figure 2.25). Species of Special Concern listed by NYSDEC are also avoided for dispersal actions. As needed bird dispersal actions were conducted on a limited basis at Croton Falls Reservoir during pump station operations in 2023 and 2024. There were no dispersal actions at the additional four as needed reservoirs (Table 2.19).

Waterbird Depredation Actions

Under a contract between the Westchester County Airport and the USDA Wildlife Services, removals of Canada geese occurred at Kensico Reservoir for aircraft protection. FAA guidance requires commercial airport operators to develop and implement a plan to identify all aviation hazards such as bird strikes at off-airport properties. Westchester Airport applies a 7-mile radius extending from the outer boundaries of the airport to conduct Canada goose management activities. In Westchester County, Kensico Reservoir has been identified as an important bird attraction area located on the western side of the airport and therefore subject to bird mitigation actions. From 2021 through 2025, the USDA under DEP permission removed 19 Canada geese to reduce risk of bird strikes to departing from and arriving at the airport aircraft.

Waterbird Deterrence

DEP conducted annual springtime breeding surveys and nest/egg depredation for Canada geese, mute swans, and mallard ducks within reservoir property to suppress reproductive success, which in turn eliminates population recruitment and breaks site fidelity of nesting adults. Preliminary surveys of waterbird nests began in late March and continued through late

Figure 2.25 DEP conducting waterbird observations and dispersals.

July for late nesting birds. During the reporting period, the WMP conducted 779 surveys of 219 nests and depredated 1,094 eggs as shown in Table 2.19 and Table 2.20.

Each nest and egg was labeled, and each egg was punctured with a probe to break the membranes, thereby destroying the embryo. After puncturing, eggs were replaced in the nest to allow incubation to continue. A small number of goose nests were destroyed late in the breeding season to encourage the birds to relocate off reservoir property during the annual post-nuptial molt, when the birds were rendered flightless for several weeks. All depredation activity was conducted under the terms of a USFWS registration for Canada geese and NYSDEC permit for mute swans.

DEP staffed seasonally monitored (April through July) for nesting cliff swallows (*Petrochelidon pyrrhonota*), barn swallows (*Hirundo rustica*), and tree swallows (*Tachycineta bicolor*) on reservoir infrastructure (e.g. wires, buildings) where they could impact water quality. In the event nests are identified they would be removed along with eggs/young under a USFWS depredation permit. None were depredated during the reporting period.

Table 2.19 Egg depredation summary for Canada geese and mute swans, 2021-2025.

Reservoir	Surveys	Canada geese nests (eggs depredated)	Mute swan nests (eggs depredated)	Depredation success rate for Canada geese/mute swans (no. surviving young)
Kensico	36	49 (198)	0	97.06% (6 goslings)
West Branch	35	22 (106)	0	95.50% (5 goslings)
Rondout	17	25 (107)	0	82.95% (22 goslings)
Ashokan	17	38 (181)	0	82.65% (38 goslings)
Croton Falls	36	48 (283)	2 (11)	100% (0 goslings/0 cygnets)
Cross River	37	25 (107)	0	82.95% (22 goslings)

Table 2.20 Egg depredation summary for mallards and swallows, 2021-2025.

Reservoir	Surveys	Mallard nests (eggs depredated)	Swallow nests (eggs depredated)	Depredation success rate for mallards (number surviving young)
Hillview	601	10 (101)	0 (0)	100% (0 ducklings)

Baitfish (Alewives)

In response to entrainment of baitfish (mostly alewives (*Alosa pseudoharengus*)) into the water intake structures at Ashokan Reservoir and their subsequent entry into Kensico Reservoir, the DEP waterfowl management contractor installed a temporary collection boom around the Catskill Influent Chamber as needed to collect and remove the dead fish. Table 2.21 presents an estimate of the amounts of alewives collected during each bird dispersal season (August 1 through March 31) at Kensico from 2021 to 2025. DEP also monitors entrainment of baitfish at West Branch and Rondout reservoirs and the entry into Kensico at the Delaware Influent Chamber, however no fish collections were required during this reporting period. Alewives are an attractive food source for gulls and some species of ducks. When large numbers of fish are flushing into the reservoir, the gulls become very difficult to manage. Installation of the boom and collections of baitfish are based on daily observations and installed only as needed from year to year.

Table 2.21 Alewife collections, 2021–2025.

Season (August 1 – March 31)	Estimated Amount (pounds)
2021 - 2022	4
2022 - 2023	297
2023 - 2024	97
2024 - 2025	310

Wildlife Excrement Sanitary Surveys

DEP conducts sanitary surveys at the Kensico Reservoir as a proactive measure to identify and remove wildlife excrement before it washes into the water supply from shoreline locations adjacent to effluent structures and potentially elevates fecal coliform levels. From 2021 to 2025, DEP's contractor conducted 204 wildlife sanitary surveys at Kensico Reservoir (Table 2.22). In February 2023, DEP implemented routine weekly sanitary surveys in addition to its longstanding practice of conducting them 24 to 48 hours prior to significant precipitation. Of the 16,819 fecal samples collected, 63% were confirmed to species level with 7,307 (43%) attributed to Canada geese, 6,144 (37%) to passerine birds, 2,621 (16) % to white-tailed deer, and the remaining 4% to rabbit, coyote, raccoon, bobcat, mink, domestic dog, mink, fox, striped skunk, and unknown mammals. All samples were removed from the property following collections.

Table 2.22 Wildlife excrement sanitary surveys, 2021 – 2025.

Species	Excrement Samples Collected					
	2021	2022	2023	2024	2025	Total by Species
Canada Geese	135	103	6,084	366	619	7,307
Passerine Birds	234	112	2,023	1,942	1,833	6,144
White-tailed Deer	460	1,348	316	147	350	2,621
Eastern Cottontail Rabbit	13	34	26	166	267	506
Unknown Mammal	24	24	33	22	25	128
Coyote	5	7	27	21	10	70
Raccoon	8	6	3	0	1	18
Bobcat	0	8	8	0	0	16
Domestic Dog	4	0	0	0	0	4
Mink	1	0	0	0	2	3
Fox	0	0	1	0	0	1
Striped Skunk	1	0	0	0	0	1
Total by Year	885	1,642	8,521	2,664	3,107	16,819

2.9 Ecosystem Protection Program

2.9.1 Wetlands Protection Program

Freshwater wetlands provide numerous functions and values that help maintain the high-quality of surface waters in the watershed. They intercept and store runoff to help abate flooding, prevent erosion, trap sediment, and cycle nutrients such as carbon and nitrogen. Wetlands also recharge groundwater and sustain stream baseflow, which is crucial to maintaining aquatic habitat during dry periods. Wetlands also provide habitat for numerous plant and animal species. Sensitive species like the marbled salamander (*Ambystoma opacum*), spotted turtle (*Clemmys guttata*), and the bog turtle (*Glyptemys muhlenbergii*) rely on swamps, marshes, and seasonal

pools for their life cycles. Wetlands also afford many recreational opportunities like boating, fishing, nature watching, and education.

Recognizing these important functions and values, DEP implemented a Wetlands Protection Strategy in 1996 to characterize and protect wetlands in the watershed. The Strategy was updated with each subsequent FAD renewal and the last update occurred in 2018. The following sections summarize those actions over the reporting period.

Wetland Mapping

Work was completed in 2022 on the contract to expand the 2015 Light Detection and Ranging (LiDAR) wetland mapping pilot study to the entire watershed. Incorporating LiDAR-derived topography and high-resolution aerial photography into an automated mapping protocol significantly increased the acreage of vegetated wetlands mapped throughout the watershed as compared to the most recent (2005) National Wetlands Inventory (NWI). Mapped vegetated wetland acreage nearly doubled WOH and increased by approximately 70% EOH. In addition, by amending the local resolution National Hydrography Dataset with over 400 miles of new connecting features, the percentage of wetlands estimated to be unconnected to the stream network decreased from 10% to 2% EOH, and from 8% to 3% WOH. This is a significant decrease from the 35% and 54% of wetlands that would be predicted to be unconnected using the medium resolution NHD.

Given the high degree of topographic relief, and smaller average wetland sizes, accurately mapping wetlands in the WOH watershed is more challenging than EOH. Hence, DEP completed a desktop accuracy assessment for the WOH LiDAR derived wetland coverage in 2024. DEP wetlands scientists evaluated 1,000 randomly selected points to determine whether they were correctly represented as wetland or upland in the LiDAR-derived coverage. The LiDAR-derived coverage correctly mapped 62% of the points that fell within wetland areas, whereas the NWI included only 33%.

Reference Wetland Monitoring

DEP gains information on the characteristics and functions of watershed wetlands through its wetland monitoring program. DEP has collected vegetation, soils, and long-term hydrologic data from vegetated and seasonal pool (vernal pool) wetlands throughout the CAT/DEL watershed. These data provide benchmarks to guide wetland protection and management efforts and identify ecological trends from factors such as surrounding land use, climate change, or invasive species.

From 2021 to 2025, DEP added 42 seasonal pool wetlands to the monitoring program, including three in the Kensico watershed, bringing total pools monitored to 60. Seasonal pool condition and productivity can be important indicators of landscape scale ecosystem functioning. Seasonal pools serve as storage basins which trap surface water and prevent erosion. They recharge shallow sub-surface aquifers and store large amounts of carbon relative to their area. Water quality data (pH, dissolved oxygen, temperature, and specific conductivity) were collected from seasonal pool sites throughout the growing season. Spring adult breeding amphibian and invertebrate surveys, and amphibian egg mass counts were also conducted (Figure 2.26). In addition to providing indicators of condition and function of seasonal pools on City-owned lands, DEP used these data to evaluate and inform regulatory thresholds for productive vernal pools under the revised NYS Article 24 regulations for Wetlands of Unusual Importance.

Figure 2.26 Adult spotted salamander (Ambystoma maculatum) from a seasonal pool monitoring site.

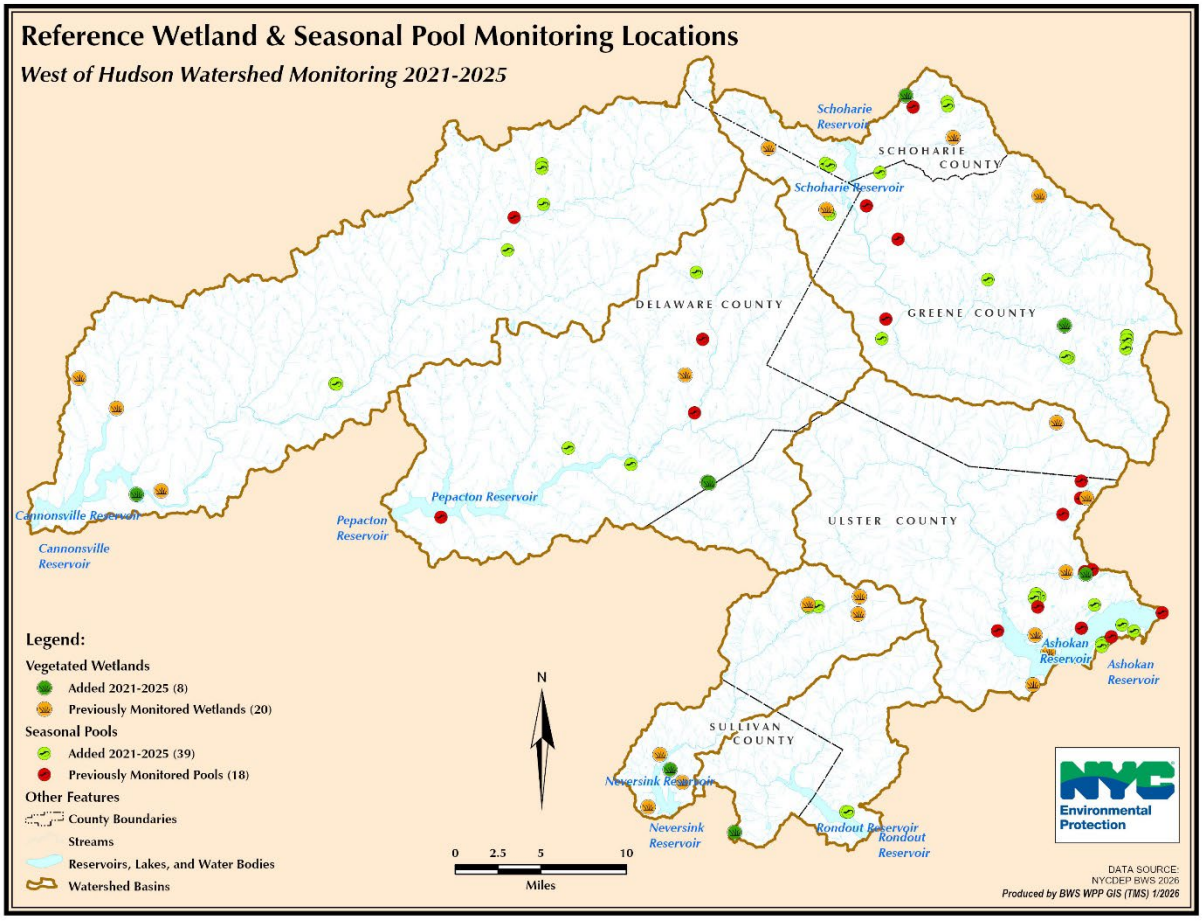


Figure 2.27 Wetland and seasonal pool monitoring locations. Three additional pools are located EOH in the Kensico Reservoir basin.

DEP added eight vegetated reference wetland monitoring sites in the WOH watershed (Figure 2.27). Newly added wetland types include inland poor fens, hemlock swamps, high elevation peatlands, and bogs, all of which were previously unrepresented or under-represented in the reference wetlands monitoring program. Monitoring sensitive, carbon accumulating wetland types like high elevation peatlands and inland poor fens can improve understanding of the response of these ecosystems to climate change and further characterize watershed sources of dissolved organic carbon. Water table loggers were installed in all eight wetlands, and soil samples were collected from three wetlands for analysis of carbon content, macronutrient composition, and macro-fossils. Soil temperature, water table elevation, and plant species and cover data were collected at the sites to characterize and evaluate ecological trends over time.

DEP continued its partnership with New York Natural Heritage Program (NYNHP) to help develop statewide wetland assessment methodology (Development of Wetland Assessment Protocols in New York - New York Natural Heritage Program). To date, DEP has evaluated 14 wetlands using this methodology.

Watershed Regulatory Program

DEP continued to review federal, state, and municipal wetland permit applications in the watershed to provide comments when alternatives that would avoid, minimize, or mitigate wetland and water quality impacts were identified. From 2021 through 2025, DEP reviewed a total of 183 wetland permit applications in the watershed, the majority of which (136) were in non-FAD basins.

Of the 47 applications in the FAD basins, 35 were submitted pursuant the NYS Freshwater Wetlands Act (NYS Environmental Conservation Law, Article 24), which regulates freshwater wetlands and their 100-foot adjacent areas. The remaining wetland applications in FAD basins included 10 that were pending before local municipalities in New York and Connecticut and two were federal wetland applications (filed under Section 404 of the Clean Water Act, P.L. 92- 500, as amended by P.L. 95-217). Of the 136 applications in the non-FAD portion of the Croton System, 73 were submitted pursuant to Article 24, 50 were applications before local municipalities and 13 were federal wetland applications.

The majority of the applications in both FAD (74%) and non-FAD (84%) basins were for activities that would not result in a reduction of wetland area, such as aquatic invasive species management, pond dredging, and adjacent area impacts (Figure 2.28). This demonstrates the cumulative effectiveness of wetland protection programs at minimizing permitted encroachments. This analysis does not, however, capture activities that do not require permits or pre-construction notification.

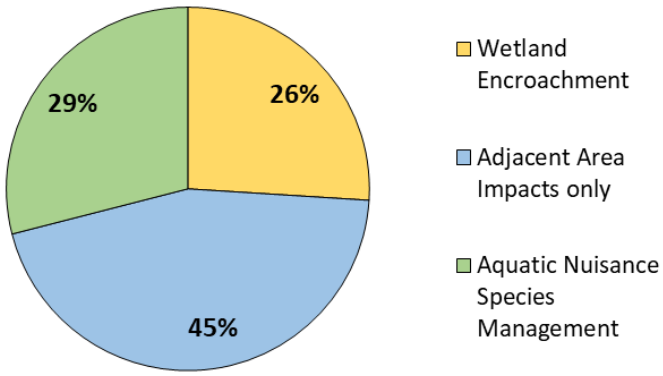


Figure 2.28 Activity types in wetland permits reviewed in FAD basins 2021-2025.

During the reporting period, DEP remained engaged and provided input on critical issues surrounding state wetland jurisdiction under NYS Freshwater Wetlands Act. In 2025, NYSDEC implemented changes to Freshwater Wetland Regulations (6 NYCRR Part 664) necessitated by 2022 amendments to the NYS Freshwater Wetlands Act. As of January 1, 2025, former regulatory maps (generally depicting wetlands 12.4 acres and larger) became informational only, and additional informational mapping (including wetlands beneath the 12.4-acre threshold) was

provided. The expanded informational maps increased the total acreage of DEC-mapped wetlands in the watershed from approximately 23,000 to 33,000 acres. NYSDEC also expanded its jurisdiction over smaller wetlands with expanded criteria for wetlands of "unusual importance". Effective 2028, NYSDEC's jurisdiction will be extended to wetlands 7.4 acres and larger. In 2024, DEP provided comments on NYSDEC's proposed amendments to its Freshwater Wetland Regulations (6 NYC Part 664) prior to their 2025 issuance. In 2025, DEP commented on NYSDEC's Proposed Draft Freshwater Wetlands General Permit (GP-0-25-003), and on five new, and modifications to four existing, Statewide General Permits for various activities in state-regulated freshwater wetlands and wetland adjacent areas, protected waterbodies, and navigable waters.

Land Acquisition

According to the NWI and NYSDEC Previously Mapped Freshwater Wetland coverages, there are approximately 15,190 acres of wetlands in the Catskill/Delaware (CAT/DEL) watershed. Since 1997, DEP has protected 3,137 acres or 20.6% of these wetlands through its LAP (See Section 2.2). This includes an additional 120 acres of wetlands acquired during the 2021-2025 FAD assessment period. In the CAT/DEL watershed, pre-MOA DEP lands contain 970 acres (6.4%) of wetlands, with an additional 1,337 acres (8.8%) of wetlands located on state or other protected lands, amounting to 35.8% of wetlands being on protected lands in the CAT/DEL watershed. Table 2.23 summarizes the acreage of wetlands protected through acquisition for both the CAT/DEL and Croton watersheds.

DEP Forest Management Project Review

DEP conducts an interdisciplinary review of its proposed forest management projects to ensure long-term responsible stewardship of natural resources on City lands. As part of this review, DEP wetland scientists delineate on-site wetlands that are treated as exclusion zones in which no disturbance is permitted under normal circumstances. Moreover, the 100-foot buffer surrounding wetlands is considered a special management zone, where tree removal and equipment operation are limited. From 2021-2025, DEP wetland scientists delineated 89 wetlands comprising 78.9 acres in 15 proposed forest management projects on City lands.

Education and Outreach

Throughout the review period DEP staff conducted numerous educational outreach programs for college students, the public, and other watershed stakeholders on wetland ecology and conservation. DEP led five field ecology classes with students from the SUNY Ulster. The classes focused on field identification of wetland plants and soils and discussed structured monitoring of wetland mitigation sites. DEP also presented the results of the LiDAR wetlands mapping project at annual coordination meeting of the National Association of Wetland Managers in 2022. Other outreach activities included several public programs celebrating American Wetlands Awareness Month (May) and programs on vernal pool ecology.

Table 2.23 Wetlands and Deepwater habitats Acquired or Protected by the NYC LAP in the Catskill/Delaware and Croton Systems as of December 31, 2025.

Description	Acres	% of Total Watershed Acreage	% of Total Land Acquired	% of Total Wetlands or Deepwater Habitats in System
Catskill/Delaware System (Ashokan, Schoharie, Rondout, Neversink, Pepacton, Cannonsville, West Branch, Boyd Corners, Kensico basins)				
Total Acreage of Entire Watershed	1,048,660			
Total Acreage of Wetlands (both NWI and DEC-regulated) in Entire Watershed (excluding Deepwater Habitats**)	15,190	1.45%		
Total Acreage of Deepwater Habitats in Entire Watershed	28,335	2.70%		
Total Acreage of Wetlands and Deepwater Habitats in Entire Watershed	43,526	4.15%		
Total Lands Under Contract or Closed by NYCDEP as of 12/31/25†*:	155,316	14.81%		
Within those total lands under contract or closed:				
Total Acreage of Wetlands (both NWI and DEC-regulated, excluding Deepwater Habitats**)	3,137		2.02%	20.65%
Total Acreage of Deepwater Habitats**	231		0.15%	0.81%
Total Acreage of Wetlands and Deepwater Habitats**	3,368		2.17%	7.74%
Croton System				
Total Acreage of Entire Watershed	212,700			
Total Acreage of Wetlands (both NWI and DEC-regulated) in Entire Watershed (excluding Deepwater Habitats**)	20,025	9.41%		
Total Acreage of Deepwater Habitats in Entire Watershed	10,808	5.08%		
Total Acreage of Wetlands and Deepwater Habitats in Entire Watershed	30,834	14.50%		
Total lands under contract or closed by NYCDEP as of 12/31/25†*:	1,937	0.91%		
Within those total lands under contract or closed:				
Total Acreage of Wetlands (both NWI and DEC-regulated, excluding Deepwater Habitats**)	96.0		4.96%	0.48%
Total Acreage of Deepwater Habitats**	1.6		0.08%	0.02%
Total Acreage of Wetlands and Deepwater Habitats**	97.6		5.04%	0.32%

** Source: SWP GIS, December 31, 2025. Note: Acres are calculated directly from areas of GIS polygons and therefore may not match exactly other acreage totals submitted by DEP. Watershed statistics calculated from LiDAR-derived 1m basin boundaries updated in 2014.*

*** Categories considered "Deepwater Habitats" include reservoirs or large lakes (L1), unconsolidated bottom (L2UB), riverbeds (RUB & RRB) or streambeds (RSB). Categories considered wetlands include Palustrine Systems and exclude the Deepwater Habitats classes as well as all upland (U), and unconsolidated shore (L2US).*

† Includes fee, conservation easements, and farm easements. Excludes non-LAP and pre-MOA land.

Statistics produced by J. Tuscanes, BWS SWP GIS, 1/22/2026

2.9.2 DEP Forest Management Program

Maintaining healthy and vigorously growing watershed forests is a critical component of DEP's comprehensive long-term source water protection program. The best regulation of

nutrients and ability to withstand environmental changes is provided by growing a diverse, resilient forest across the watershed. The primary responsibility of the Forest Management Program is to manage DEP's watershed forests by applying science-based silvicultural practices to maintain or enhance conditions ideal for long-term production of high-quality water. The program also reviews and monitors proposed forest activities on conservation easement lands and provides forest management guidance on land-use permits and DEP projects.

During the five-year period, City-owned watershed lands increased from approximately 174,800 acres to 175,800 acres (0.5%) and the acreage protected under conservation easements increased from approximately 26,100 acres to 26,900 acres (3%).

Watershed Forest Management Plan Revision

Forest management projects (FMPs) on City-owned lands are guided by DEP's Watershed Forest Management Plan (WFMP), first completed in 2011 through a contract with the USFS and updated in 2017 to incorporate additional lands acquired and revisions to Conservation Practices and Process for DEP Forest Management Projects (Conservation Practices). The 2017 FAD required revision of the WFMP, which has been a primary focus of the DEP Forest Management Program over this five-year reporting period.

From 2021 to present, prior versions of the WFMP were reviewed by the full complement of DEP Foresters, who developed a plan for completing the revision in-house. While the current WFMP generally summarizes City-owned watershed forest lands as a whole, the revised WFMP will take a basin-specific approach to account for varying regional conditions. A Forestry Program Data Coordinator was hired to analyze inventory data to support basin-specific forest planning. Forested lands that have been acquired since 2017 were also assessed for inclusion in this evaluation. These analyses are largely complete, and several chapters have been drafted to ensure adequate time for stakeholder review and completion of the environmental assessment by the March 2027 deadline.

In 2025, DEP again updated its Conservation Practices which guide protection of natural resources during forest management activities. Forests contain natural resources in addition to trees that are important not only for potential water quality protection, but also for their own intrinsic value. Some examples include wetlands, seasonal pools, springs, riparian areas, and threatened and endangered species. The Conservation Practices contain a framework for conducting forest management by means of commercial timber harvesting while protecting these co-existing resources.

The updates to the Conservation Practices reflect changes to federal and state regulations regarding streams, wetlands, and threatened and endangered species. Language was also revised relating to inspection protocols, reuse of forestry improvements, harvesting restrictions on steep slopes, and buffers between log landings and nearby dwellings. This revised document will be included in the 2027 WFMP.

To provide additional support and guidance for the 2027 WFMP Revision, two literature reviews were completed in 2025. The first, titled "Forest Health in the Northeastern United States: State-of-the-Knowledge on Threats, Monitoring, and Management" was completed by a researcher and professor at the City University of New York (CUNY) Graduate Center. This literature review utilized the Catskill Science Collaborative (CSC) research fellowship program hosted by the Cary Institute of Ecosystem Studies. The second, a review of wildfire and forest regeneration threats, was completed in collaboration with Watershed Water Quality Modeling Program as part of their efforts to explore links among climate change, forest condition, and water quality.

Forest Management Projects

DEP's primary vehicle for managing watershed forests owned in fee by the City is through carefully designed timber harvest projects which are made available for public bidding. The individual projects are designed for maximum water quality protection through adherence to the Conservation Practices. These include in-depth review from DEP staff as representatives to the Forestry Interdisciplinary Technical Team.

From 2021 to 2025, the Forestry Program bid out 18 FMPs totaling 2,796 acres. Roughly one third of these acres were located on properties acquired by the LAP while the remainder took place on high priority reservoir buffer lands (Table 2.24). Interannual variation in total acres awarded over the five-year reporting period can be attributed to the impacts of COVID on the expense budget, causing a decline in 2021, followed by a 'catch up' in 2022, and on the prioritization of WFMP plan revision, particularly in 2025.

Table 2.24 Number of forest management projects awarded over the last five years.

Year project Awarded	No. of pre-MOA projects Awarded	No. of LAP projects Awarded	Acres of pre-MOA projects	Acres of LAP projects	Total acres
2021	0	2	0	143	143
2022	3	2	751	419	1,170
2023	3	1	655	108	763
2024	2	2	285	125	410
2025	1	2	131	179	310
Total	9	9	1,822	974	2,796

As was the case in the prior five-year period, project selection in the early part of this five-year period was heavily influenced by ongoing impacts from invasive species, particularly emerald ash borer (EAB). Ash (*Fraxinus sp*.) has retained good stumpage value while other hardwood species have not, allowing timber harvests with a focus on significant ash salvage to provide enough value to subsidize other necessary thinning and forest stand improvement (FSI) work on the same project.

The Kelly Road FMP, completed in 2024 on two adjoining properties acquired by DEP in 2008 and 2020 in the Town of Neversink, Sullivan County, is a good example of this approach. The project lies on moderate slopes on a headwater tributary to the Chestnut Creek which empties directly into the Rondout Reservoir some three miles to the east, so maintaining a healthy, resilient forest on these slopes and protecting water quality while doing so, is clearly of the utmost importance.

This 88 acre project contained almost 95,000 board feet of white ash (*Fraxinus americana*) which was infested by EAB. Hence, 70% of the sale's total timber volume came from ash, whose removal created a range of canopy openings that will encourage regeneration of a variety of tree species. Additional crown thinning was conducted across the project site to reduce stocking and therefore tree-to-tree competition and favor a healthy, diverse species mix. The same regeneration would be much more limited if the ash was left to gradually succumb over a prolonged period and any gaps in the canopy would be quickly filled in by neighboring trees.

In some of the ash salvage focused FMPs where ash dominated a portion of the stand, DEP foresters utilized a silvicultural technique known as a patch cut where almost all overstory trees are removed to promote regeneration of a higher proportion of early successional trees such as birch (*Betula sp*.), cherry (*Prunus sp*.), poplar (*Populus sp*.), and oak (*Quercus sp*.). Without this silvicultural intervention, these species are becoming less prevalent in the watershed forest, as a younger cohort of these shade intolerant species cannot get established under a closed canopy. Since this is a concern across the watershed forest holdings, patch cuts have been used in multiple projects such as Scutt Mountain North (Figure 2.29) and Wright Brook in the Cannonsville basin (Figure 2.30), Southslope in the Schoharie basin (Figure 2.31), and Shavertown Heights in the Pepacton basin (Figure 2.32). As the EAB infestation has moved through the watershed over the past 15 years, opportunities for ash salvage harvests have become more limited since dead ash trees are unmarketable. Therefore, these types of projects will become less prevalent over future reporting periods.

Where deer browse is particularly intense, regeneration is unlikely to succeed even when stimulated by an opening in the canopy. DEP therefore partnered with experts at the Cornell Cooperative Extension during the current reporting period to identify and design a novel and cost-effective means of protecting regeneration. As a result, part of the patch cut within the Highland FMP (awarded in 2025) in the Ashokan basin will be protected with a slash wall.

Figure 2.29 Patch cut on the Scutt Mountain Forest Management Plan.

Figure 2.30 Patch cut on the Southslope Forest Management Plan.

Figure 2.31 Patch cut on Shavertown Heights Forest Management Plan.

A slash wall is a barrier constructed out of tree branches and trunks that are impenetrable to deer and therefore protects the growing seedlings on the inside. The slash wall slowly breaks down over the course of eight to 10 years and by that time the regeneration will have grown out of reach of the deer. This project will provide a demonstration of this technique to regional forest managers and loggers.

FMPs follow slightly different priorities in the City's EOH watershed. Here, the City's ownership of forested buffer around the reservoirs is often in very narrow strips of land, and land acquisition has been focused in the West Branch, Boyd Corners, and Kensico basins. This ownership pattern, combined with a much more suburban setting, municipal regulations, high deer numbers, and infestations from a multitude of invasive species, has limited the role of traditional timber harvesting as a tool for managing the City's forest lands. These factors often require forest stewardship interventions whose cost cannot be offset by the value of timber harvested. Therefore, during this assessment period, EOH foresters designed and bid out two forest stewardship contracts to address forest health issues. Under this model, rather than accepting payment for timber removed, the City is paying contractors for various forest

Figure 2.32 Patch cut on Wright Brook Forest Management Plan.

stewardship activities such as invasive species control, pre-commercial Forest Stand Improvement thinning, and planting and protection from deer browse. One hundred and twenty three acres on the north shore of the New Croton Reservoir were inventoried and designated for these contracts which were registered in 2024 and work commenced in 2025.

Continuous Forest Inventory

During the reporting period, the Forestry Program conducted a thorough assessment of the Continuous Forest Inventory (CFI) program which was established in 2002. As part of this effort, DEP foresters evaluated whether the distribution of over 400 CFI plots adequately represented the range of forest types on City owned lands. DEP foresters also revisited and evaluated approximately 30% of the plots. Through this analysis, DEP determined that revisions to the CFI program were required to improve its representation of forest types, to ensure better long term monumentation for resampling needs, and to better align data collection techniques

with the USFS Forest Inventory and Analysis (FIA) procedures. DEP is currently exploring the resource requirements and feasibility of implementing a representative CFI in alignment with FIA protocols on City-owned forest lands, as these data will provide information on forest trajectories to further inform long-term management needs.

2.9.3 Invasive Species Management

DEP's Invasive Species Management Strategy strives to protect water quality, watershed ecosystems, and infrastructure from the negative impacts of invasive species. The strategy outlines actions to prevent new introductions of invasive species; to detect new infestations early and respond to them rapidly; to control and manage existing populations to support specific projects; to mitigate the impacts of species that cannot be otherwise managed; and to restore sites to prevent further impacts. This document was a FAD deliverable in 2016 and updated in 2022.

Recognizing that all invasive species cannot be managed in all places, DEP uses judicious consideration when selecting how to minimize the negative impacts from these harmful pests, pathogens, plants, and animals. Close coordination with watershed partners and stakeholders is critical to understanding the threat and how best to respond. During the reporting period, DEP implemented the strategy's five goal areas through intra-agency collaboration and external partnerships. A selection of these priority projects is highlighted below.

Prevention and Pathway Risk Management

During this reporting period, DEP strengthened its boat and equipment decontamination policy to include motor flushing, which has become a common technique to remove residual water that may harbor invasive organisms within a boat motor. In 2025, DEP updated the Small Boat Program Guide for staff and contractors to include guidance on motor flushing and worked with regional field staff to ensure the best measures available are being taken to flush out all residual water from boat motors and bilge compartments prior to entering another waterbody.

DEP also took preventive measures along the Ashokan Rail Trail, a popular 11.5-mile trail with three main parking areas and trailheads along the length of the Ashokan Reservoir. Given the high volume of foot and bicycle traffic, the trail presents a risk for invasive species introduction and dispersal of seeds along the length of the trail and spread to surrounding areas. DEP worked with the CCCD to install boot brush stations at each trailhead over the reporting period. Boot brush stations have been shown to reduce weed seeds entering a natural area on hikers' boots. Each station also contains an informational sign with details about invasive species that could be moved along the trail that visitors can read while they brush their boots.

In 2021, DEP first detected the fishhook waterflea (*Cercopagis pengoi*) in New Croton Reservoir and has been working to prevent its spread through outreach. DEP developed informational signs and posted them along the shoreline to educate anglers about properly decontaminating gear prior to moving it to other waterbodies. Fishhook waterflea was detected in Pepacton and Rondout reservoirs in 2023 and DEP conducted outreach at bait shops in the watershed and through the Recreation Newsletter.

Early Detection and Rapid Response

Hydrilla (*Hydrilla verticillata*) is an uncommon and highly damaging species in New York and is considered an early detection and rapid response target for immediate management. DEP has managed this species throughout the reporting period in New Croton Reservoir where contractors treated 250 acres of nearshore area with herbicides containing fluridone (Sonar H4C, Sonar One, and Sonar Genesis) annually. While the population of hydrilla has been reduced, small pockets remain within harder to treat areas in the reservoir. Total abundance of hydrilla has steeply decreased since treatment began in 2021, with only five dense patches detected in the last two treatment years, down from 281 in 2020 (prior to the start of reservoir-wide treatment). Drought and increased diversion of Croton water into distribution lowered water levels and exposed large portions of hydrilla beds in 2024. This, combined with continued treatment, significantly decreased the underground overwintering tuber bank found in 2025 surveys, which is critical to eliminating this population. As several more years of treatment are anticipated to achieve full eradication, DEP is moving forward with another contract to manage this population.

In 2022, after five years of monitoring without detections, Giant hogweed (*Heracleum mantegazzianum*) was successfully eradicated from City lands and adjacent private property. This success highlights the power of the partnership between DEP, NYSDEC and the Lower Hudson Partnership for Regional Invasive Species Management (LH PRISM), working together across property boundaries to address this human health hazard. If left unchecked, giant hogweed grows in dense stands and its toxic sap can cause severe skin burns and blindness. DEP will continue to periodically monitor the area to confirm eradication.

Japanese knotweed (*Reynoutria japonica*) is a widespread riparian invasive plant throughout much of the Watershed but is relatively rare along the Chestnut and Rondout Creeks in the Rondout Basin. Since 2023, DEP has been working with the Rondout Neversink SMP and Sullivan SWCD to eradicate Japanese knotweed in this basin. Collaboration with partners is critical in this effort, as it provides the ability to treat across property lines both on City and private lands. Consistent treatment has resulted in eradication at several sites and large reductions in the population at many others. DEP will continue to monitor and treat the populations on City lands and support the Rondout Neversink SMP's eradication efforts.

Control and Management

In riparian floodplains, mile-a-minute (*Persicaria perfoliata*) can rapidly proliferate and smother herbaceous plants and tree seedlings with its barbed impenetrable mats. It also poses a threat to successful forest regeneration in large blowdowns, wetland edges, and forest management projects. DEP has been working to manage mile-a-minute through biological, chemical, and manual control in multiple project settings throughout the reporting period with variable success. In 2025, DEP applied for grant funding to advance the research into the most

efficient methods to control this species to ensure the success of restoration plantings in areas where mile-a-minute is present.

DEP has been working with the New York State Hemlock Initiative at Cornell University since 2017 on the establishment of biological control insects to manage the invasive hemlock woolly adelgid (*Adelgis tsugae*) in eastern hemlock (*Tsuga canadensis*). Over the reporting period, DEP supported the release of biological control agents and monitored them for their successful establishment. To move toward a more comprehensive strategy to maintain healthy eastern hemlock in the Watershed, DEP began work with Sullivan County Soil and Water Conservation District in 2025 under a USFS Landscape Scale Restoration grant to implement an integrated pest management approach to managing hemlock woolly adelgid across City and private lands in the Neversink Basin. DEP also began a similar but smaller scale project with Westchester County Parks in 2025 with funding administered by Westchester County Soil and Water Conservation District along Muscoot Creek in the Muscoot Basin.

Water chestnut (*Trapa natans*) can rapidly cover quiescent coves, increase temperature, reduce water quality, and make these areas impassable by boat. Over the last decade, water chestnut has established in Croton Falls, Muscoot and New Croton Reservoirs. Large storm events during the reporting period have broken off rafts of water chestnut in Muscoot Reservoir and distributed it downstream, along the shoreline throughout New Croton Reservoir, where it has become more widespread each year despite efforts to manually remove it. The next hydrilla management contract will also include mechanical control of water chestnut, which can be successfully eradicated with consistent removal.

Mitigation of Impacts

Zebra mussels (*Dreissena polymorpha*) pose a significant threat to the water supply. DEP first received reports of them in Lake Mahopac, an upstream lake that feeds the Muscoot River and Amawalk Reservoir, in 2015. Veligers were found in the Muscoot River and Amawalk Reservoir in 2018. DEP detected adult zebra mussels in Amawalk Reservoir in 2021, along the shoreline throughout New Croton Reservoir in 2022, and several individuals were found in Jerome Park Reservoir in 2025. During the reporting period, DEP collaborated across directorates to track this infestation through continued monitoring of veliger concentrations by plankton tows and settling plates, and inspections with remote operated vehicles, divers and dewatered visual examinations of the New Croton Aqueduct, gatehouses, intakes and the Croton Water Filtration Plant for settled adults. DEP has observed no appreciable impacts to the infrastructure from mussels during the reporting period. Infestation risk for the FAD reservoirs by zebra mussels is currently considered low. Water chemistry in these reservoirs, especially calcium and alkalinity, is limiting for veliger and adult survival.

While zebra mussels stand to impact DEP's constructed infrastructure, forest pests can reshape natural forest structure. During the reporting period, DEP worked with researchers from the Harvard Forest through a Forest Ecosystem and Monitoring Cooperative grant and from

Cuny Hunter College to develop remote sensing tools to detect changes in forest canopy condition from extreme weather events, and forest pests and disease. DEP is leveraging forest inventory data and access to over 100,000 acres of watershed lands to help improve these tools that will allow foresters to monitor forest conditions to identify potential management needs and prioritize responses to the multitude of threats to forest health remotely.

Throughout the reporting period DEP continued to participate in a Monitoring and Managing Ash (MaMA) project to identify lingering ash (Fraxinus spp.) trees that may be resistant to emerald ash borer (*Agrilus planipennis*). DEP staff and SUNY Ulster interns monitored four ash mortality plots throughout the WOH watershed. Two lingering ash trees were identified in the Ashokan Basin and scion, or twigs used for grafting, were collected and are being used by Cornell University to breed resistant individuals. More information about the MaMA project is available at www.monitoringash.org.

Beech leaf disease (*Litylenchus crenatae* subsp. *mccannii*), which damages leaf buds and leads to leaf deformity and canopy thinning, was first detected and spread throughout the entire watershed, decimating beech trees over the reporting period. While there are no landscape scale treatment methods, DEP has been actively engaged with the Beech Leaf Disease Coalition and is piloting mitigation techniques, including construction of temporary deer exclosures in dense beech (*Fagus grandifolia*) stands and seeding in areas that lack understory vegetation. These measures are designed to proactively encourage native species regeneration as the beech trees inevitably die. DEP has erected three deer exclosures for this purpose since 2024 and will continue to install them in critical areas as time and resources allow.

Restoration

Decommissioning dams and lowering impounded ponds creates a vulnerable zone of formerly submerged land that is primed for invasive plant establishment. During the reporting period, DEP restored and managed invasive species on two such sites on City-owned lands within the watershed. DEP designed and implemented restoration plantings at the former Camp Alamar on Leetown Brook in the Boyd Corners basin in 2025 after several years of invasive species management efforts. DEP also managed invasive species and monitored seeding of native plants at Camp Edward Isaacs in the West Branch basin.

In addition to the prevention efforts described above, DEP worked with the Catskill Center to restore areas that were heavily impacted by invasive species along the Ashokan rail trail focusing on scenic vistas and a stand with high mortality from the emerald ash borer near the Ashokan Station Trailhead. The Catskill Center engaged volunteers in trainings and workdays to remove invasive species and plant and maintain native tree and shrub species to restore a native tree canopy to these areas. Working with volunteers in a high visibility area has the added benefit of raising awareness of the threat invasive species pose and provides hands-on training for landowners within the watershed to implement these practices on their own property.

Partnerships

New York State Invasive Species Advisory Committee

DEP was named in statute to maintain a representative on the New York State Invasive Species Advisory Committee (ISAC) in 2007. This committee meets quarterly and provides information, advice, and guidance to the New York State Invasive Species Council on invasive species impacts, prevention, regulation, detection, and management. Over the reporting period, ISAC has provided feedback on updates to the prohibited and regulated species lists, new programs to address climate change, reforestation and invasive species, and discussed the value of an assessment of the economic impacts of invasive species.

Lower Hudson Partnership for Invasive Species Management

The LH PRISM is hosted by the New York New Jersey Trail Conference and is one of the eight statewide invasive species partnerships. LH PRISM covers an area congruent with the EOH watershed. Over the reporting period, DEP has attended all LH PRISM meetings and has held multiple terms on the steering committee for this group. DEP is also working with other LH PRISM members on the Beech Leaf Disease Coalition which has worked toward a regional emergency strategy for this disease.

Catskill Regional Invasive Species Partnership

The Catskill Regional Invasive Species Partnership (CRISP) is hosted by the Catskill Center and is the partnership that represents the WOH watershed. DEP has attended all meetings and has served multiple terms as Chair of the CRISP steering committee. DEP and CRISP held a joint strategic planning effort in 2022, and CRISP has been holding regular working group meetings to address priority topics identified in this process, including forest regeneration, construction related invasive species spread, and identifying success stories.

2.10 Environmental Infrastructure Programs

2.10.1 WWTP Regulatory Upgrade Program

Under the MOA, DEP agreed to fund the eligible costs of designing, permitting, and constructing upgrades of all non-City-owned WWTPs in the watershed. For the purposes of this program, upgrades mean equipment and methods of operation that are required solely by the WR&R, and not by federal or state law. DEP completed all WWTP upgrades required under the FAD.

Since the City is obligated to pay for capital replacement of watershed equipment and methods, DEP entered into an agreement with NEIWPCC to manage this program. During the reporting period, NEIWPCC engaged with WWTP owners to address requests for replacement of watershed equipment. Minor equipment (e.g. filter cartridges, pumps) is replaced as needed to ensure each facility functions properly and in accordance with the WR&R. DEP also funds the

replacement of minor equipment under established operation and maintenance (O&M) agreements with each WWTP owner.

2.10.2 Septic System Rehabilitation and Replacement Programs

Residential Septic Program

The Residential Septic Program provides for pump-outs and inspections of septic systems serving single or two-family residences in the WOH watershed, upgrades of substandard systems, and rehabilitation or replacement of systems that are failing or reasonably likely to fail in the near future. The CWC administers the septic program. The total City funding commitments for the program have been over $185 million since 1997.

Historically, the Residential Septic Program was implemented in a prioritized fashion according to potential impact to the City's water supply. The program initially targeted the 60-day travel time area, followed by areas within defined limiting distances from streams. After CWC solicitated homeowners in priority areas, CWC opened the program to the entire WOH watershed in July 2018, and it remains available to all residential property owners. Table 2.25 shows the number of septic systems managed or remediated from 2021 to 2025.

Table 2.25 Number of septic system remediations from 2021 to 2025.

Year	Septic System Remediations
2021	240
2022	268
2023	291
2024	257
2025	230

From 1997 through December 2025, 7,200 septic systems were repaired, replaced, or managed under the septic program.

Expanded Septic Program

The Expanded Septic Program provides funding to reimburse non-residential properties in the WOH watershed for repairs to septic systems. Through CWC, eligible businesses with 20 or fewer employees, not-for-profit organizations with five or fewer locally based employees, and governmental entities are reimbursed for 100% of the cost of septic repairs and qualifying modifications and expansions. Additionally, for small businesses with 21 or more employees and not-for-profit organizations with six or more locally based employees, the program provides 75% of the costs of repairs and qualifying modifications up to $100,000 for a single system and 100% of any cost over $100,000. The applicant is responsible for securing an approved DEP design for the construction of the septic system remediation. Between 2021 and 2025, 100 septic remediations have been completed with program funding, bringing the total remediated to 129 since the program's inception in 2008.

Cluster Septic Program

Established in 2011, the Cluster Septic Program funds the planning, design, and construction of cluster systems in 13 communities in the WOH watershed. Eligible communities may elect to study and establish septic districts that would support cluster systems and tie multiple properties to a single disposal system. DEP has provided CWC with $2 million in cluster program funding and $1 million to support eligible O&M costs for cluster communities.

Since program inception, CWC has contacted the towns of Middletown, Neversink, Olive and Shandaken due to septic failures being identified in the cluster areas at Clovesville, Neversink, Woodland Valley Road, Travers Hollow, and Shokan. To date, no community has elected to participate in the Cluster Septic Program and so the failed septic systems were addressed by CWC through the Residential Septic Program.

2.10.3 Septic Maintenance Program

Proper septic maintenance is important for prolonging the life and efficiency of a septic system. The key component to avoiding septic failure is periodic tank pumping. Routine maintenance prevents groundwater pollution and surfacing effluent. While the cost of repairing or replacing a septic system can be expensive, the effort and expense of routine maintenance is relatively minor.

The Septic Maintenance Program, funded by DEP and administered by CWC, is a voluntary program originally open to homeowners who constructed new septic systems after 1997 or participated in the CWC septic repair program. It is intended to reduce the occurrence of septic system failures through regular pump-outs and maintenance. CWC also develops and disseminates septic system maintenance educational materials.

To participate in the program, the septic system owner obtains an inspection checklist and reimbursement form from CWC and then contracts with a licensed septage hauler to have the septic tank pumped. The septic system owner pays the hauler and then submits the signed checklist and completed reimbursement form to CWC along with a copy of the contractor's invoice and proof of payment. CWC reimburses the septic system owner 50% of eligible costs for pump-outs and maintenance. The number of participants in the septic maintenance program generally increases each year. Table 2.26 shows participation in the program between 2021 and 2025. Since program inception in 2004, 6,643 septic system owners have been paid 50% of eligible costs for septic system pump-outs and maintenance.

Table 2.26 Septic Maintenance Program participation 2021-2025.

Year	Number of septic pump-outs
2021	604
2022	667
2023	680
2024	714
2025	851

Septage Acceptance Facilities

DEP, in coordination with CWC, continues to evaluate septage disposal needs in the WOH watershed, with a goal of advancing projects that supplement regional septage acceptance capacity. As required by the Revised 2017 FAD, DEP funded CWC to initiate and complete feasibility assessments for the towns of Windham and Prattsville to determine the extent to which each facility can support regional septage management needs.

The Windham feasibility study, approved in February 2024 and completed in December 2024, determined that the Windham WWTP can accept approximately 39,000 gallons per day (gpd) of septage with targeted improvements, including a septage receiving station, a 20,000-gallon holding tank, and associated hydraulic upgrades. In May 2025, DEP and CWC authorized the Town to initiate design. The draft Prattsville feasibility study, approved in January 2024 and completed in September 2025, proposed modifications that would allow the Prattsville WWTP to accept approximately 2,760 gpd of septage. DEP and CWC anticipate receiving a final feasibility study and authorizing design to commence in early 2026.

2.10.4 Sewer Extension Program

The Sewer Extension Program concluded in 2016. DEP completed projects in the towns of Roxbury (Grand Gorge WWTP), Hunter-Haines Falls (Tannersville WWTP), Neversink (Grahamsville WWTP), Hunter-Showers Road (Tannersville WWTP), Shandaken (Pine Hill WWTP) and Margaretville/Middletown (Margaretville WWTP).

2.10.5 Community Wastewater Management Program

The Community Wastewater Management Program (CWMP), funded by DEP and administered by CWC, provides for the design and construction of community wastewater systems, including related sewerage collection systems, and/or the creation of septic maintenance districts, in identified WOH communities where there is a perceived potential threat to water quality posed by failing and likely to fail septic systems.

Prior to 2021, completed CWMP projects included Bloomville, Boiceville, Hamden, DeLancey, Bovina, Ashland, Trout Creek, Lexington, South Kortright, Shandaken, and Claryville. Remaining CWMP projects at the beginning of 2021 included: West Conesville,

Table 2.27 Completed CWMP projects 2021 to 2025.

Community	Project	Flow (gpd)	Septics displaced	Date completed
West Conesville	Community Septic System	13,000	35	2022
New Kingston	Community Septic System	9,000	28	2024
Halcottsville	Pump to Margaretville WWTP	15,000	40	2025

Halcottsville, and New Kingston. In total, all three CWMP projects were completed during the FAD assessment period (Table 2.27).

The following summaries highlight the accomplishments of the program that were made during the past five years. Pursuant to the Revised 2017 FAD, a wastewater project was proposed for the Shokan hamlet and reporting on that project is included herein.

New Kingston – Community Septic System

DEP approved a block grant of $7.7 million for a 9,000 gpd community septic system for the Hamlet of New Kingston in the Town of Middletown. DEP approved the project design in 2022, and the Town bid the project in 2023. The Town completed construction of the community septic system and commenced connection of parcels in 2024.

Halcottsville – Sewer Collection System with connection to Margaretville WWTP

DEP approved a block grant of $11,454,000 for a large-diameter gravity sewer with pump station and force main connecting to the City-owned Margaretville WWTP with a design flow 14,075 gpd. DEP approved the project design in 2021, and the Town bid the project in 2022. The Town completed construction of the sewer collection system and commenced connection of parcels in 2025 (Figure 2.33).

Shokan – MBR WWTP treating combined flow from Shokan and Boiceville

DEP approved the project and block grant of $48,715,000 for the project serving the hamlets of Shokan and Boiceville in August 2020. The approved project would be a collection system in Shokan and the transmission of flow from the Boiceville WWTP to a new membrane bioreactor (MBR) WWTP in Shokan. The combined flow from the hamlets of Shokan and Boiceville is 243,000 gpd. The Town of Olive commenced the pre-construction phase in 2020 and completed pre-construction phase in 2025. Following receipt of bids, DEP issued a revised block grant approval letter and the Town awarded construction contracts in December 2025. Construction is anticipated to commence in 2026.

Figure 2.33 Halcottsville CWMP - Main Pump Station Storage Tank Installation.

2.10.6 Stormwater Programs

Stormwater Retrofit Program

Jointly administered by CWC and DEP, the Stormwater Retrofit Program provides funding for the design, permitting, construction, and maintenance of stormwater best management practices to address existing stormwater retrofit runoff in concentrated areas of impervious surfaces. Since its inception, DEP has committed over $27 million for capital, operation and maintenance, and community-wide stormwater infrastructure assessment and planning initiatives.

DEP and CWC jointly worked together to develop a new funding pathway – Retrofit Feasibility Studies – for preliminary engineering work that can be used by potential applicants to investigate a site for retrofit installation viability. Feasibility studies assess basic site conditions and calculate water quality benefits to address water quality issues at the selected site. From

2021 through 2025, three feasibility studies commenced work and one completed study resulted in a completed project at Olive Free Library.

During 2021 through 2025, four stormwater retrofit projects totaling over $2.3 million were completed (Table 2.28). During the reporting period, DEP and CWC also approved a preliminary design project for the highway garage in the Town of Jewett, as well as retrofit feasibility studies for Pine Hill Community Center and Main Street in the Town of Margaretville.

Table 2.28 Completed stormwater retrofit projects 2021-2025.

Applicant	Funding
Ashokan	
Olive Free Library	$91,893
Pepacton	
Fleischmanns Lake Street	$311,295
Cannonsville	
Delhi Riverwalk Phase	$127,040
Delaware Academy II	$1,810,411

Future Stormwater Controls Programs

The Future Stormwater Controls Programs pays for the incremental costs of stormwater measures required solely by the New York City WR&R above state and federal requirements in stormwater pollution prevention plans and individual residential stormwater plans for new construction after May 1, 1997.

There are two separate programs developed to offset additional compliance costs incurred as a result of the implementation of the City's WR&R. Since 1997, DEP and CWC have worked cooperatively on the Future Stormwater Controls Program (MOA-128) and the Future Stormwater Controls Paid for by the City (MOA-145) Stormwater Programs.

DEP provided over $36 million to establish the MOA-128 Program, which is administered by CWC to reimburse municipalities and large businesses 100% and small businesses 50% for eligible costs. Through 2025, CWC has paid over $15 million for eligible incremental costs for stormwater controls required by the WR&R. Pursuant to the 1997 MOA, CWC has also transferred over $17 million to other watershed programs.

The MOA-145 Program reimburses low income housing projects and single-family home owners 100% and small businesses 50% of eligible costs. DEP historically managed this program since 1997 but worked with CWC to transfer administration of the MOA-145 Program for the WOH watershed starting in 2018. Through 2025, CWC has paid over $2.5 million for eligible incremental costs under the MOA-145 Program.

2.11 Kensico Water Quality Control Program

Kensico Reservoir, located in Westchester County, is the terminal reservoir for the City's Catskill/Delaware water supply system. Because it provides the last impoundment of Catskill/Delaware water prior to entering the City's distribution system, DEP has prioritized watershed protection in the Kensico basin.

2.11.1 Wastewater-Related Nonpoint Source Pollution Management Programs

Septic Reimbursement Program

DEP initiated the Kensico Septic System Rehabilitation Reimbursement Program to reduce potential water quality impacts that can occur through failing septic systems. The program was initially implemented through NYSEFC but now is managed in-house and provides funding to reimburse a portion of the costs to rehabilitate eligible failing septic systems or connect those systems to an existing sewage collection system. The program is voluntary, with the goal of encouraging property owners to have their septic systems inspected and, if failing, rehabilitated. All residential systems in the Kensico Basin are eligible.

Since inception in 2008, a total of 39 systems have been rehabilitated in the Kensico basin with 13 of those repairs completed between 2021 and 2025. The total amount reimbursed since inception is $389,000, with approximately $127,000 reimbursed between 2021 and 2025.

DEP continues to make residents aware of available funding through annual direct mailings to approximately 700 eligible properties (Figure 2.34). The mailings include information about the program and DEP contact information. DEP also maintains contact with key staff in towns and local health departments.

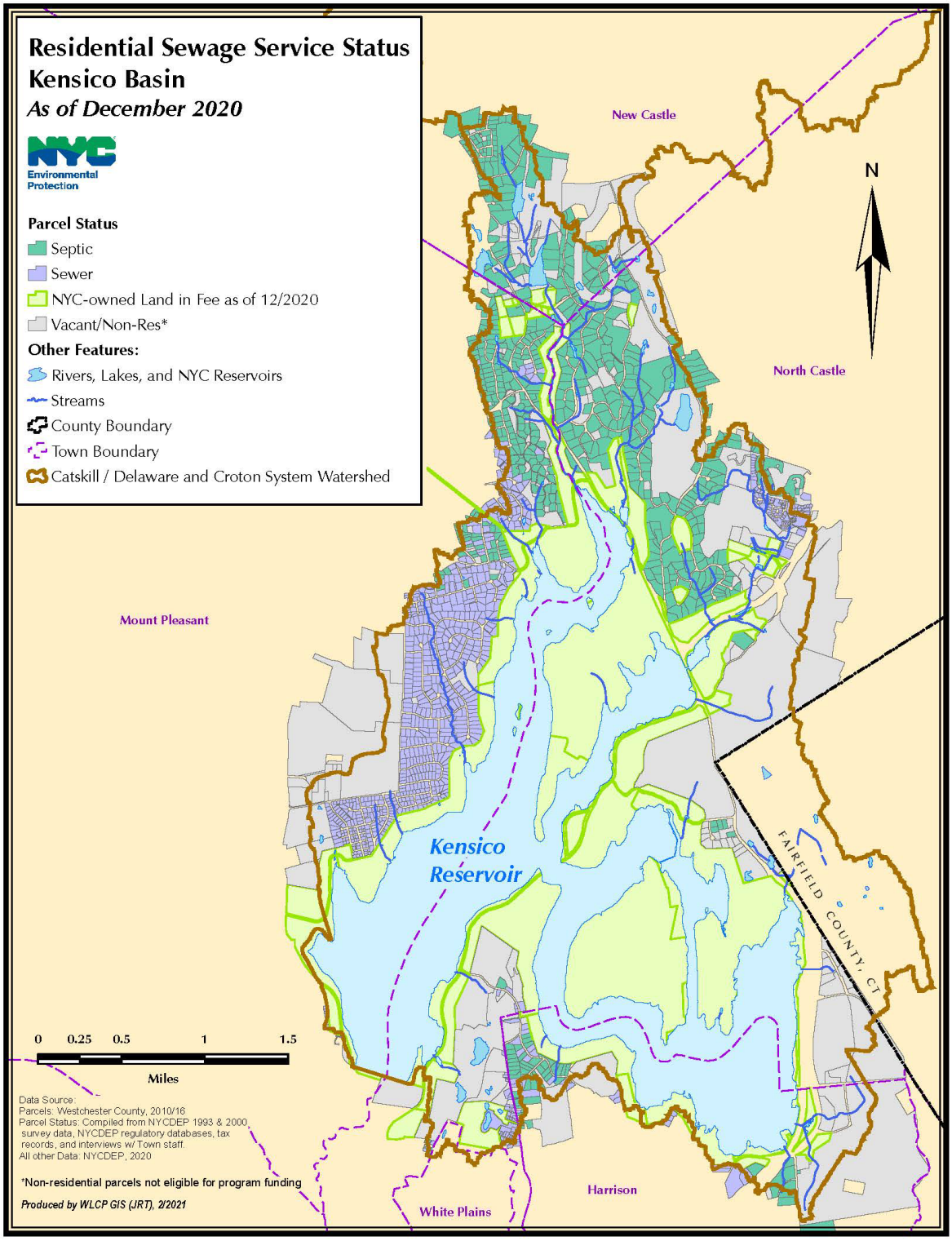


Figure 2.34 Map showing sewer service status of residential parcels in the Kensico Reservoir Basin.

West Lake Sewer

The West Lake sewer trunk line, owned and maintained by Westchester County, conveys untreated wastewater to treatment facilities located elsewhere in the county. DEP previously funded the installation of a sanitary sewer remote monitoring system for the trunk line to provide real-time detection of problems such as leaks, system breaks, overflows, and blockages. There were no overflows or concerns during the reporting period, and the units appear to be working well with regular battery replacements and other routine maintenance performed by Westchester County. DEP conducted annual visual inspections of the trunk line to assess the condition of exposed infrastructure. DEP also conducted routine partial inspections throughout the reporting period in association with ongoing maintenance of Kensico stormwater BMPs near the trunk line. DEP noted no defects or abnormalities.

Video Inspection of Sanitary Sewers

DEP established a program to periodically inspect targeted portions of the sanitary sewer system located within the Kensico basin. DEP's contractor completed the Comprehensive Summary Report of selected areas and notified the Town of Mount Pleasant of the inspection results in 2022.

2.11.2 Stormwater-Related Nonpoint Source Pollution Management Programs

BMP Inspection and Maintenance

DEP has constructed stormwater management and erosion abatement facilities throughout the Kensico basin to reduce pollutant loads to the reservoir. DEP and its contractor inspected and maintained these facilities, shown in Figure 2.35, throughout the 2021 to 2025 reporting period, according to the O&M guidelines. Maintenance consisted of grass weed-whacking, seed and mulch, overgrown and nuisance vegetation removal, fallen and dead tree removal, chain link fence repair, sediment removal, debris removal, and rip-rap swale repair and repositioning. All BMPs are performing as designed.

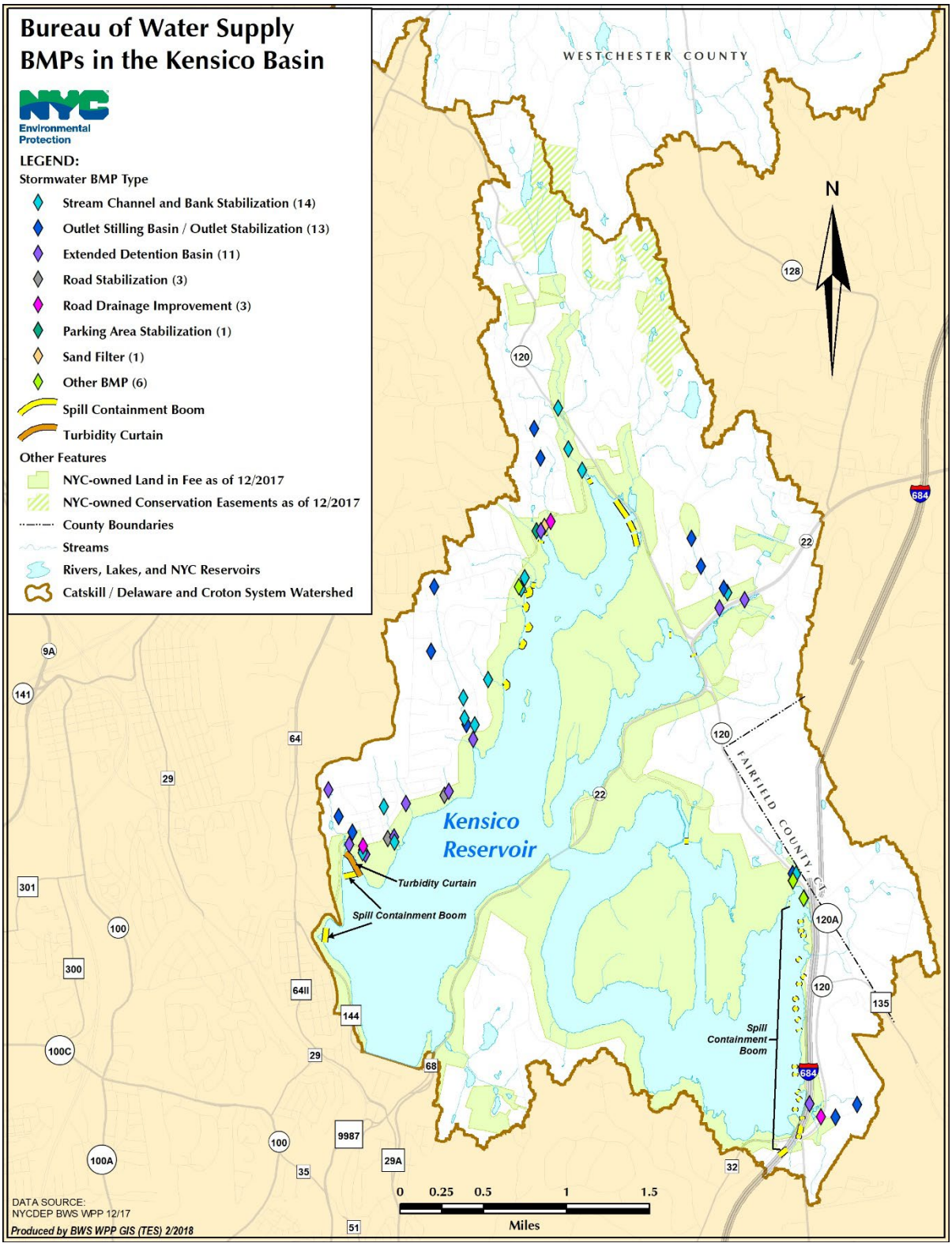


Figure 2.35 BMPs within the Kensico Reservoir Basin.

Spill Containment Facilities

DEP maintains spill containment facilities in and around Kensico Reservoir to improve spill response and recovery. Throughout the five-year reporting period, DEP conducted routine maintenance at the spill boom sites to ensure they are available in the event of a spill.

During the reporting period, there were no spills that required the deployment of booms. Minor events are noted below.

- In December 2021, seven gallons of hydraulic oil were released at the Kensico Reservoir Shaft 17 main security gate. The oil was removed using hydrocarbon absorbents.
- In January 2023, 15-20 gallons of ethylene glycol were accidentally released within the city's Delaware Aqueduct Shaft 17 facility. DEP performed the necessary cleanup within the building and there were no water quality impacts.
- In May 2024, a motorcycle accident occurred where the motorcycle was submerged in the reservoir but did not leak any fluids. DEP inspected the area and confirmed that no spill impacted the reservoir or required the deployment of the spill containment booms.
- In June 2024, a minor vehicular leak of diesel fuel occurred at the Delaware Shaft 18 facility. Speedy-Dry absorbent material was applied to the impacted asphalt surface.
- In September 2024, during weekly inspections of hazardous waste storage area at DEP's Delaware Shaft 18 facility, three 5-gallon buckets of waste generated and labeled from other DEP facilities, and which were previously unaccounted for, were identified. No spill occurred but DEP updated the hazardous waste inventory log to include the items.
- In December 2024, a small two-person prop plane crashed on the median of I-684 just north of Exit 2. Fuel did spill onto the grass and soil but did not enter a storm drain located 50 feet north of the crash site. DEP inspected the storm drain and deployed soft boom around the storm drain, as a precaution. Rye Lake Reservoir, which feeds into Kensico Reservoir was not impacted.

Turbidity Curtain

DEP continues to monitor and inspect the extended primary curtain and the backup turbidity curtain that are designed to direct flows from Malcolm and Young brooks farther out to the main body of Kensico Reservoir. In 2021, DEP replaced a 200-foot-long portion of the back-up turbidity curtain. In September 2025, DEP conducted a diving inspection to assess the condition of the curtains. DEP's BMP contractor conducted an underwater diving inspection on September 10, 2025. The resulting inspection report notes that the majority of backup yellow curtain skirts are in failing condition and describes the majority of primary black curtain skirts in poor or passing condition. All anchors passed inspection; however, the majority of eye bolt hardware is noted in failing or poor condition. While the black curtain is functioning as intended,

the yellow curtain has surpassed its intended useful life. DEP intends to replace a 200-foot-long portion of the black turbidity curtain in the first half of 2026. Note that the pending Kensico-Eastview Connection contract includes a component to replace both existing curtains with one heavy duty, 1300-foot-long turbidity curtain.

Upper Effluent Chamber

As part of the Kensico-Eastview Connection project and reconstruction of the Upper Effluent Chamber (UEC), DEP will stabilize the shoreline near the UEC, replace the existing Malcolm Brook turbidity curtain, and remove sediment near the UEC intake channel. In July 2025, DEP's engineering consultant completed design of the shoreline stabilization project. Construction of the project is anticipated to commence in 2026.

Shaft 18 Shoreline Stabilization

Since the Catskill/Delaware Ultraviolet Disinfection Facility (CDUV) began operating, all Kensico water flows through the Delaware Effluent Chamber at Shaft 18. Increased reliance on Shaft 18, together with changing weather patterns, necessitated shoreline stabilization measures near the effluent chamber to maintain turbidity levels in compliance with state and federal water quality standards.

Prior to the reporting period, DEP hired an engineering firm to study and design a shoreline stabilization project on both sides of Shaft 18. The shoreline stabilization and protection measures included approximately 700 feet at the western shoreline and approximately 475 feet at the cove area. DEP completed all work at the cove in 2020 and all work at the western shore in 2022 (Figure 2.36).

Westchester County Airport

The Westchester County Airport is located east of Kensico Reservoir in close proximity to Rye Lake. Because of the airport's closeness to the reservoir, DEP continues to review any activities being proposed at the airport. Below is a summary of DEP's review during the 2021 to 2025 reporting period.

In 2022, Westchester County relaunched a public engagement program on the Airport Master Plan and held two public meetings in September. The supplement to the airport master plan is moving forward, though there is currently no deadline for completion and no new information concerning the plan was made available to the public in 2024. Westchester County's website notes, however, that the Airport Master Plan will be updated and the process will not expand the airport's existing 700-acre footprint, increase the current 240-passenger (per half hour) limit, or eliminate the Airport's voluntary curfew on overnight flights. To date, release of the Master Plan is still pending.

Figure 2.36 Completed shoreline stabilization improvements at Shaft 18.

In November 2023, DEP issued comments on Westchester County's environmental review for the Westchester County Airport snow equipment storage building. Although the project does not require DEP approval of a stormwater pollution prevention plan (SWPPP), DEP reviewed the SWPPP report and a Draft Supplemental Environmental Assessment prepared pursuant to the requirements of the National Environmental Policy Act and the FAA. In December 2024, DEP issued technical comments on the proposal and by April 2025 all DEP issues and concerns were sufficiently addressed.

The Rye Lake Filtration Plant is proposed by Westchester Joint Water Works (WJWW) on airport property in the Town of Harrison. DEP issued an approval of the SWPPP on May 26, 2023 and a separate tree clearing amendment to the SWPPP was issued on December 19, 2024. On October 15, 2024, WJWW obtained both a NYSDEC Industrial SPDES Permit for stormwater and potable discharges and a NYSDEC Article 24 Wetlands Permit. Site tree clearing occurred in January 2025 and construction of the filtration plant commenced in November 2025.

Westchester County installed a new 12-inch water main in the vicinity of the airport on New King Street in 2024 to address per- and polyfluoroalkyl substances (PFAS) contaminated water supply wells at various commercial facilities in the area.

Park Place at Westchester is a private 980-space parking garage proposed in the Town of North Castle. DEP issued formal SWPPP approval in December 2024 in accordance with the City's WR&R. To date, no construction has commenced.

In accordance with a 2019 NYSDEC consent order, Westchester County prepared a site characterization work plan to assess perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), and other groundwater contaminants at and near the airport, which was accepted into the NYSDEC Brownfield Cleanup Program. NYSDEC released a draft remedial investigation work plan in October 2022. DEP reviewed and commented on this plan in 2022; the plan remains under review by NYSDEC.

Since identifying an uncapped landfill at the airport in 2015, Westchester County has performed sampling and laboratory analysis of groundwater, surface water, landfill soils, and accumulated iron flocculent. Results of soil samples collected from eight test pits indicate exceedances for certain metals and mercury. The landfill/soil mound is expected to be addressed through Westchester County's participation in the NYSDEC Brownfield Cleanup Program. The landfill is still under investigation and has been incorporated into the remedial investigation work plan mentioned above.

2.11.3 Wildlife Sanitary Surveys

DEP conducts sanitary surveys at the Kensico Reservoir as a proactive measure to identify and remove wildlife excrement before it washes into the water supply and potentially elevates fecal coliform levels. From 2021 to 2025, DEP's contractor conducted 204 wildlife sanitary surveys at Kensico Reservoir (Table 2.29). In February 2023, DEP increased the survey routine from 24 to 48 hours prior to significant precipitation events to a weekly survey. Of the 16,819 fecal samples collected, 7,307 (43%) were attributed to Canada geese, 6,144 (37%) to passerine birds, 2,621 (16) % to white-tailed deer, and the remaining 4% to rabbit, coyote, raccoon, bobcat, mink, domestic dog, mink, fox, striped skunk, and unknown mammals. Of the excrement samples collected, 63% were confirmed to species level. All samples were removed from the property following collections.

Table 2.29 Kensico Reservoir wildlife sanitary surveys.

Species	Excrement Samples Collected					
	2021	2022	2023	2024	2025	Total by Species
Canada Geese	135	103	6,084	366	619	7,307
White-tailed Deer	460	1,348	316	147	350	2,621
Passerine Birds	234	112	2,023	1,942	1,833	6,144
Eastern Cottontail Rabbit	13	34	26	166	267	506

Species	Excrement Samples Collected					
	2021	2022	2023	2024	2025	Total by Species
Unknown Mammal	24	24	33	22	25	128
Coyote	5	7	27	21	10	70
Raccoon	8	6	3	0	1	18
Bobcat	0	8	8	0	0	16
Domestic Dog	4	0	0	0	0	4
Mink	1	0	0	0	2	3
Fox	0	0	1	0	0	1
Striped Skunk	1	0	0	0	0	1
Totals (13 Species / Unknowns)	885	1,642	8,521	2,664	3,107	16,819

* Data reported up through December 17, 2025.

2.12 East of Hudson Non-Point Source Pollution Control Program

The EOH Nonpoint Source Pollution Control Program supplements DEP's existing regulatory efforts and other initiatives to address nonpoint pollutant sources in the four EOH FAD basins: West Branch, Croton Falls, Cross River, and Boyd Corners.

2.12.1 Wastewater Programs

Septic Programs East of Hudson

DEP supports Westchester and Putnam counties in their efforts to reduce the potential impacts of improperly functioning or maintained septic systems. Westchester County, Putnam County, and their respective municipalities continue to implement the septic requirements of the NYSDEC MS4 General Permit, which obligates municipalities and counties to implement programs for the inspection, maintenance, and rehabilitation of septic systems.

DEP previously partnered with the EFC to implement the Septic System Rehabilitation Reimbursement Program in priority areas of the EOH Catskill/Delaware watershed and basins hydrologically connected to the Croton Falls Reservoir (i.e., Bog Brook, Diverting, East Branch, and Middle Branch). Since 2023, DEP has managed this program in-house. From 2021 to 2025, DEP completed the annual direct mailings to eligible residents to promote the program and issued reimbursements for 52 septic repairs, of which 36 were completed in the West Branch and Boyd Corners basins and 16 were completed in the Cross River, Croton Falls, and upstream, hydrologically connected basins.

EOH Community Wastewater Planning Grant Program

Pursuant to the 2017 FAD, DEP developed a grant program, administered by NEIWPCC, to provide funding to EOH watershed municipalities for preliminary planning of community wastewater solutions for eight areas where septic systems may impact water quality. Based on

preliminary studies conducted by NYSDEC, the 2017 FAD identified the following areas to be studied: 1) areas surrounding Lake Waccabuc, Lake Truesdale, and Lake Kitchawan in the Cross River basins, and 2) Palmer Lake, Lake Gilead, Lake Casse, Lake View Road, and Mud Pond Brook in the Croton Falls basins. DEP completed the summary FAD report in 2022.

Video Sanitary Sewer Inspections

DEP implements an inspection program for targeted portions of the sanitary sewer system located within the West Branch and Croton Falls basins. DEP's contractor completed the Comprehensive Summary Report of these selected areas and DEP notified the Towns of Carmel and Kent of the inspection results in 2022.

2.12.2 Stormwater Facility Inspection and Maintenance

The Facility Inspection and Maintenance Program ensures that previously constructed stormwater remediation facilities continue to function as designed through routine inspections. Maintenance is completed under the warranty in each facility's construction contract during the first year and thereafter under DEP's maintenance program contract. Inspection and maintenance follow procedures contained in the maintenance contract. During 2021 to 2025, DEP inspected all facilities as required, with 82 facilities requiring vegetation removal, 69 requiring sediment and/or debris removal, 18 requiring stone riprap repairs, 20 requiring tree removal, and nine requiring seed and mulch. All stormwater facilities are functioning as designed.

2.12.3 Stormwater Retrofit Grant Program

DEP funds a grant program through the EOHWC for eligible municipalities to construct the stormwater retrofits needed to satisfy municipal permit obligations under Section IX.A.5.b of the NYSDEC MS4 General Permit. The MS4 Permit mandates that EOH watershed municipalities achieve nonpoint source phosphorous reductions through the construction of stormwater retrofits. Retrofit types vary and may include detention basins, channel stabilization projects, and pocket wetlands, among others (Figure 2.37).

DEP contracted with the EOHWC to provide $22 million to support the design and construction of stormwater retrofits in the EOH FAD basins and those basins upstream of the Croton Falls Reservoir. From 2021 to 2025, EOHWC expended or committed approximately $8 million of the initial $15 million payment for retrofit projects in the West Branch, Boyd Corners, Cross River, Croton Falls, and upstream hydrologically connected basins. Since inception, EOHWC's retrofit program has removed an estimated 460.5 kg P/yr. from these basins toward their 10-year MS4 requirement of 919 kg P/yr. EOHWC anticipates achieving their 10-year requirement, begun in 2010, in 2026.

Figure 2.37 View of a bio-retention area installed at Scolpino Park, East Branch pocket wetland in the Middle Branch Reservoir Basin.

2.13 Catskill Turbidity Control

Due to the nature of the underlying geology, the Catskill watershed is prone to elevated levels of turbidity in streams and reservoirs. High turbidity levels are associated with high flow events, which can destabilize stream banks, mobilize streambeds, and suspend the glacial clays beneath the streambed armor. The design of the Catskill System considers local geology and provides for settling within Schoharie Reservoir, Ashokan West Basin, Ashokan East Basin, and the upper reaches of Kensico Reservoir. Under normal circumstances, the extended detention time in these reservoirs is sufficient to allow the turbidity-causing clay solids to settle out and the system easily meets the SWTR turbidity standards (5 NTU) at the Kensico effluent. Occasionally after extreme rain/runoff events in the Catskill watershed, DEP has used aluminum sulfate (alum) as chemical treatment to control high turbidity levels.

Since 2002, DEP has undertaken several studies and implemented significant changes to its operations to better control turbidity in the Catskill System. DEP has implemented many of these measures pursuant to the 2002 and 2007 FADs and the Shandaken Tunnel and Catalum SPDES permits. A comprehensive analysis, the Catskill Turbidity Control Study, was conducted by DEP with the Gannett-Fleming-Hazen and Sawyer Joint Venture in three phases between 2002 and 2009. DEP implemented several alternatives based on the results of this study: a system-wide Operations Support Tool (OST) that allows DEP to optimize reservoir releases and diversions to balance water supply, water quality, and environmental objectives; an interconnection of the Catskill Aqueduct at the Delaware Aqueduct Shaft 4 to improve overall

system dependability; and structural improvements to the Catskill Aqueduct stop-shutter facilities. The Catskill-Delaware Interconnection and the Catskill Aqueduct stop-shutter facilities projects achieved functional completion in 2016.

2.13.1 Catalum Consent Order and Environmental Review

Rain events in October and December 2010 caused elevated turbidity levels in the Ashokan Reservoir. In addition to alum at Kensico, DEP also utilized the Ashokan Release Channel as part of a strategy previously approved by NYSDOH and EPA to ensure all drinking water standards were met. Using the channel raised concerns from communities along the Esopus Creek downstream of the reservoir.

In February 2011, NYSDEC commenced an administrative enforcement action against the City for alleged violations of the Catskill Aqueduct Intake Chamber Catalum SPDES Permit (NY0264652) regarding operation of the Ashokan Release Channel and alum addition. NYSDEC and DEP negotiated a consent order to resolve the alleged violations, which took effect in October 2013. The consent order included penalties, environmental benefit projects, a schedule of compliance, and an Interim Release Protocol for the channel's operation.

Consistent with the consent order, DEP requested a modification to the Catalum SPDES Permit in 2012 to incorporate turbidity control measures in water diverted from Ashokan Reservoir and to postpone dredging of alum floc at Kensico Reservoir until completion of certain infrastructure projects. The proposed modification is subject to environmental review under the State Environmental Quality Review Act (SEQRA), for which NYSDEC is lead agency. Below is a timeline for the Catalum environmental impact statement (EIS) development:

Scope

NYSDEC released a draft scope for the Catalum EIS for public comment from April 9, 2014, to August 29, 2014. More than 550 commenters submitted more than 900 comments. The final scope was issued on March 22, 2017, and it took into consideration feedback from the public review process and includes responses to the comments received.

DEIS/SDEIS

A preliminary draft environmental impact statement (DEIS) was submitted to NYSDEC on May 30, 2019. NYSDEC released the DEIS for public comment on December 16, 2020. DEIS public hearings were held on February 4, 2021 and March 3, 2021. The public comment period for the DEIS closed on June 16, 2021. Over 1,300 comments were received.

On January 10, 2022, NYSDEC issued a "Scope for the Supplemental Environmental Impact Statement for the Catalum SPDES Permit Modification." Which requires DEP, as the project sponsor, to prepare a Supplemental Draft Environmental Impact Statement (SDEIS) that is limited to analyzing the specific adverse environmental impacts that were not addressed or inadequately addressed in the DEIS. On February 9, 2022, NYSDEC issued a "Combined Notice of Intent to Prepare a Supplemental Draft Environmental Impact Statement (SDEIS) and Notice

of Acceptance of Scope". The combined notice was published in the Environmental Notice Bulletin and reflected the January 10, 2022 Scope document. On October 5, 2022, DEC announced a draft modification to the Interim Release Protocol for review and comment by the Ashokan Release Working Group.

During 2023 and 2024, DEP and NYSDEC continued reviewing comments submitted in response to the DEIS and discussing the scope of the SDEIS. The final review copy of the response to comments was submitted to NYSDEC on August 14, 2024. On July 1, 2024, DEC and DEP issued a Revised Interim Release Protocol (IRP) for the Ashokan Reservoir. In 2025, NYSDEC continued review of the responses to the DEIS comments.

2.14 Geographic Information System

DEP used its Geographic Information System (GIS) for multiple purposes during the assessment period: to support numerous FAD and MOA programs; to manage the City's interests in water supply lands and facilities; to display and evaluate the efficacy of watershed protection through maps, queries, and analyses; and to support watershed, reservoir, and operational modeling efforts. Primary GIS resources include a centralized geodatabase (the GIS library), the WaLIS, and Global Positioning System (GPS) technology. This report summarizes GIS technical support for programs and modeling applications; the completion or acquisition of new GIS data layers; improvements to GIS infrastructure; and dissemination of GIS data.

2.14.1 GIS Technical Support

DEP used its GIS to perform technical support and data development, including GPS fieldwork, for a variety of watershed protection programs and modeling applications. A core function of its GIS enables DEP to create customized statistical reports and maps depicting land ownership, land cover extent, hydrographic and topographic features, riparian and flood zones, water supply facilities, or program implementation status over particular basins or political boundaries. DEP continuously develops and maintains these core GIS analyses for program design and planning, engineering screening, regulatory jurisdiction determination, emergency response, water supply operations, and recreational outreach. GIS-derived graphics were also created for reports, posters, presentations, and peer-reviewed publications. A few examples are provided below.

Digital elevation models (DEMs) were used to generate custom sub-basin boundaries for specific water quality sampling locations. DEP also incorporated DEMs into global climate models to generate local predictions of future climate conditions. DEP relies on data such as reservoir bathymetry, USDA Soil Survey Geographic Database (SSURGO2) soils, land cover, and land use to drive model analyses.

In 2023 GIS staff worked with LAP and SAP staff to implement a new solicitation approach. This new approach uses forest cover data, Stream Preservation Areas, and SMP project locations to target land purchases in areas the City would like to pursue stream

restoration projects. This helped the SAP work in closer coordination with the SMP to identify collaborative projects.

Reservoir firefighting/dipping maps were updated for DEP, state, and local emergency responders. These will be used during wildfire events to direct aircraft to suitable water scooping areas based on required setbacks from facilities, buoys, eagle nests, and other sensitive areas.

Staff continued deploying DEP GIS layers into DEP Police helicopters at Hudson Valley Regional Airport in Dutchess County. The layers are used for real-time navigation to DEP facilities and property boundaries. Figure 2.38 shows a screenshot of the navigation system in the helicopter. The background image is from the helicopters live camera showing the landscape in real time. The blue boundary is a loaded GIS layer of a City fee property. DEP easement and WAC easement boundaries have also been loaded, for DEP and WAC staff to conduct easement inspections. This helps with continually improving and updating how we can efficiently inspect DEP interests from the air.

Figure 2.38 Photo of the DEP helicopter navigation screen.

2.14.2 Completion or Acquisition of New GIS Data Layers and Aerial Products

New GIS layers were completed during the assessment period resulting from DEP's ongoing data development efforts. USGS, under an inter-governmental agreement with DEP, completed a bathymetric survey of the 13 East of Hudson reservoirs and 3 controlled lakes using a multibeam echosounder combined with light detection and radar to generate 3.28-foot raster grids of the bathymetric surfaces, bathymetric contours at 2-foot intervals of elevation, and

elevation-area-capacity tables (the final report is here: /pubs.usgs.gov/sir/2021/5057/sir20215057.pdf). The contract concluded in 2021, and deliverables included raw and corrected survey points, derived topographic surfaces of each reservoir bottom from those points, 2-foot contours of reservoir depth derived from each topographic surface, and stage-area-volume tables in 0.01-foot increments. Based on these products, DEP completed a matrix of capacity changes for each reservoir since construction. Depth grids derived from the bathymetry are being used as inputs to reservoir water quality models. In addition, all official reservoir boundaries and their dependent data in DEP's version of the National Hydrography Dataset (NHD) have been revised from both new bathymetry and existing 1-meter topography. DEP wrote and ran QA scripts to review all draft deliverable's and incorporated the final data into DEP's GIS and modeling databases.

DEP went under contract with New York State Office of Information Technology Service (ITS) to collect updated high-resolution aircraft-based orthoimagery and LiDAR-based elevation data for the water supply watershed. ITS will collect data covering the entire watershed area, including orthoimagery for all relevant counties, and a 3-mile buffer encompassing the Catskill and Delaware Aqueducts. ITS will develop the following products for DEP: Leaf-on Orthoimagery, Leaf-off Orthoimagery, and LiDAR-based elevation model, including derived contour lines. Imagery and LiDAR were collected during 2025 and deliveries are expected in 2026. A subsequent future contract could turn these data deliverables into land cover, land use, and impervious surface data layers. These products are essential to a wide range of landscape analysis and monitoring efforts, as an indicator of non-point source pollution and development.

As part of ongoing annual data maintenance, DEP regularly updates or overhauls several existing feature classes. These include mission-critical data for various DEP programs, such as countywide digital tax parcels, City-owned land or interests, state-owned land, water supply facilities, stream restoration projects, septic repairs, and engineering project locations. DEP performed annual hydrography and drainage basin data edits, including a matrix of data dependencies. These annual edits are based on corrections observed in the field from Regulatory and Engineering Programs, Water Quality and other DEP staff. The edits have been expanded to now include USGS NHD layers in further basins outside the immediate water supply region to support DEP's Community Water group. Annual updates on locations of sensitive, threatened, or endangered species on City-owned lands were received from the New York Natural Heritage Program (NYNHP) to supplement data collected by the DEP Wildlife Studies Program. Under a less-frequent update cycle, the MOA-designated areas layer was modified based on recent town resolutions. DEP obtained the latest version of SSURGO2 soils data from USDA and numerous other updates from the NYS GIS Clearinghouse, including New York State Departement of Transportation (NYSDOT) transportation features and NYSDEC layers.

2.14.3 GIS Infrastructure Improvement

DEP upgraded user software to ArcGIS Pro, which is a major shift from previous versions of ESRI professional desktop GIS software, with cloud-based licensing, and a more sophisticated user interface. DEP continued to maintain its GIS infrastructure during the assessment period by upgrading ArcGIS Pro software; diagnosing database performance issues; updating schemas and servers to improve database speed; building and testing new geodatabase scripts; evaluating and refining user security levels on servers for different databases; and backing up all databases.

DEP also continued to upgrade and maintain WaLIS, which has operated on over 200 DEP user workstations. Staff modified workflow assignments and a vast amount of email triggers related to the large number of retirements and other staff attrition. WaLIS development shifted its focus to running WaLIS remotely via the Remote Desktop Protocol (RDP). RDP WaLIS will align with employee's current hybrid remote work schedule and with BIT's initiative to replace users' desktop workstations with portable laptops. This approach provides full desktop functionality from any location, providing the DEP user uses DEP's Virtual Private Network (VPN) secure credentials and DEP-provided secure login with multi-factor authentication.

DEP updated and released versions of WaLIS to improve efficiency and with new functionality for changes in process for encroachments and observations. The SMP project data, LFA, and SMIP awards have now been centralized into the centralized WaLIS database and are available for project managers to edit and run reports on.

WaLIS developed a new tool that is being used by BWS Capital Programs Management to track the Rondout Pressure Tunnel (RPT) leak applications received and their approval status and guides the program as a visual aid. This allows us to identify the key problem areas by highlighting "clusters" of parcels for claims received that are confirmed to be tied to RPT leaks as well as those areas where claims are determined to be unattributed to the leaking RPT. Capital Programs Management is also using WaLIS as a platform to save related program files (applications, approvals) and to update the parcels' status throughout the duration of the program.

GIS staff also worked with the SMP to upgrade the Stream Analyst Extension Tool. This tool is a GIS extension custom written to provide a standardized method for DEP and local partners to collect Stream Feature Inventory field data across the WOH watershed. The tool not only allows users to modify and link field collected data but also allows county partners and DEP to centralize their data into a shared GIS standardized geodatabase. This tool was rewritten by GIS staff to be compatible with ArcGIS Pro technology.

The GIS program has been moving into developing mobile applications for staff to collect field data on mobile devices and directly upload into our centralized databases. This improvement helps with the efficiency of field work coupled with avoiding data silos. This

required infrastructure improvement, portal service development, and coordination and support from the Bureau of Information Technology.

Maintenance was performed on numerous GPS units used by various programs, including replacing aging units, updating data dictionaries, updating software, and tracking inventory for all GPS hardware and software. 3 new Trimble TDC600 GPS units were procured that capture the latest data collection technologies. The Trimble TDC600 is a rugged, all-in-one smartphone and GNSS data collector designed for professional surveying and GIS applications. It features a 6-inch high-resolution screen, an Android 8.0 operating system, and a powerful processor, making it capable of running various field applications, including those from Trimble and third-party developers like Environmental Systems Research Institute (ESRI). Key features include built-in cameras and Wi-Fi connectivity, and an all-day battery, along with a MIL-STD-810G rating for durability.

2.14.4 Data Dissemination to Stakeholders

Using established in-house data sharing policies, DEP reviews all outside requests for GIS data and provides these data to watershed partners and interested parties as required. Each year, DEP provides over 55 stakeholders and communities with semiannual data updates in January and July for newly acquired and existing City-owned lands. DEP shares updated watershed recreation data with Ulster County, WAC, and the Catskill Center for their recreation website mapping applications, and to the NYC Open Data Portal. Throughout the assessment period, DEP responded to data sharing requests from NYSDOH, NYSDEC, NHNHP, NYS Office of the Attorney General, WAC, CWC, EOH Watershed Corporation, Catskill Center, New Jersey Department of Environmental Protection, US Army Corp of Engineers, FEMA, many colleges and universities, Central Hudson, NY Power Authority, New York/New Jersey Trail Conference, Hudson Highlands Land Trust, New York Botanical Garden , County Soil and Water Conservation Districts, and various counties, towns, and consultants working on DEP-related watershed projects.

GIS staff implemented a plan in late 2023 to disseminate DEP's most requested "shareable/public" watershed GIS data layers by establishing an online GIS data sharing platform using ESRI's ArcGIS Online (AGOL). This agrees with recommendations that were made by the National Academy of Sciences. This will improve quality control by preventing out-of-date data from being used by the public and will reduce overhead on staff for individual data requests. Staff put this plan into action in 2024. Because of this, GIS worked with the Bureau of Legal Affairs to update our in-house data sharing policies, with support from the Deputy Commissioner.

The publicly accessible web-based Watershed Recreation Mapping Tool provides flexibility to the public when searching for a recreation property based on location or partial name. DEP now hosts AGOL layers that sync, via scripts, from our production database to AGOL weekly for the public to consume the most up-to-date information.

2.15 Regulatory Review and Enforcement

The Regulatory and Engineering Programs Division (REP) is the BWS entity responsible for the review of land development activity in the City's watershed, for the inspection of sewage treatment facilities and active construction sites, and for the pursuit of enforcement actions as required.

REP is divided into three regional sections with offices located in the watershed in Arkville, Kingston and Valhalla. In addition, REP includes the SEQRA Coordination Section which manages the bureau's environmental review obligations via coordination with municipal planning boards and state agencies.

Regional section staff primarily review, approve, inspect and monitor subsurface sewage treatment systems (SSTS), WWTP, sewer systems, SWPPP, Individual residential Stormwater Permits (IRSP), the construction of new impervious surfaces, and various non-point sources of pollution. Engineering reports, sizing and drainage calculations, and facility plans are reviewed for compliance with the WR&R and established New York State technical standards.

2.15.1 SEQRA Coordination

All projects in the NYC watershed are subject to the provisions of New York State Environmental Conservation Law, the corresponding regulations, and the SEQRA. As an agency with the authority to issue discretionary approval, DEP is subject to the provisions of SEQRA which requires that an approving or funding agency consider the environmental impacts of the entire action before approving any specific element of that action. To comply with the requirements of SEQRA, DEP can either participate in a coordinated review conducted by the lead agency or conduct its own uncoordinated review.

These reviews are processed by the SEQRA Coordination Section in conjunction with an internal technical team made up of staff with a wide variety of expertise from other units within BWS.

As an involved agency in most instances, DEP's comments alert interested parties to its regulatory authority, are intended to assess any potential adverse impacts associated with the activity and identify adequate mitigation measures. SEQRA reviews are typically conducted in conjunction with municipal planning boards and the NYSDEC. This cooperative regulatory framework helps to ensure DEP participation in the review of proposed activities at the earliest stage of project planning. REP has issued comments on 576 SEQRA notices since January 1, 2021, an increase of 20% over the prior five-year reporting period.

2.15.2 Project Review

By way of review and strict application of limiting distances and design standards for land development activities, the regulatory program continues in its mission to protect the water supply against contamination, degradation, and pollution of source waters in the watershed.

For the review of new, altered and repaired SSTSs, DEP applies NYS standards for design including the residential system requirements noted in Appendix 75-A which NYSDOH most recently amended in March 2016 and the NYSDEC intermediate system design standards last updated in March 2014. SSTS designers and contractors continue to employ the combination of septic tanks and standard absorption fields to manage on-site wastewater with enhanced treatment units utilized for repairs on marginal or physically constrained sites. DEP received 3231 SSTS applications during the reporting period, a 29% increase over the prior five-year reporting period.

From a stormwater standpoint, DEP received 243 applications during this reporting period, reflecting a slight increase from the prior reporting period. Both SWPPP and IRSP applications continue to rely heavily on infiltration and bioretention systems to meet both the treatment and runoff reduction criteria required by the latest NYS Stormwater Management Design Manual.

Additionally, REP's regional sections review and provide comments on other applications pending before municipal, state and federal agencies that have the potential to adversely impact water quality in the watershed. These regulated activities include stream disturbances, wetland and buffer disturbances, mining operations, transportation projects, solid waste management facilities, industrial activities and timber harvests.

2.15.3 Inspections

All new, altered and repaired septic systems are inspected during the construction phase by DEP staff or inspected by local health department personnel pursuant to delegation agreements with respective watershed counties (Putnam, Ulster and Westchester).

REP staff conduct weekly inspections of all approved active stormwater construction sites from commencement of work through final stabilization. Staff are also responsible for investigating citizen complaints of possible violations of water quality standards including turbid discharges, illicit solid waste disposal, leaking petroleum bulk storage, and discharges from improperly stored road salt.

To ensure that WWTPs are operated and maintained in accordance with the limits established in their SPDES permits, DEP inspects most wastewater facilities within the watershed on a quarterly basis, and seasonal wastewater facilities twice annually. DEP personnel also share their technical expertise with plant operators and offer easy-to-implement operational modifications. These changes often result in improvements to plant operations and reduced long-term maintenance costs.

2.15.4 Enforcement

DEP reserves the authority to pursue enforcement action upon confirmation of sources of pollution or contamination to the City's water supply. To resolve identified violations in a timely manner, formal Notice of Violation (NOV) procedures are initiated which entail review by

DEP/City legal staff. Legal staff remain involved should further steps, including litigation, become necessary.

During the reporting period, DEP issued a total of 44 NOVs for violations of the WR&R. These violations include the failure of residential SSTSs, non-compliance with approved SWPPPs, commencement of construction without prior DEP approval, and the improper storage and management of cow manure.

2.15.5 Watershed Rules & Regulations

REP's most significant accomplishment during this reporting period was finalizing amendments to the WR&R. New York City first established watershed regulations in 1917 to protect its water supply and provide oversight of activities that might cause contamination. Those regulations were modified significantly in the 1990s with the signing of the Watershed MOA and were most recently updated in 2010 and 2019. The latest WR&R amendments were completed solely to address recent changes in state law concerning the protection of wetlands and their adjacent areas.

Effective February 28, 2025, the amendments revised the definition of "wetland" in DEP's rules to ensure continuity as NYSDEC amended its freshwater wetlands regulations to align with amendments to the New York State Freshwater Wetlands Act which took effect on January 1, 2025. Under the Article 24 Amendments, NYSDEC wetland delineations are no longer based on the NYSDEC mapping process that previously governed such delineations. Accordingly, these amendments are designed to preserve DEP's existing jurisdiction within specified limiting distances from wetlands subject to NYSDEC jurisdiction as of December 31, 2024, thereby maintaining the status quo.

In addition, these amendments add a new subdivision to section 18-17 that incorporates by reference maps identifying wetlands in the watershed subject to NYSDEC jurisdiction as of December 31, 2024, and makes these maps available to the public for inspection and copying at New York State Department of Health, Office of Regulatory Affairs, Tower Building, Room 2415, Empire State Plaza, Albany, NY 12237. The maps are also available on NYSDEC's Environmental Resource Mapper website.. Finally, subdivisions (1) through (11) of section 18-17 are also amended to add web page access links to each of the referenced materials.

In accordance with the Citywide Administrative Procedures Act (CAPA), DEP published the proposed amendments in the City Record in December 2024. As required under CAPA, DEP published the amended regulations a second time in the City Record on January 29, 2025, and pursuant to Public Health Law (PHL), initiated publication of the revisions once a week for two consecutive weeks in at least one newspaper with circulation in each watershed county. Affidavits of each publisher/proprietor of the newspaper in which the WR&R amendments were published were filed in the county clerk's office of each county by June 2025 in accordance with PHL.

2.16 Waterborne Disease Risk Assessment

EPA's Surface Water Treatment Rule and DEP's WDRAP share a common goal – public health protection. The objectives of the WDRAP help provide assurance that this goal is met. Components of WDRAP have evolved over time; but the essential purpose and the core organizational structure have remained consistent over the years. WDRAP is a joint agency program involving NYCDOHMH and DEP. Established in 1993, the program has continued under a series of intra-city agreements (ICAs) between these two city agencies. The WDRAP ICA lays out each agency's roles and responsibilities. In 2022, DEP and the NYCDOHMH renewed their collaboration by finalizing a new ICA which took effect July 1, 2022, and will continue through June 30, 2027.

The core objectives of WDRAP are the following:

- Obtain data on the rates of giardiasis and cryptosporidiosis in NYC, along with demographic and risk factor information on cases and patients; and
- Provide a system to track gastrointestinal illness (as indicated by diarrhea or vomiting) to ensure rapid detection of any outbreaks.

These two core objectives are met via the two main programs of case surveillance and syndromic surveillance. Aside from these main programs, additional activities are carried out relevant to WDRAP. Outreach and educational activities related to increasing awareness of the epidemiology and transmission of waterborne parasitic disease are undertaken.

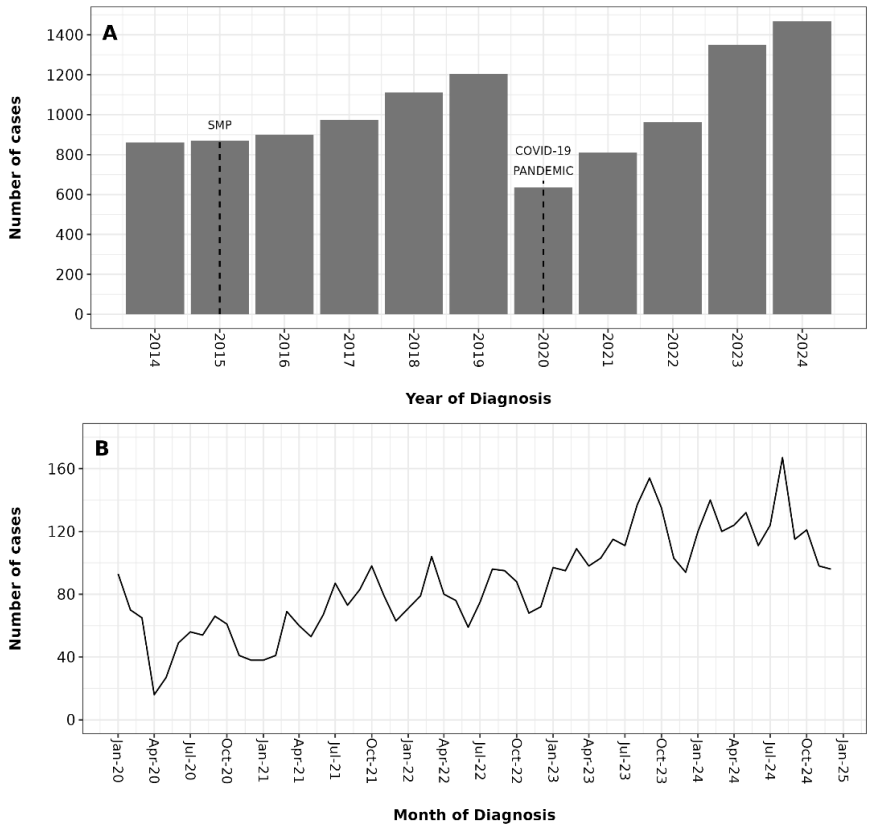
Each year, a WDRAP annual report is produced which includes program implementation updates, as well as charts, maps, and other figures presenting data findings. Some brief highlights and other sample findings are provided below for this assessment report. Further details, can be found in the WDRAP annual reports, which are available at: https://www1.nyc.gov/site/dep/water/waterborne-disease-risk-assessment.page .

2.16.1 Disease Surveillance

Cryptosporidiosis and giardiasis diagnoses are reportable to the NYCDOHMH under the City health code. The vast majority of cases are reported by electronic laboratory reports which began in 2011. This report presents data for giardiasis and cryptosporidiosis from 2020-2024. All cryptosporidiosis cases are assigned for interviews to collect further demographic information as well as details on potential transmission risks. Giardiasis cases are not typically interviewed unless the person is known to be in a position where there is an increased risk of secondary transmission (e.g. food handler, healthcare worker, child attending childcare, or childcare worker). Brief highlights of case surveillance data are provided below.

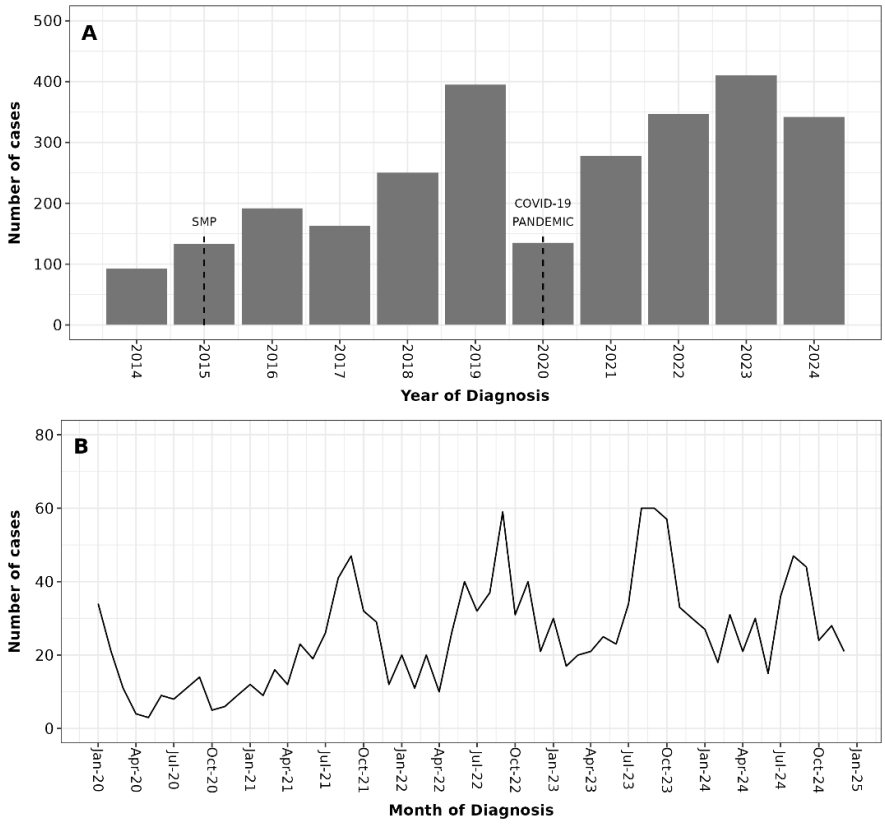
City-wide Trends

Three figures are provided in this chapter which summarize NYC trends from 2014 to 2024: Figure 2.39 and Figure 2.40 summarize temporal trends for giardiasis and cryptosporidiosis, respectively, from 2014 through 2024. Figure 2.41 shows cases of giardiasis and cryptosporidiosis diagnosed exclusively by syndromic multiplex polymerase chain reaction (PCR) panels (SMPs), 2015-2024.



Annual giardiasis counts, NYC, 2014 - 2024 (A) and Monthly giardiasis counts for the last five years (B). The first vertical dotted line shows the date when the first NYC laboratory reported results from syndromic multiplex panels for enteric diseases (2015), and the second marks the start of the COVID-19 pandemic (2020).

Figure 2.39 Giardiasis trends in NYC



Annual cryptosporidiosis counts, NYC, 2014-2024 (A); and Monthly cryptosporidiosis counts for the last five years (B). The first vertical dotted line shows the date when the first NYC laboratory reported results from SMPs for enteric diseases (2015), and the second marks the start of the COVID-19 pandemic (2020).

Figure 2.40 Cryptosporidiosis trends in NYC

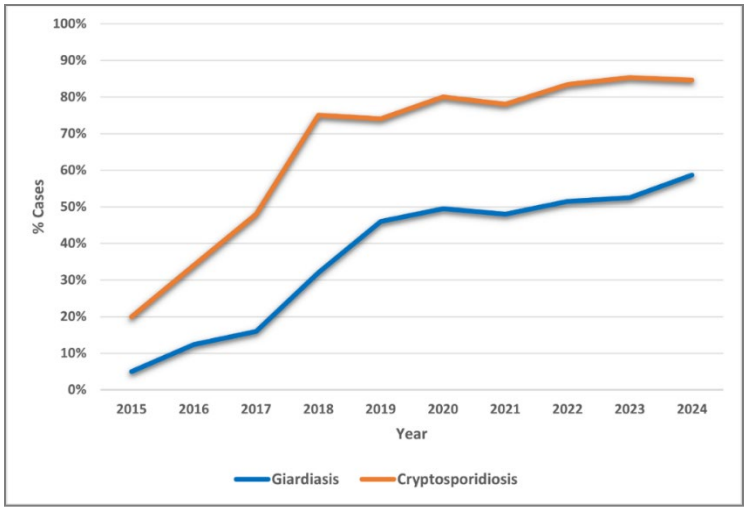


Figure 2.41 Cases of giardiasis and cryptosporidiosis, diagnosed exclusively by SMPs, 2015 – 2024.

The figures show the trend of increasing case reports for giardiasis, and particularly for cryptosporidiosis, which started in 2015 and continued through 2024 (Figure 2.39 and Figure 2.40). This increase in case reports coincides with the increasing adoption by clinical laboratories of a new type of diagnostic test. These newly-adopted assays, SMPs, can test for the presence of a wide range of enteric pathogens including Cryptosporidium and Giardia. This new test platform has led to a substantial increase in diagnosed and reported cases – in NYC and across the United States. The trend of increased giardiasis and cryptosporidiosis cases being diagnosed in NYC is most likely a reflection of improved disease detection related to the new diagnostic tests rather than an actual increase in community level of illness. The proportion of giardiasis patients diagnosed exclusively by an SMP test at a hospital or commercial laboratory has grown from 5% in 2015 to 58.7% in 2024 (Figure 2.39). Similarly, the proportion of cryptosporidiosis patients diagnosed exclusively by an SMP test at a hospital or commercial laboratory has grown from 20% in 2015 to 84.5% in 2024.

Another temporal trend noted is that cryptosporidiosis is highly seasonal, with patients presenting more frequently in the warmer summer months compared to the winter months. Seasonality of giardiasis is less pronounced.

Demographic Highlights

During this assessment period, trends, counts, and rates of giardiasis and cryptosporidiosis continued to reflect findings of the past 10 years, specifically 2020-2024; when results were consistently higher among males compared to females and were typically highest among men aged 20 to 44 years old. The highest rates of infection were typically in Manhattan, commonly clustered in the Chelsea-Clinton neighborhood. Among cryptosporidiosis patients, rates were typically highest among White, non-Hispanic persons followed by Hispanic persons and Black/African American persons. The demographic patterns seen in NYC for both giardiasis and cryptosporidiosis are largely consistent with person-to-person spread, particularly sexual transmission among men who have sex with men, as well as international travel (Alleyne et al. 2020). Additionally, data suggest that neighborhood level poverty is not a determinant for either parasitic infection.

2.16.2 Risk Factor Results

Interviews are conducted with cryptosporidiosis patients to collect data on commonly reported potential risk exposures (e.g., international travel, high-risk sexual activity, contact with animals, tap water consumption), and HIV/AIDS status. While the determination of a statistical association between cryptosporidiosis infection and exposure to possible risk factors cannot be made without reference to a suitable control population, examination of data can reveal interesting and potentially informative patterns. A few findings are included here as examples. Patients who were immunocompetent were significantly more likely to report international travel and to report exposure to recreational water during their incubation period. Additionally, men 20-59 years old were more likely to report high-risk sexual practices with an increased risk for

fecal contact compared to older men and women. Although we do not have reliable data on whether a patient identifies as a man who has sex with men, high rates of cryptosporidiosis among men were consistently identified in areas known to have an above-average proportion of residents who are men who have sex with men, such as Chelsea-Clinton. Additional discussion of demographics and potential risk exposures of interviewed cases is included in WDRAP annual reports.

Additionally, in 2022, a routine cluster detection algorithm detected an increase of cryptosporidiosis in a Brooklyn neighborhood. In total, there were 47 cases diagnosed in September through November 2022. The median patient age was 28 years (range:0-75 years); 25 (53%) of the cases were male. A supplemental questionnaire revealed that eleven patients (23%) reported local and international travel, and eight patients (17%) reported water exposure (aside from drinking). Ten (21%) patients reported attending or working in schools. BCD staff presented this increase to a community-based organization and provided health education to patients on the symptoms and transmission of cryptosporidiosis. Data gathered by the NYC Health Department indicated that this outbreak was not related to the NYC water supply.

Syndromic Surveillance

The tracking of sentinel populations or surrogate indicators of disease ("syndromic surveillance") can be useful in assessing gastrointestinal (GI) disease trends in the general population. Such tracking programs provide greater assurance against the possibility that a citywide outbreak would remain undetected. In addition, such programs can potentially play a role in limiting an outbreak's extent by providing an early indication of a problem so control measures may be implemented rapidly. NYC maintains four distinct and complimentary syndromic systems. Recent summary highlights are provided on each, below.

Hospital Emergency Department (ED) System

Electronic tracking of hospital emergency department logs is conducted to monitor chief complaints and diagnosis data including symptoms of gastrointestinal illness. Data from 52 hospitals is collected and analyzed daily. There have been no significant changes to this system during this assessment period.

Anti-Diarrheal (ADM) and Over-the-Counter (OTC)Medication

Sales of over-the-counter (OTC) or non-prescription anti-diarrheal medications (ADM) at major pharmacies are monitored electronically. Data from approximately 300 drug stores is received and analyzed daily. During this reporting period, one of the three major pharmacy chains participating in the program closed (RiteAid). Walgreens and CVS continue to report data to the program on a nearly daily basis. If one store's data is not received by 9 pm on a given day, statistical analysis is performed on the existing data, and the second store's data are incorporated the next day.

Clinical Laboratory System

Monitoring of the number of stool specimens submitted to a clinical laboratory for microbial testing continued during this period. There have been no significant changes to this system during the assessment period.

Nursing Home Sentinel Surveillance

The nursing home surveillance system remains in operation. GI outbreaks in sentinel nursing homes are monitored, and NYCDOHMH staff assist in the investigation of any identified outbreaks. There have been no significant changes to the system since 2002.

Syndromic Surveillance Results Summary

As described in annual WDRAP reports, data from NYC's syndromic surveillance systems have proven useful in demonstrating annual citywide seasonal trends of norovirus and rotavirus. Knowledge of these trends provides a baseline of data which should improve the City's ability to detect aberrations. Data from emergency departments and pharmacy syndromic surveillance systems are received daily. For the clinical lab, system data are received several times a week. Nursing home data are received on an event basis. Data are analyzed for any unusual trends or signals. Monthly summary reports are also prepared and provided by the NYC Health Department to DEP. Data for each year is summarized in the WDRAP annual reports. The NYCDOHMH communicates syndromic surveillance findings to DEP on a routine basis and notifies DEP of any signals of concern. In 2024, there were data transmission issues in the OTC Surveillance system starting on June 6, 2024, which lasted for a few weeks and resulted in fewer stores reporting to the system from two participating pharmacy groups. On July 19, a global technical outage involving software from the cybersecurity firm CrowdStrike hit the OTC system which further impacted the number of stores reporting medication sales through the end of July/early August. During this time, NYCDOHMH staff actively worked with the different pharmacy groups to restore data workflows and backfill the missing data. Since WDRAP has multiple elements including our mainstay ED Syndromic Surveillance system, there is some redundancy to ensure that we were not missing possible outbreaks during the period when fewer stores were reporting. All four syndromic surveillance systems continued to be operational during the assessment period, and there was no evidence of a drinking water-related outbreak in NYC during the assessment period, consistent with findings of prior years.

2.16.3 WDRAP in 2020 – Impact of COVID-19 Pandemic

The COVID-19 pandemic had an impact on reported incidence of both cryptosporidiosis and giardiasis in NYC in 2020. As with all other reportable diseases, the counts of new cases detected and reported decreased sharply starting in March 2020 when stay-at-home orders were instituted by New York State (New York State 2020). As discussed in the 2016-2019 FAD Assessment report, the drop in parasitic infections was likely a combination of genuine reduction in disease transmission and a decrease in healthcare seeking behavior. Incidence of most reportable diseases began to increase as NYC reopened, including cryptosporidiosis and

giardiasis. Case counts returned approximately to pre-pandemic levels by 2021with the introduction of COVID-19 vaccination, resumption of international travel, and reopening of schools, restaurants, and other settings where people congregate leading to opportunities for parasitic enteric disease transmission (Thompson et al. 2020).

Outreach/Education

Outreach and education activities continued during the current assessment period. Outreach is primarily conducted by the NYC Health Department Bureau of Communicable Disease staff and included presentations to community organizations on the topic of parasitic diseases and hand hygiene. Some additional outreach/education efforts undertaken during this assessment period are noted below.

DEP BWS staff presentations relevant to WDRAP during this assessment included those at the annual interagency Pathogen Technical Working Group meeting held in May, and the Watershed Science and Technical Conference held in September. Conversations with the medical and public health communities and others serve to enhance awareness of waterborne diseases and may also lead to more complete disease diagnosis and reporting.

2.16.4 Conclusions

NYC's core ongoing WDRAP operations continued during this assessment period. There were no major programmatic changes implemented by NYCDOHMH or DEP during this time. During the 2020-2024 assessment period, there was no evidence of an outbreak of waterborne diseases in NYC. WDRAP program implementation continues, and reports continue to be prepared and submitted as per the FAD schedule.

2.17 Education and Outreach

During the current FAD assessment period, DEP continued to collaborate with the CWC, WAC, Cornell Cooperative Extensions, county Soil and Water Conservation Districts, Catskill Center, the Catskill Regional Invasive Species Partnership, the Lower Hudson Partnership for Invasive Species Management, Trout Unlimited, and other partners to increase knowledge and awareness among key audiences about source water protection, land conservation and stewardship, stream corridor protection, stormwater and wastewater, flood response and preparedness, invasive species, watershed recreation, riparian buffers, and other topics.

DEP and its partners use numerous strategies and tools to educate specific audiences and target outreach to the broader public. One tool for reaching large numbers of constituents continues to be DEP's website, which serves as a repository for DEP's annual consumer confidence report, press releases, watershed regulations, recreation maps, regulatory guidance documents, environmental education materials, and FAD reports. DEP routinely issues myriad press releases each year that educate the public about the water supply, watershed protection, watershed recreation, and environmental education programs.

DEP also uses social media such as Twitter, Facebook, Instagram and Flickr to disseminate real-time updates, announcements, videos, and photos directly to subscribers and followers. During the past five years, DEP has amassed more than 22,000 followers on NYC Water Facebook, nearly 10,000 followers on NYC Watershed Facebook, more than 24,200 followers on NYC Water Twitter, and more than 19,590 followers on NYC Water Instagram. DEP's NYC Water Flickr Page contains over 14,160 photos and archival images.

As acknowledged by the NASEM in its 2020 FAD Expert Panel Report, DEP's Watershed Recreation Program "exemplifies the spirit and letter of the MOA." During this FAD assessment period, DEP continued to engage watershed residents and downstate water consumers in the enjoyment and stewardship of City-owned watershed lands and reservoirs, even though in-person events such as family fishing days and reservoir cleanups have been curtailed since the COVID-19 pandemic. Among many highlights, DEP continued to disseminate the Watershed Recreation e-newsletter to more 100,000 subscribers, while collaborating with Ulster County to manage and maintain the Ashokan Rail Trail, which attracts upwards of 150,000 visitors in recent years. Most recently, DEP also began using a new expedited recreational permitting process to allow organizations, schools, and other groups to use City-owned lands for low-impact outreach and recreation activities.

During the current FAD assessment period, DEP's Education Office conducted several hundred environmental education programs annually that reached approximately 40,000 students, educators, agency staff, and other professionals every year. DEP accomplished this through classroom visits, guided tours and field trips, programs at the Visitor Center at Newtown Creek Wastewater Resource Recovery Facility, and the use of multi-disciplinary online, print and digital resources. DEP hosted and collaborated on dozens of professional learning opportunities for teachers, school administrators, parent coordinators, and non-formal educators. Since 2019, DEP's professional learning opportunities have been approved by the New York State Education Department for state-certified teachers seeking to receive continuing education credits.

During this FAD assessment period, DEP's annual Water Resources Art and Poetry Contest engaged about 2,000 students and educators, while Trout in the Classroom attracted over 18,000 students and 150 teachers each year. DEP sponsored several in-City performances of "City That Drinks the Mountain Sky" for thousands of attendees, collaborated with local museums to support educational events and exhibitions, and partnered with WAC to conduct an annual watershed forestry bus tour for approximately 50 non-formal educators. DEP continued to utilize the "Understanding NYC's Water Story" curriculum guide and "From Mountain Top to Tap" educational map and study guide to help students explore the water supply system. Additionally, DEP developed new resources, including the "Drippy's Water Adventure" coloring book, a collection of virtual tours about NYC's water systems, and a resource guide of lessons and activities about water conservation and drought awareness.

During this FAD assessment period, the Watershed Agricultural Program organized several dozen farmer education programs every year, including workshops, farm tours, webinars, classroom instruction, producer group meetings, the annual Catskill Regional Agricultural Conference, and the annual Delaware County "Clean Sweep" Chemical Disposal Day. The Watershed Agricultural Program generally engages 600-800 participants per year in farmer education programs. WAC continued to promote its programs through its main website, in addition to promoting local farm and forestry products through the Pure Catskills campaign.

Education is a cornerstone of the WAC Forestry Program, which targets landowners, loggers, foresters, and the wood-products industry with messaging about the importance of well-managed working forests. During this FAD assessment period, the WAC Forestry Program continued to utilize the MyWoodlot website as an educational resource for forest landowners while the four watershed model forests continued to host educational events reaching thousands of landowners, loggers, students, and members of the public. WAC sponsored 8-10 logger training workshops each year that resulted in approximately 100 individuals achieving or retaining Trained Logger Certification (TLC) status throughout the FAD assessment period. WAC also sponsored 30-40 watershed forestry bus tours each year for thousands of students and adults, primarily in-City water consumers. A total of 115 teachers attended WAC's annual Watershed Forestry Institute for Teachers during 2021-2025, while more than 1,000 students participated in the annual Green Connections School Partnership Program.

Education is also a cornerstone of the SMP, which conducts or sponsors a diverse slate of targeted training programs, workshops, public presentations, interpretive hikes, volunteer planting events, and school-based activities for streamside landowners, local officials, highway departments, flood response professionals, watershed youth, and the scientific community. During the current FAD assessment period, the SMP continued to support an ongoing series of annual educational offerings that include the following highlights: Ashokan Watershed Conference, Schoharie Watershed Summit/Month, Rondout Neversink Anglers Symposium, Leave No Trace Stream Stewardship Program, Summer Youth Stream Snorkeling Program, Watershed Scientist in Residence Program, Youth Climate Change Leadership Summit, Erosion and Sediment Control and Emergency Stream Intervention trainings, Community Flood Mitigation workshops, and the biennial Catskill Environmental Research and Monitoring Conference (which took place in 2022 and 2025). The SMP continued to host the Catskillstreams website, which is repository for information including all Local Flood Analyses (LFAs) and the newly completed "Stream Processes 101" training for municipal officials. The SMP also continued to employ the Watershed Conservation Corps, a summer internship program funded by DEP through a contract with SUNY Ulster, while funding riparian buffer assistance interns through SUNY Delhi.

CWC continued to implement a Public Education Grants Program that has awarded 905 education grants since 1997 totaling approximately $5 million. During 2021-2025, CWC awarded 141 grants totaling just under $916,000 to schools and organizations in both New York City and the watershed for projects and programs that increase knowledge and awareness of the

water supply. During the current FAD assessment period, CWC also sponsored several septic system maintenance workshops every year for homeowners, and numerous other stormwater and wastewater workshops for municipal officials and local professionals. CWC continued to keep watershed residents informed about issues and programs via its primary organizational website, press releases, e-newsletters, and a special website dedicated to watershed educators.

Finally, DEP and its partners regularly attended numerous community outreach events and speaking engagements during this FAD assessment period. Perennial highlights include the Belleayre Annual Fall Festival, Bovina Farm Day, Career Day (multiple locations), Catskill Outdoor Expo, Delaware County Fair, Delhi Harvest Festival, Deposit Lumberjack Festival, Earth Day (various school events), Family Farm Day, Grahamsville Little World's Fair, Greene County Youth Fair, Invasive Species Awareness Week, Lower Hudson Valley Engineering Expo, Margaretville Cauliflower Festival, Meredith Dairy Fest, NYC Environmental Expo, NYC Watershed Science and Technical Conference, NYS Floodplain Managers Annual Conference, NYS Wetlands Forum, NYS Woodsmen's Field Days, Olive Day, Rockland Community College World Fishing and Outdoor Expo, Shandaken Day, SPDES permit outreach meetings, Take Your Child To Work Day (multiple locations), Teatown Eagle Fest, Ulster County Fair, and the Westchester County Regional Envirothon.

3. The Catskill System

3.1 Introduction

3.1.1 The Catskill System Overview

The Catskill System consists of two reservoirs – Schoharie and Ashokan – located west of the Hudson River in Ulster, Schoharie, Delaware and Greene counties. The Catskill system was constructed in the early part of the 20th century. Ashokan Reservoir went into service in 1915 and Schoharie in 1926. The water residence times for the three Catskill System reservoirs over a 59-year period (1967 to 20Table25) are depicted in Figure 3.1. Schoharie consistently has the shortest water residence time due to the high hydraulic load that is delivered by its large watershed. Schoharie water residence time averages about one and a half months. Ashokan West averages about 2.5 months, though it varies depending on operational requirements (balancing reservoirs, maintenance, etc.), as observed in 2023 and 2024. Ashokan East typically averaged about four months until 2007, when diversions started being flagged as originating from either the East or West Basin, allowing better residence time estimations for both basins. Since then, residence times averaged closer to seven months. Residence times at Ashokan East similarly increased over the last decade, in part due to the maintenance of the Catskill Aqueduct and to prepare Ashokan Reservoir for use during the Rondout West Branch Tunnel shutdown in 2024. In general, the evolution of a basin to a new steady state takes approximately three times the duration of its water residence time. Depending on the operational requirements we would expect Schoharie to adjust to new nutrient loading levels in about four months, whereas Ashokan West would take about seven months and Ashokan East one to two years to re-equilibrate.

3.1.2 Catskill System Operations

The elevation and location (East and/or West Basin) of withdrawal at Ashokan Reservoir can be adjusted as needed throughout the year to divert the best quality water from the reservoir. These changes are also made to meet operational needs, such as lowering the West Basin to create a void to accept more runoff during large storm events. Water enters Ashokan's West Basin and, after a settling period, is withdrawn from the West Basin, East Basin, or a blend of West and East basins. Water can also move from the West Basin to the East Basin via the Ashokan Dividing Weir. The operational strategies implemented at Ashokan from 2020 until the end of 2024 are discussed in detail in this section and illustrated in Figure 3.2. Diversions from Schoharie Reservoir are subject to NYS SPDES Permit (NY-026-8151) issued September 1, 2006. These diversions enter Ashokan Reservoir via the Shandaken Tunnel Outlet and the Esopus Creek where the SPDES permit establishes requirements related to discharge waters from Schoharie Reservoir to the Esopus Creek.

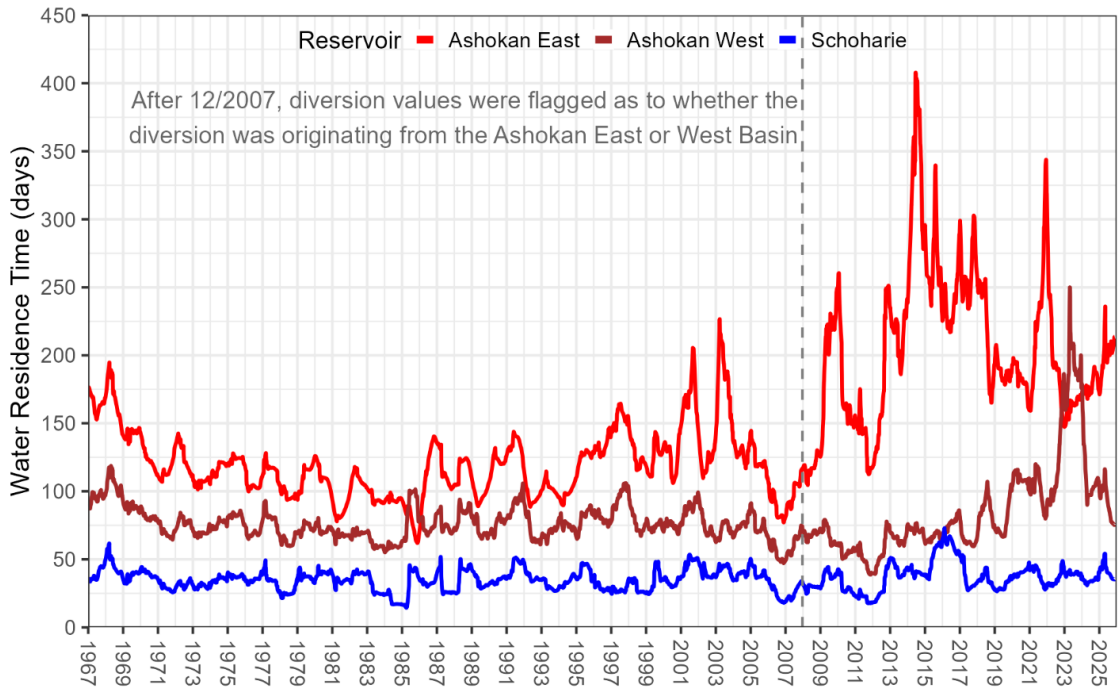


Figure 3.1 Water residence time in the Catskill System Reservoirs, 1967-2025.

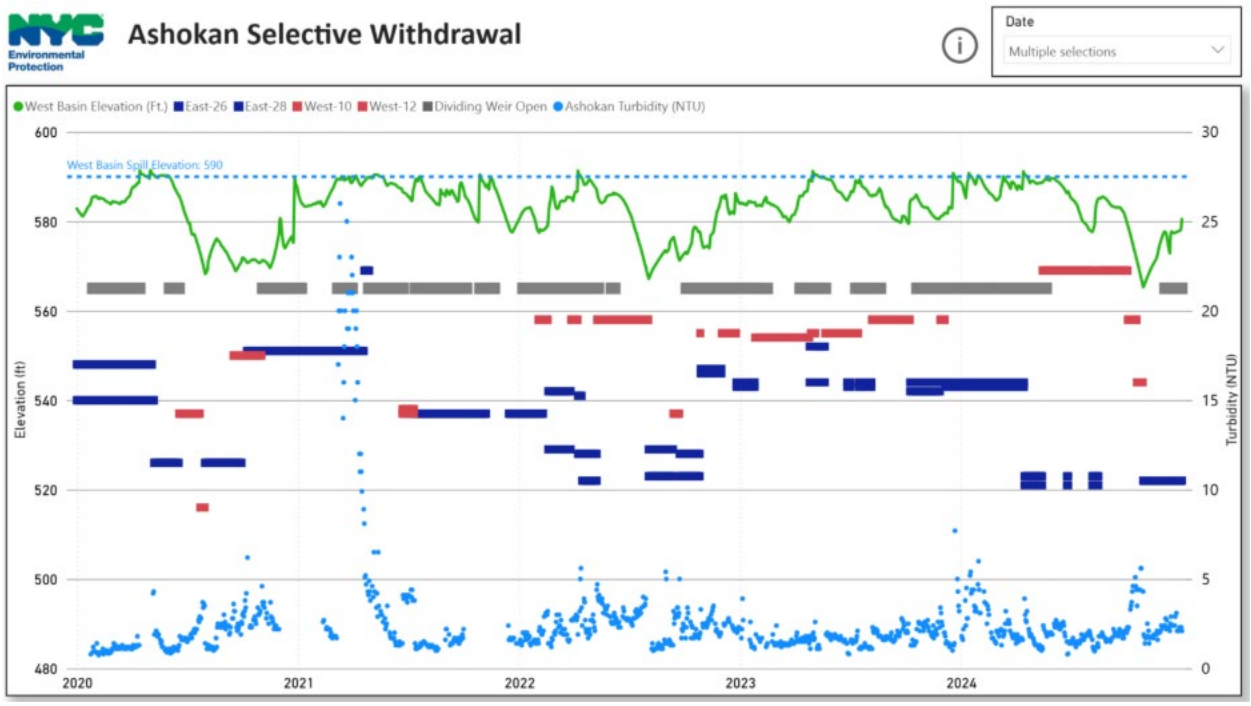


Figure 3.2 Ashokan Operations (2020-2024).

In 2020, turbidity was the main water quality component driving operational changes, as surrogates for disinfection byproduct formation potential (DBPfp) were relatively low throughout the year. In January 2020, the Catskill Aqueduct was shut down for the Catskill Aqueduct Repair and Rehabilitation Project (CAT-RR). By the end of January, the aqueduct was back in operation and flow was increased to 585 MGD, drawing from the East Basin. The dividing weir flow was adjusted to balance the basins. During April and May, there were three more aqueduct shutdowns for repairs. By the middle of June, the Ashokan diversion was switched to draw from the West Basin. The Ashokan release channel was used during May to improve water quality and for spill mitigation. In October, when Ashokan turbidity levels reached 5 NTU, the diversion was switched from a West Basin draw to an East/West Basin blend until November. There was one more shutdown in support of CAT-RR in December which continued through the end of the year.

In 2021, a combination of water quality and infrastructure improvements were driving operational changes at different times throughout the year. The Catskill Aqueduct was offline for CAT-RR until February 8, 2021, when flow was restored with an East Basin draw. The Ashokan Reservoir West Basin elevation and turbidity continued to rise throughout February. The dividing weir was opened to prevent excessive West to East Basin spill, which can lead to short-circuiting of turbid water at the East Basin intakes. While less impactful, opening the weir ultimately resulted in increased turbidity in the East Basin, prompting diversions from Ashokan Reservoir to decrease throughout March and April. Water from Ashokan Reservoir was diverted mostly from the East Basin for the remainder of the year, except for a period between mid-June and mid-July. The dividing weir was utilized nearly the entire year to enable the transfer of water from the West to East Basin to balance the system. A second Catskill Aqueduct shutdown occurred at the end of the year from October 1, 2021, through mid-December (Figure 3.3).

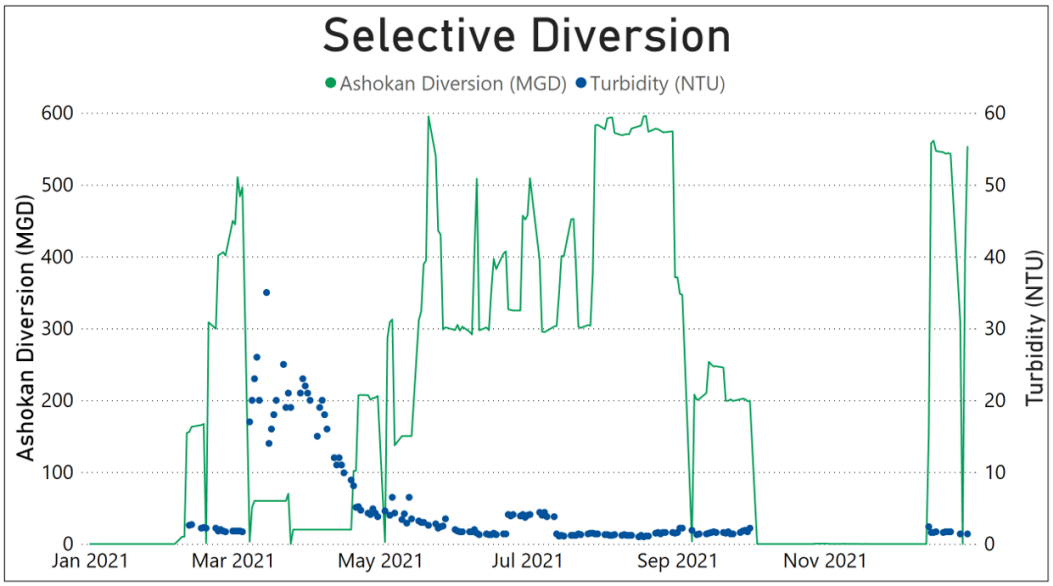


Figure 3.3 Ashokan Flow and Turbidity in 2021.

In 2022, water quality in the Catskill System was excellent throughout the year with lower levels of both turbidity and UV254. Diversions from Ashokan Reservoir were maximized throughout the winter and spring to mitigate and help recover from the 2021 disinfection by-product (DBP) violation. During this time, the West Basin elevation was maintained well below spill level due to maximized diversions in combination with a dry summer period, use of the dividing weir, and West Basin withdrawals. The West Basin elevation increased throughout the fall due to rainfall and aqueduct shutdowns to support remotely operated vehicle (ROV) work in early December 2022.

Similar to 2022, water quality in the Catskill System was excellent for most of 2023. The West Basin remained below spill elevation most of the year except for a brief period in early May when the basin spilled. At the end of the year, a mid-December storm event led to a tremendous amount of runoff that increased the West Basin elevation nearly eight feet over two days (582.9' on December 17, 2023 to 590.77' on December 19, 2023). In response to this event, DEP began operating the Catskill-Delaware Interconnection at Shaft 4 (CDIS4) on December 22, 2023. This reduced the volume of turbid Ashokan Reservoir water from reaching Kensico by introducing Delaware System water into the Catskill Aqueduct. This system configuration was held into the new year.

In 2024, water quality in the Catskill System continued to be excellent for most of the year. The West Basin elevation remained below spill except for a few minor events due to storms during the winter and spring. DEP continued operating CDIS4 through January 14, 2024, and again from February 2, 2024 through February 14, 2024. During the 2024 winter/spring period, the dividing weir was utilized consistently to move water from the West Basin into the East Basin without spilling over the weir. On April 15, 2024, the withdrawal elevation was lowered from 544' to 522' to improve water quality diverted from Ashokan Reservoir.

After the active winter/spring period, operations were focused on executing the Rondout West Branch Tunnel (RWBT) shutdown. The diversion from the Ashokan Reservoir was switched to the West Basin in May to preserve excellent water quality in the East Basin in preparation for the shutdown. CDIS4 remained offline until it was re-activated on July 20, 2024, to conserve Ashokan Reservoir water. The West Basin withdrawal continued until October 28, 2024, with two intake elevation changes required due to decreasing elevation, which was exacerbated by a lack of precipitation. The West Basin draw continued until October 28, 2024, when diversions switched to the East Basin to maintain adequate flow during the RWBT shutdown. This configuration continued for the remainder of the shutdown and after its bailout on December 13, 2024 due to drought conditions.

3.1.3 Water Quality Trending and Assessment

Water quality trending requires a much longer time period than the current five-year reporting period. Trend assessment in this report includes data from 1993 through 2024 and allows an examination of changes over the past 32 years in the context of changes made through

protection programs, as well as through natural variation. Status and trends were assessed at the Schoharie Reservoir and the East and West basins of the Ashokan Reservoir, and at select inflows and outflows. The current water quality status assessment used aggregated data from the last three years (2022-2024). The analytes chosen were those most important for the SWTR and meeting the requirements of the 2017 revised Filtration Avoidance Determination. The trophic status of each reservoir and the recent biological assessment profile scores for select streams were also assessed using standard criteria. Appendix C provides more detail on statistical and data collection methods.

3.2 The Schoharie Basin

The Schoharie Reservoir's watershed is 315 square miles and includes parts of 15 towns in three counties. Schoharie Creek is the primary tributary flowing into the reservoir, supplying 75% of the flow, while Manor Kill and Bear Kill provide 10% and 8%, respectively. The Schoharie Reservoir consists of one basin, almost six miles in length, and holds 21.5 billion gallons at total capacity.

Of the 201,658 acres of land in the Schoharie watershed, 79.1% is forested, 8.1% is urban or built-up land, 6.2% is in agricultural use, 5.3% is brushland or successional land, 0.1% is classified as barren land, and 1.1% is water. The ongoing protection program activities in the watershed are described in Watershed Protection Program sections.

3.2.1 Water Quality Status and Trends in the Schoharie Watershed

Status (Schoharie)

The Schoharie basin status evaluation is presented as a series of boxplots in Figure 3.4, which compare Schoharie Creek (S5I), the principal inflow to the reservoir, the reservoir (SS), and the outflow represented at the Shandaken Tunnel Outlet (SRR2CM). A site map, description of the sampling program, and details on data preparation and boxplot interpretation are provided in Appendix C.

For the current period (2022-2024), fecal coliform bacteria remained, for the most part, below the NYSDEC Stream Guidance Value of 200 fecal coliforms 100 mL^{-1} for the stream inflow site S5I. Consistent with previous evaluations, the reservoir inflow levels were higher than the reservoir and outflow values for fecal coliforms. Median turbidity was highest in the outflow with a slightly higher range of variability (median 6.5 NTU and interquartile range 5.2 NTU) in contrast to the inflow and reservoir. TP increased from inflow to reservoir to outflow, with an inflow median of 10 µg L^{-1}, reservoir median of 12 µg L^{-1}, and outflow median of 14 µg L^{-1}. Most values for TP were below the 20 µg L^{-1} benchmark in Schoharie Reservoir for this period. TSI values for Schoharie Reservoir ranged from oligotrophic to mesotrophic, with a median of 41. Conductivity medians were highest at the inflow (82 µS cm^{-1}) and slightly reduced in the reservoir and outflow (median 77 µS cm^{-1} and 73 µS cm^{-1}, respectively).

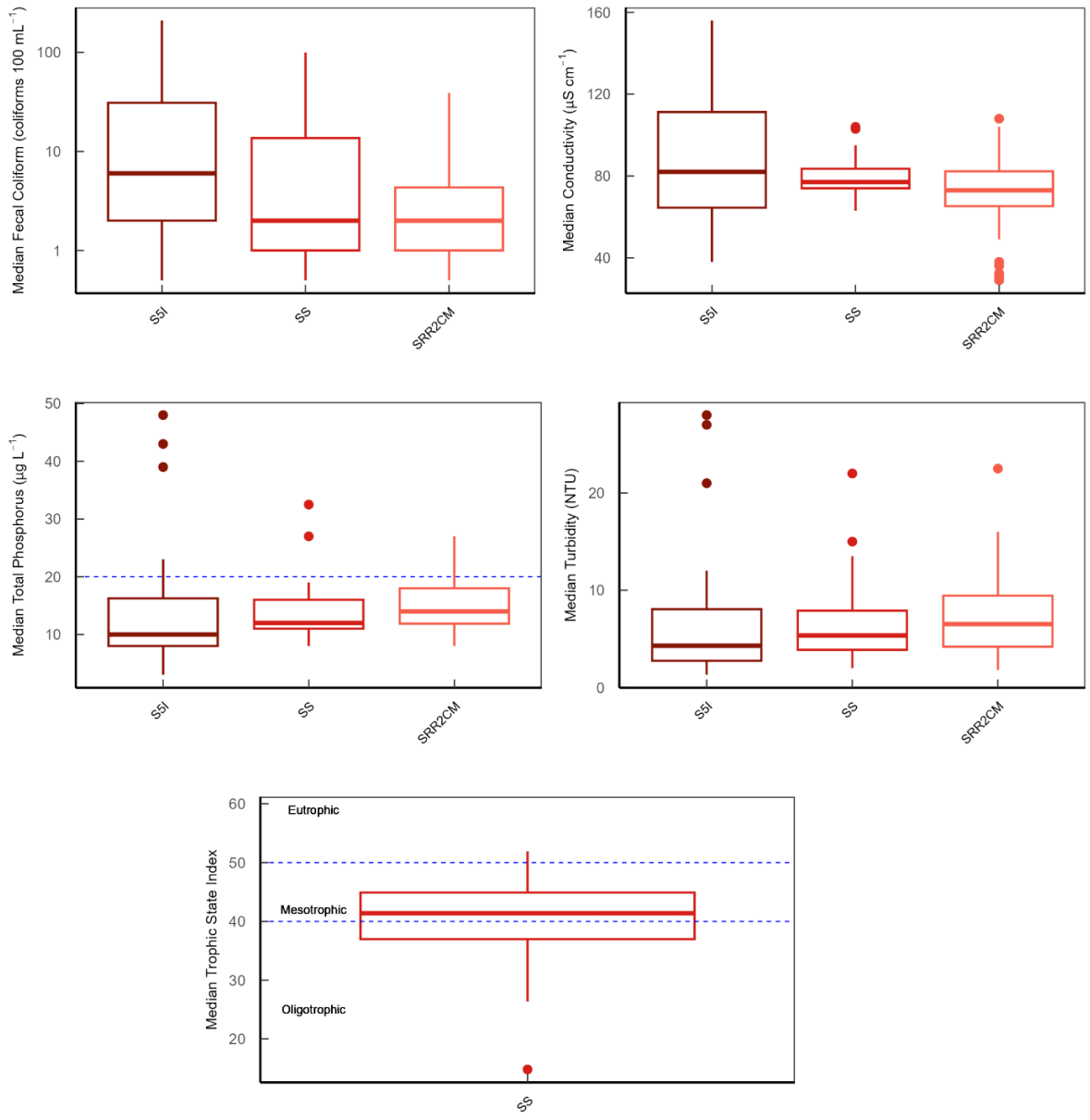


Figure 3.4 Water quality status boxplots using 2022-2024 monthly data for the Schoharie basin main inflow at Schoharie Creek (S5I), Schoharie Reservoir (SS), and the outflow at the Shandaken Portal (SRR2CM).

Trends (Schoharie)

Water quality trend plots from 1993 through 2024 are presented in Figure 3.5. Results of the Seasonal Kendall trend (SKT) and Trend Direction Assessment (TDA) analysis are provided in Table 3.1.

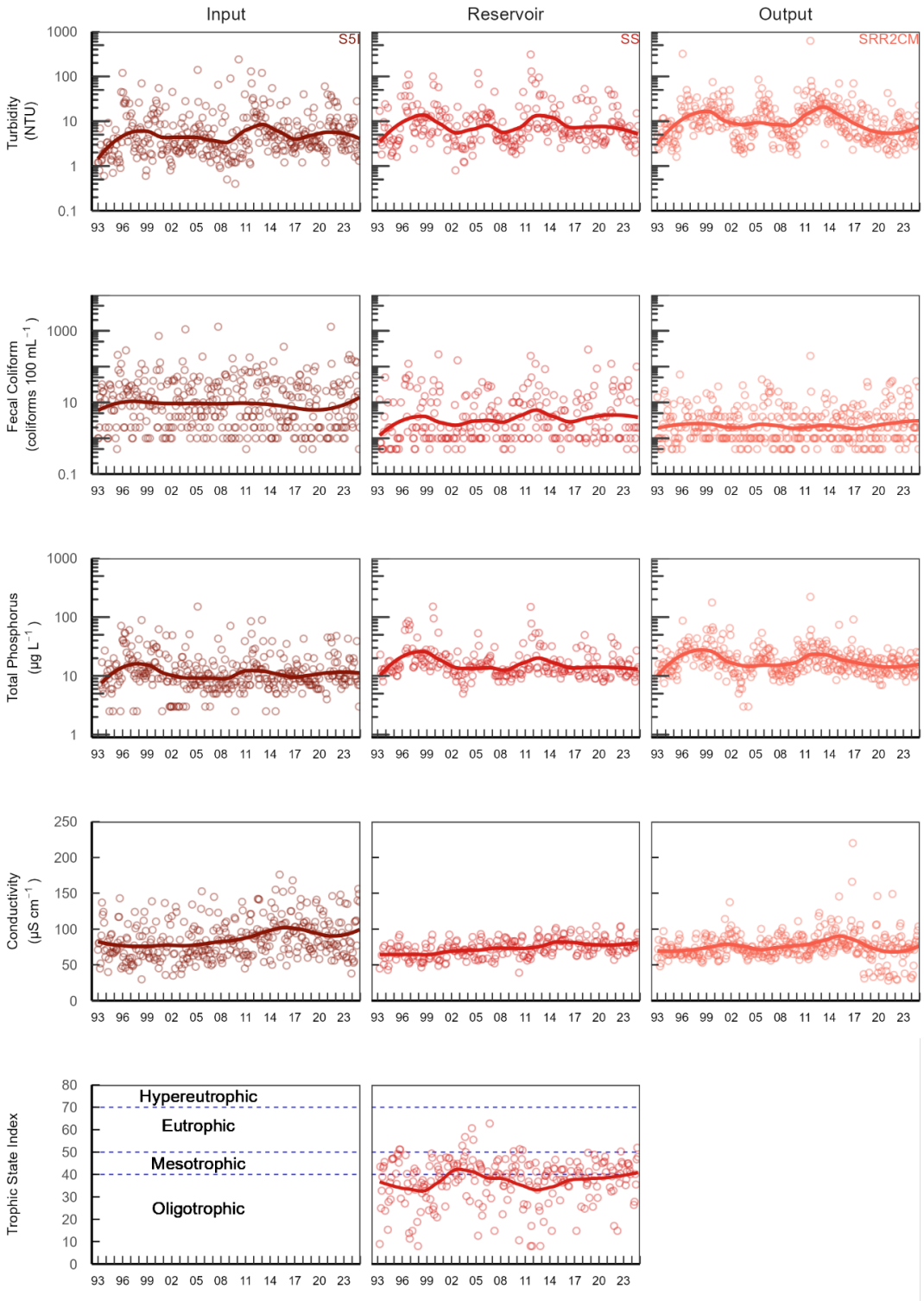


Figure 3.5 Water quality trend plots for the Schoharie basin main inflow at Schoharie Creek (S5I), Schoharie Reservoir (SS), and the outflow at the Shandaken Portal (SRR2CM).

Table 3.1 Schoharie basin trends from 1993-2024 for selected analytes.

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
S5I	Input	Turbidity	371	***	0.045	1.196	Increasing trend virtually certain
S5I	Input	Turbidity (Flow Adj.)	371	NS	0.025	0.6451	Increasing trend possible
S5I	Input	Fecal Coliform	354	NS	0	0	Trend exceptionally unlikely
S5I	Input	Fecal Coliform (Flow Adj.)	354	NS	-0.034	-0.4197	Decreasing trend about as likely as not
S5I	Input	Total Phosphorus	354	NS	0	0	Decreasing trend possible
S5I	Input	Total Phosphorus (Flow Adj.)	354	NS	-0.025	-0.2496	Decreasing trend possible
S5I	Input	Conductivity	353	***	0.802	0.9785	Increasing trend virtually certain
S5I	Input	Conductivity (Flow Adj.)	353	***	0.859	1.047	Increasing trend virtually certain
Schoharie	Reservoir	Turbidity	254	NS	0.009	0.134	Increasing trend unlikely
Schoharie	Reservoir	Fecal Coliform	254	***	0.018	0.8929	Increasing trend virtually certain
Schoharie	Reservoir	Total Phosphorus	244	***	-0.125	-0.893	Decreasing trend virtually certain
Schoharie	Reservoir	Conductivity	240	***	0.563	0.761	Increasing trend virtually certain
Schoharie	Reservoir	Trophic State Index	249	NS	0.036	0.0919	Increasing trend possible

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
SRR2CM	Output	Turbidity	375	***	-0.074	-0.816	Decreasing trend very likely
SRR2CM	Output	Fecal Coliform	372	NS	0	0	Trend exceptionally unlikely
SRR2CM	Output	Total Phosphorus	364	***	-0.105	-0.619	Decreasing trend very likely
SRR2CM	Output	Conductivity	373	***	0.267	0.360	Increasing trend virtually certain

*[1]The p-values for each trend test are symbolized as follows: NS (Not Significant) = p ≥ 0.20, * = p < 0.20, ** = p < 0.10, *** = p < 0.05.*

Long-term decreasing turbidity trends were identified in Schoharie Reservoir's outflow (SRR2CM), and the basin has recovered from the peaks observed in 2011 following Hurricane Irene and Tropical Storm Lee. Excessive flows associated with those storms caused stream channels to incise into banks creating new erosional sources and expanding old ones, elevating turbidity for several years post-storm.

There is strong evidence of a small increasing fecal coliform trend in the reservoir. As shown by the LOWESS curve, the sharpest increase from 1995 to 1999 was driven largely by a 1995 to 1996 winter flood event and Tropical Storm Floyd in September 1999. Concentrations peaked again in late 2011 and were associated with Hurricane Irene and Tropical Storm Lee. More recent fecal coliform concentration increases in 2021 and 2023 were associated with large scale rain accumulations in excess of four-inches (Tropical Storms Henri and Ida in 2021 and a localized rain on snow event that took place in December of 2023).

Prior to 2010, a declining phosphorus trend was associated with recovery from historic flooding events during the 1995-1996 winter, the 2001-2002 drought and from point source reductions associated with upgrades to WWTPs. With the addition of several more years of data (2020 through 2024), a downward long-term phosphorus trend is evident in the reservoir and possibly evident in the inflow.

Analyses revealed strong evidence for long-term, continuous increases in conductivity for Schoharie Reservoir and its inflow and outflow. Flow adjustment increased the magnitude of the trend for Schoharie Creek indicating that dilution/concentration effects of rain events/droughts

do not explain the upward trend. Continuing contamination of groundwater with road deicers is the likely explanation.

TDA indicated a possible upward trend for TSI, an estimate of algal productivity based on chlorophyll *a* concentrations. A short-term decline was apparent from 2003-2014, most likely due to low clarity conditions following storm events in 2005 and 2010-2012, but the trend has steadily been on the rise since that time and including the 2021 through 2024 assessment period.

3.2.2 Biomonitoring in Schoharie Watershed

The DEP Stream Biomonitoring Program uses protocols developed by the New York State Department of Environmental Conservation to assess the health of stream macroinvertebrate communities in watershed streams. Stream impairment is assessed via a multimetric Biological Assessment Profile (BAP) score derived from stream macroinvertebrate assemblages. For full methodology details including headwater adjustment methods as established by NYSDEC in 2018, see Appendix C.

The most recent status of macroinvertebrate communities in the Schoharie basin was evaluated by the analysis of 14 total samples collected from four streams during 2022 through 2024. During this period, three sites on mainstem Schoharie Creek (202, 204, and 216) were sampled twice each, along with six samples from four sites on tributaries, including the Batavia Kill (206, 221, 233, and 269), one site on the West Kill (258), and one site on the East Kill (207). The additional sites selected on the Batavia Kill were sampled to obtain baseline data before streambed stabilization projects.

Schoharie Creek: Schoharie Creek is the primary inflow to the Schoharie Reservoir and drains 75% of the basin. Site 204 (S5I) is in Prattsville, approximately three-quarters of a mile upstream of Schoharie Reservoir. Sites 216 (S4) and 202 (S3) are located about 9 and 17 miles, respectively, upstream of the reservoir. Site 202 was assessed as non-impaired in 2022 and 2024. Although both 204 and 216 were assessed as slightly impaired in 2022, both sites were reassessed as non-impaired in 2023 (Figure 3.6). As noted by sampling personnel in 2022, sampling efforts may have been impacted by low flow.

Schoharie Creek Tributaries: From 2022 through 2024, six samples were collected from four sites on the Batavia Kill, from the headwaters to the confluence with Schoharie Creek in Prattsville. Scores from site 206 (S10) were assessed at the higher end of slightly impaired from 2022 and 2024, and non-impaired in 2023. Site 221 was assessed as slightly impaired in 2022, and sites 269 (S10-LC) and 233 (headwaters) were assessed as non-impaired. Both the East Kill (SEK) in Jewett and West Kill in Lexington were assessed as non-impaired in 2024 and 2022, respectively (Figure 3.6).

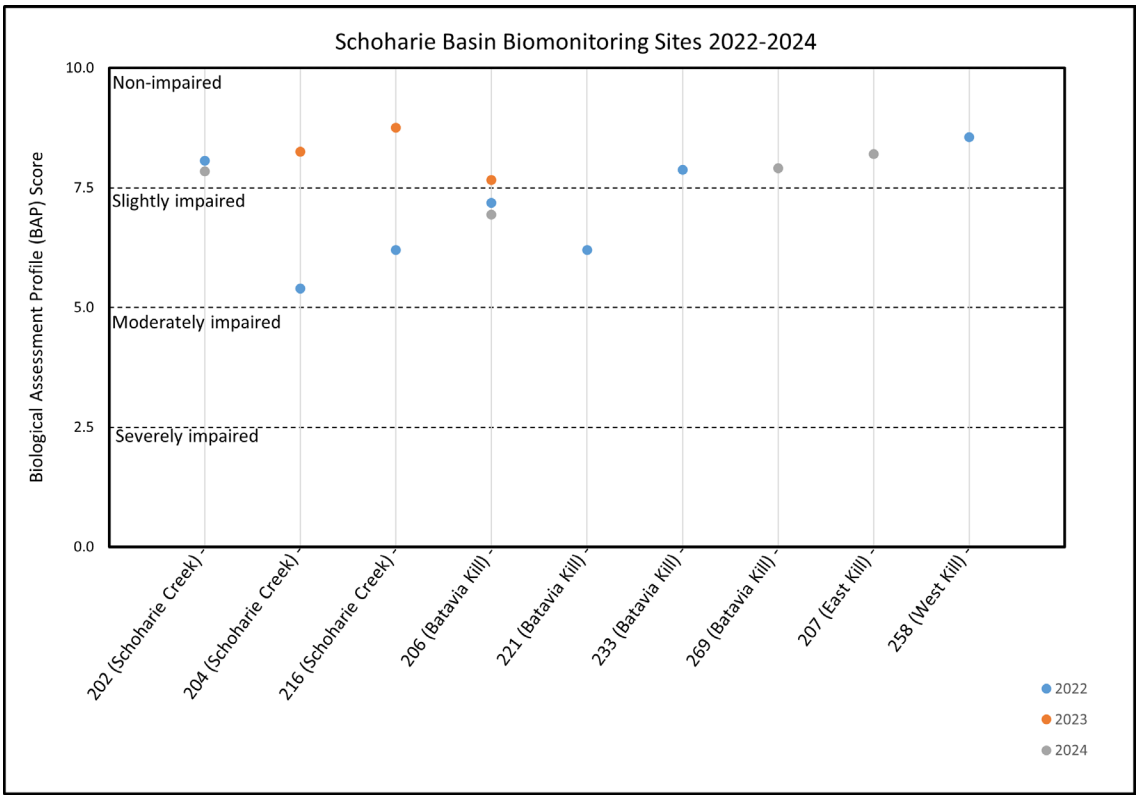


Figure 3.6 Biological Assessment Profile scores for Schoharie Watershed, 2022-2024.

Schoharie Watershed Biomonitoring Trends: Streams in the Schoharie watershed were analyzed for time-series trends in BAP scores based on a site's entire period of record. Long-term trend analysis was focused on mainstem streams with more than three years of biological assemblage data: sites 202, 204, and 216. All three sites have scored in the non-impaired category, with few exceptions, over the period of record (Figure 3.7). In 2022, samples from sites 204 and 216 contained unusually low amounts of biodiversity, which dropped BAP scores into the slightly impaired range, but both sites were resampled as non-impaired in 2023.

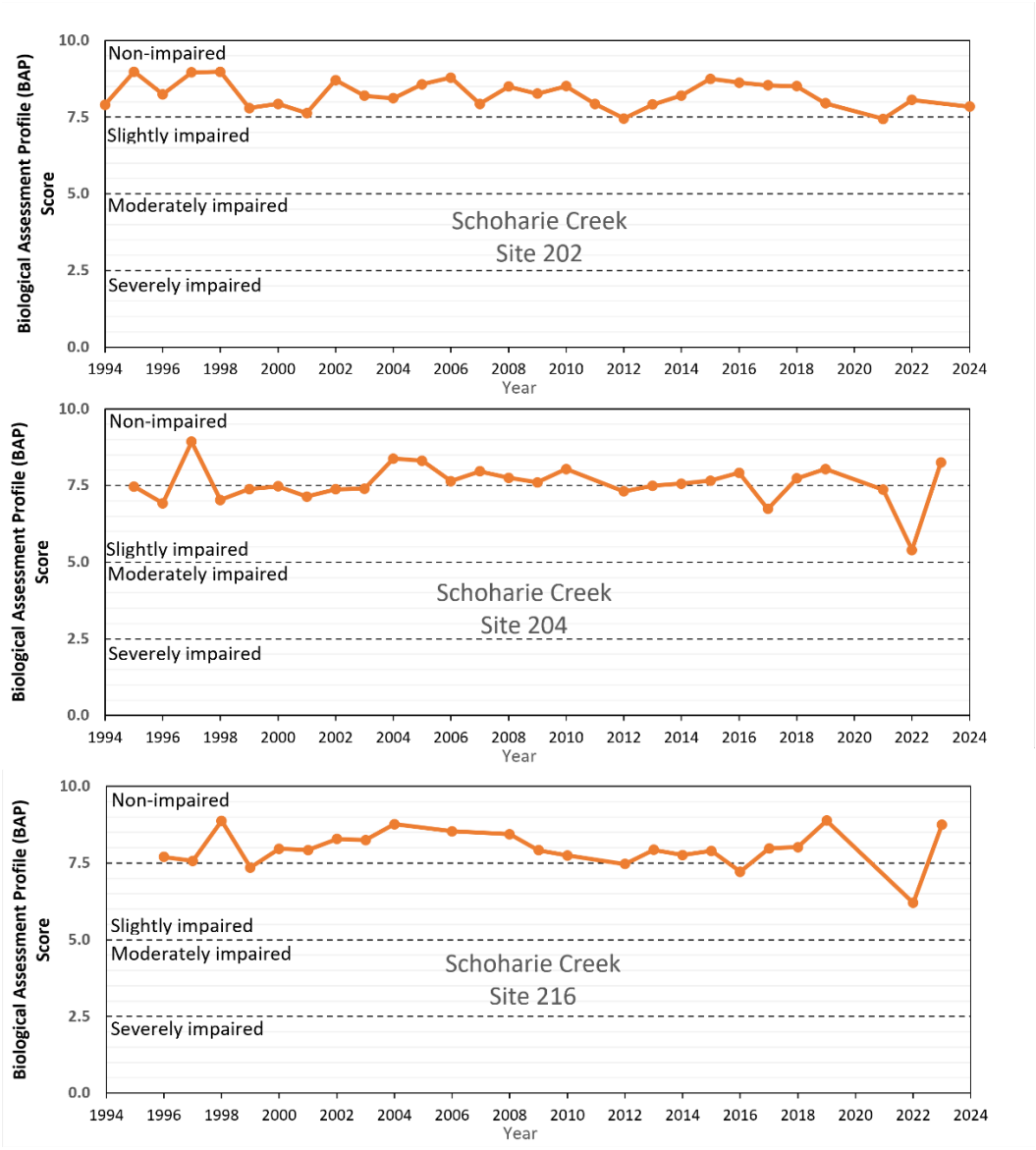


Figure 3.7 Biological Assessment Profile scores for Schoharie Creek, 1994-2024.

3.3 The West and East Ashokan Basins

The Ashokan Reservoir's watershed is 255 square miles and includes parts of 11 towns. It was formed by damming Esopus Creek, which eventually flows northeast and drains into the Hudson River. Consisting of two basins separated by a concrete dividing weir and roadway, it holds 130.1 billion gallons at total capacity and was placed into service in 1915.

Bush Kill and Esopus Creek (which also convey water from Schoharie Reservoir via the Shandaken Tunnel) are the two primary tributaries flowing into Ashokan Reservoir, with the former providing 6.4% and the latter 75.2% of water entering the reservoir. As discussed in the Catskill System Operation Overview section, water is withdrawn from the West Basin, East Basin, or a blend of West and East basins. Its water is then carried southeast under the Hudson

River via the 92-mile Catskill Aqueduct, which has a maximum depth of 1,114 feet. It enters Kensico Reservoir in Westchester, then travels south via the Delaware Aqueduct to the Catskill Delaware Ultraviolet Treatment Plant (CDUV) and into distribution at Hillview Reservoir in Yonkers.

Land use in the Ashokan watershed is classified as follows: 88.3% is forested, 4.9% is urban or built-up land, 1.1% is brushland or successional land, <0.1% is barren land, 5.2% is water, and the remaining 0.5 % is in agricultural use. Protection programs in place in the watershed are described in Watershed Protection Program sections.

3.3.1 Water Quality Status and Trends in the Ashokan Watershed

Status (West Basin)

Ashokan's West Basin status evaluation is presented as a series of boxplots in Figure 3.8 summarizing data for the principal inflow (E16I) and the reservoir (EAW). As described in Section 3.1.2, operational use of the West Basin of Ashokan (EAW) occurs either by diverting water over or through the dividing weir to the East Basin, or by sending water directly through the intake chambers in the West Basin to the outflow at EARCM. A site map, description of the sampling program, and details on data preparation and boxplot interpretation are provided in Appendix C.

For the status evaluation period (2022-2024), all median monthly values for fecal coliform bacteria fell below the NYSDEC Stream Guidance Value of 200 fecal coliforms 100 mL^{-1} for the inflow site E16I, and all median monthly reservoir coliform levels were below the SWTR benchmark of 20 coliforms 100 mL^{-1} used for source waters. Turbidity monthly medians were low for this evaluation period (median 3.6 NTU at the inflow and 2.9 NTU in the reservoir). TP followed a similar pattern with inflow and reservoir medians of 9 $\mu g\ L^{-1}$. TSI values fell primarily in the mesotrophic range. The conductivity monthly median was highest at the inflow (67 $\mu S\ cm^{-1}$) and was lower in the reservoir (median 58 $\mu S\ cm^{-1}$).

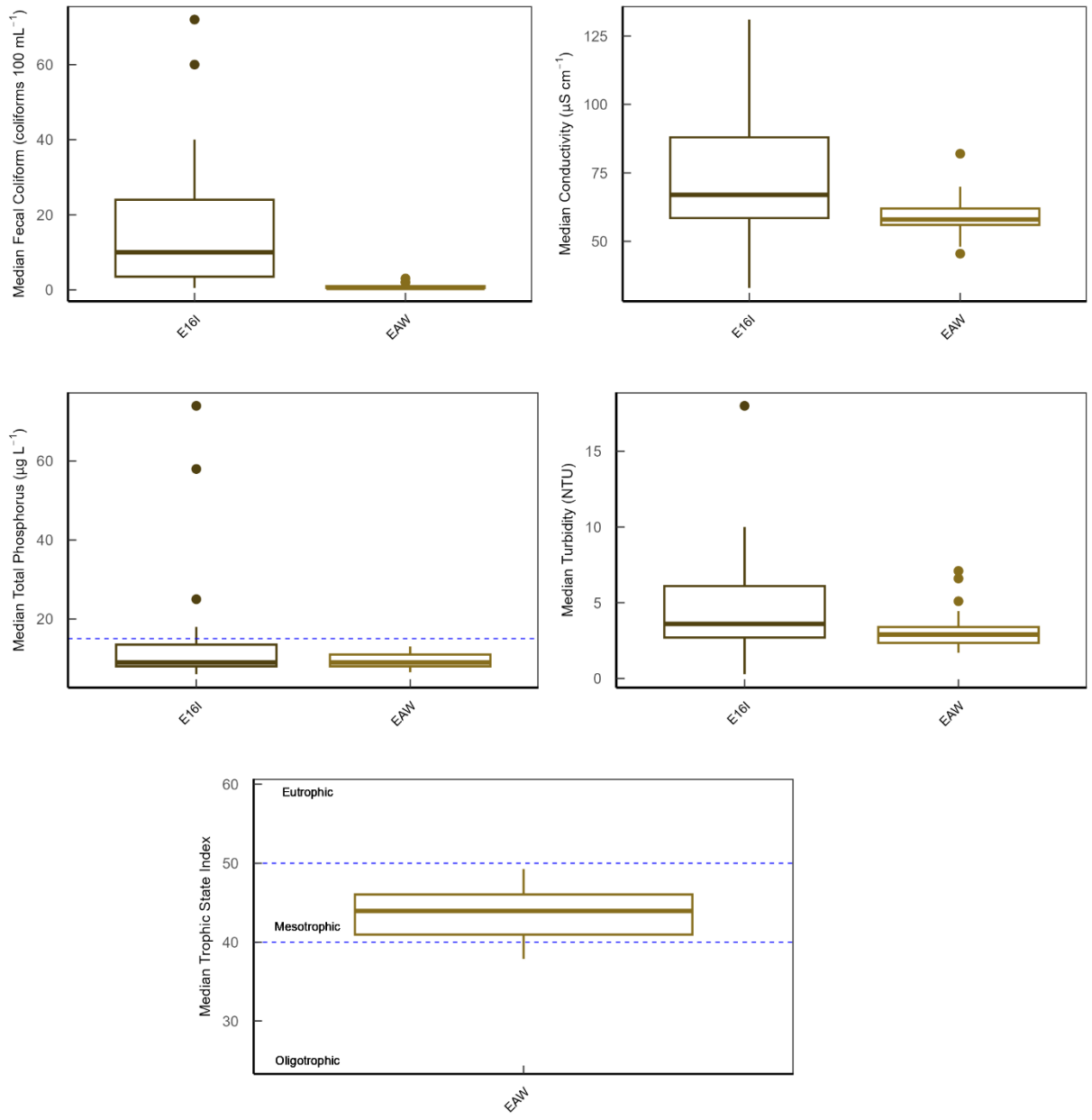


Figure 3.8 Water quality status boxplots using 2022-2024 monthly data for the Ashokan West Basin main inflow at Esopus Creek and the Ashokan Reservoir West Basin.

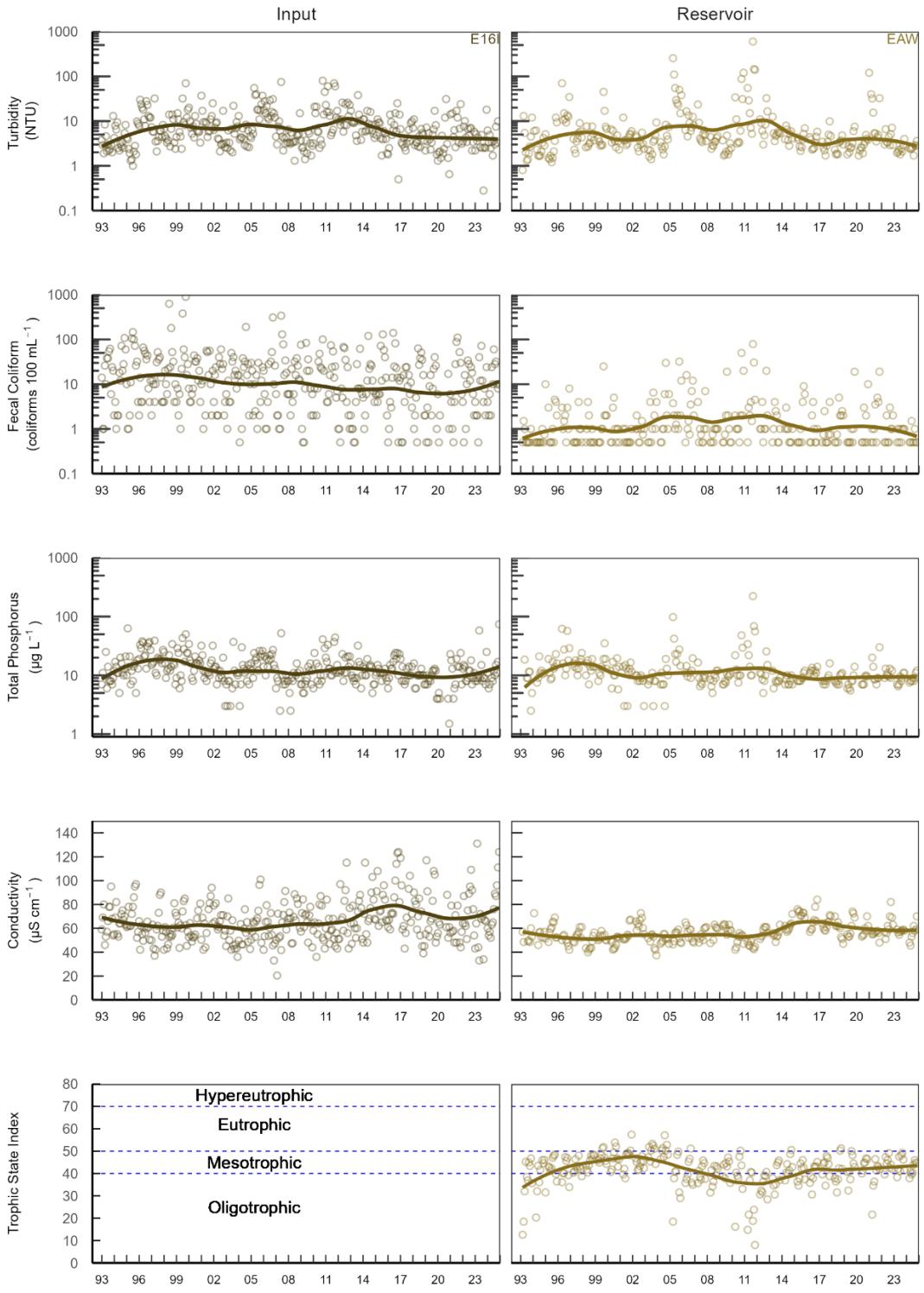


Figure 3.9 Water quality trend plots for the Ashokan West Basin (EAW) for the main inflow at Esopus Creek (E16I).

Table 3.2 Ashokan West Basin trends from 1993-2024 for selected analytes.

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
E16I	Input	Turbidity	380	*	-0.028	-0.483	Decreasing trend possible
E16I	Input	Turbidity (Flow Adj.)	380	NS	-0.022	-0.3769	Decreasing trend possible
E16I	Input	Fecal Coliform	370	***	-0.125	-1.1364	Decreasing trend virtually certain
E16I	Input	Fecal Coliform (Flow Adj.)	370	***	-0.143	-1.2956	Decreasing trend virtually certain
E16I	Input	Total Phosphorus	367	***	-0.154	-1.2821	Decreasing trend virtually certain
E16I	Input	Total Phosphorus (Flow Adj.)	367	***	-0.152	-1.2686	Decreasing trend virtually certain
E16I	Input	Conductivity	366	***	0.323	0.504	Increasing trend virtually certain
E16I	Input	Conductivity (Flow Adj.)	366	***	0.293	0.4583	Increasing trend virtually certain
Ashokan – West	Reservoir	Turbidity	282	NS	-0.018	-0.458	Decreasing trend possible
Ashokan – West	Reservoir	Fecal Coliform	277	NS	0	0	Trend exceptionally unlikely
Ashokan – West	Reservoir	Total Phosphorus	256	***	-0.119	-1.188	Decreasing trend virtually certain
Ashokan – West	Reservoir	Conductivity	264	***	0.3	0.536	Increasing trend virtually certain
Ashokan - West	Reservoir	Trophic State Index	264	***	-0.084	-0.1953	Decreasing trend virtually certain

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment

*[1]The p-values for each trend test are symbolized as follows: NS (Not Significant) = p ≥ 0.20, * = p < 0.20, ** = p < 0.10, *** = p < 0.05.*

Trends (West Basin)

Water quality trend plots are presented in Figure 3.9 and results of the SKT and TDA analysis are provided in Table 3.2.

In the years since 2011, LOWESS modeling results show a persistent decline in turbidity at both E16I and the West Basin. The decline is likely due to recovery from past storms (2010-2011) and to the relative absence of large runoff events during the 2012-2024 period.

Long-term fecal coliform trends have been on the decline for the primary input, Esopus Creek (E16I), even after adjusting for flow. Since summer 2011, there has been a steady decrease in fecal coliform counts in the West Basin coinciding with a notable absence of large runoff events through 2024.

Except for temporary increases associated with major runoff events, TP concentrations in Esopus Creek and in the reservoir have declined over the long-term record. Even after the effects of flow were removed there is strong evidence of a phosphorus decline, likely achieved through the implementation of watershed protection programs, including upgrades to the Pine Hill WWTP and establishment of the Boiceville WWTP in 2010.

There is a slight but virtually certain upward trend in conductivity detected in the Esopus Creek and West Basin. With the addition of 2020-2024 data, there is evidence that an upward conductivity trend in both the creek and reservoir will continue, with road salt being the most likely source.

There is strong evidence of a modest long-term downward trend for TSI. Although TSI consistently increased from 1993-2004, the trend suddenly reversed in April 2005 coinciding with a flooding event. Under the conditions of diminished water clarity caused by turbid floodwater, algae were unable to thrive, as reflected by the decrease in TSI. TSI has been increasing again in recent years but remains in the mesotrophic and oligotrophic zones.

Status (East Basin)

Ashokan's East Basin status evaluation is presented as a series of boxplots in Figure 3.10, showing summaries for the reservoir (EAE) and outflow (EARCM). A site map, description of the sampling program, and details on data preparation and boxplot interpretation are provided in Appendix C.

For the status evaluation period (2022-2024), all monthly median values for fecal coliform bacteria for both the reservoir and outflow were below the SWTR benchmark of 20 coliforms 100 mL^{-1} used for source waters. Turbidity was low for the evaluation period, with a median of 1.0 NTU in the reservoir and 2.0 NTU at the outflow. Note that the outflow can include water from the East or West Basin, or a blend of both. TP medians for the reservoir and outflow were 9 µg L^{-1}. TSI values ranged between oligotrophic and mesotrophic. Specific conductivity monthly medians were similar between reservoir and outflow at 58 µS $cm^{-1}$for both.

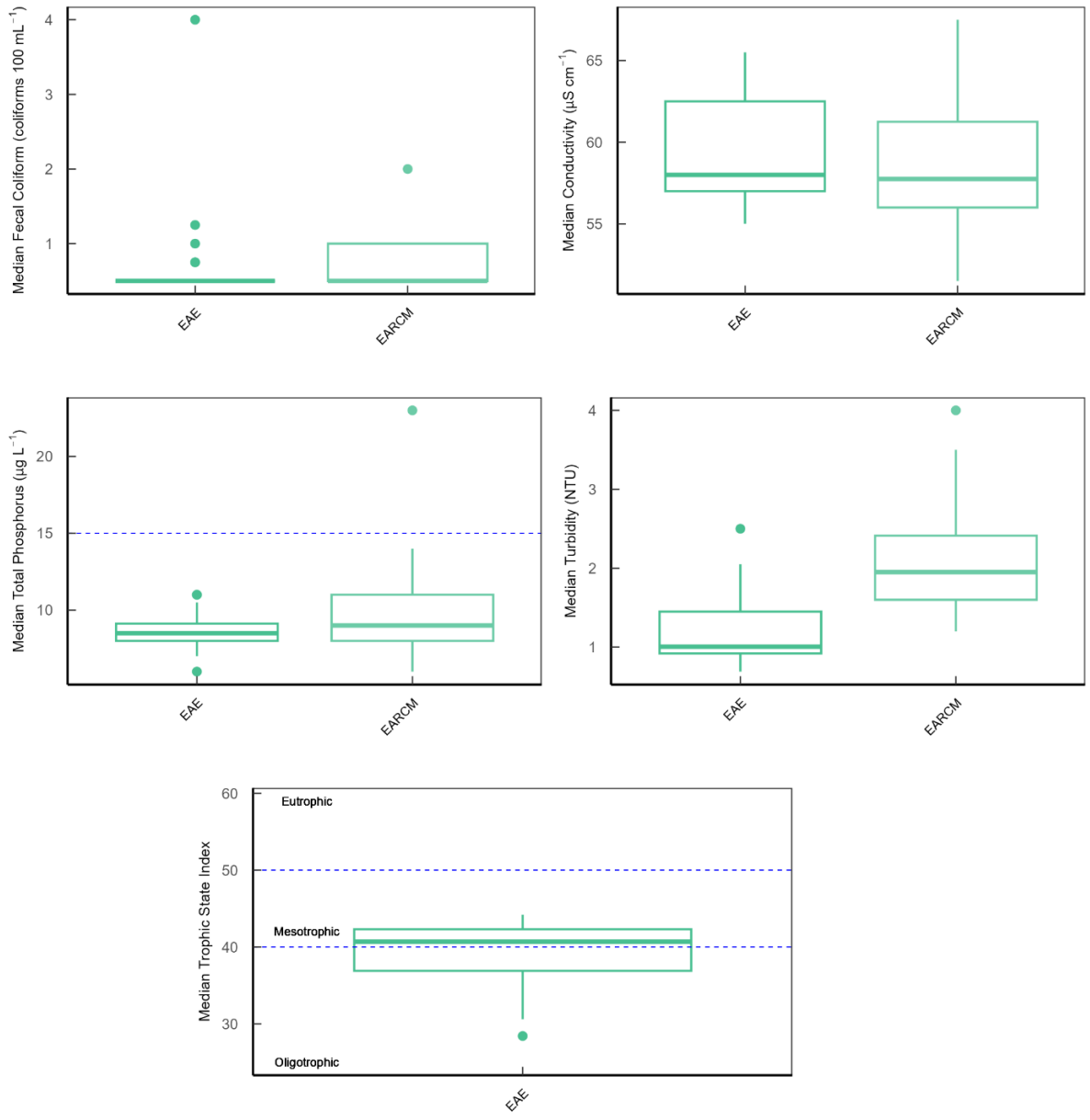


Figure 3.10 Water quality status boxplots using 2022-2024 monthly data for the Ashokan Reservoir East Basin (EAE) and the outflow at the Ashokan gatehouse (EARCM).

Trends (East Basin)

Water quality trend plots are presented in Figure 3.11 and results of the SKT and TDA analysis are provided in Table 3.3. The West Basin, the East Basin's primary source of water, is discussed in the preceding section.

A strong long-term downward turbidity trend was identified in the East Basin, and a decreasing trend is likely in its outflow, EARCM. The operational management (decision making, OST, and water quality modeling) of the Catskill System has improved overall water quality of the East Basin and allows DEP to divert from the best available source. Increases associated with storm events in 2010 and 2011 have also given way to lower turbidity levels associated with the fewer storms in recent years (2012-2024).

There is strong evidence of downward fecal coliform trends in the East Basin and the outflow of the reservoir, despite a Sen slope value of 0 caused by the many non-detect values. The initial steep decline in the reservoir, as shown by the LOWESS curve has been linked to declining bird populations resulting from closure of local landfills (important winter foraging areas) in the mid to late 1990's (DEP 2010) and was offset somewhat by runoff events in 2010 and 2011.

Despite record flooding in 2010 and 2011, declining trends were identified for TP indicating that the watershed protection programs (e.g., new and upgraded WWTPs) have successfully reduced the phosphorus pool or limited the transport of phosphorus to local streams.

Long-term upward conductivity trends were detected in the reservoir and its outflow. The increase coincides in timing and magnitude with the West Basin and its major inflow Esopus Creek (Figure 3.8 and Table 3.2). The conductivity increase is likely associated with road deicers.

A long-term downward trend was identified for TSI. No flooding events have occurred in the Esopus since 2011 that would have impacted water clarity and impaired algal productivity. Instead, decreasing phosphorus trends are a potential explanation for the decreased productivity and downward TSI trend.

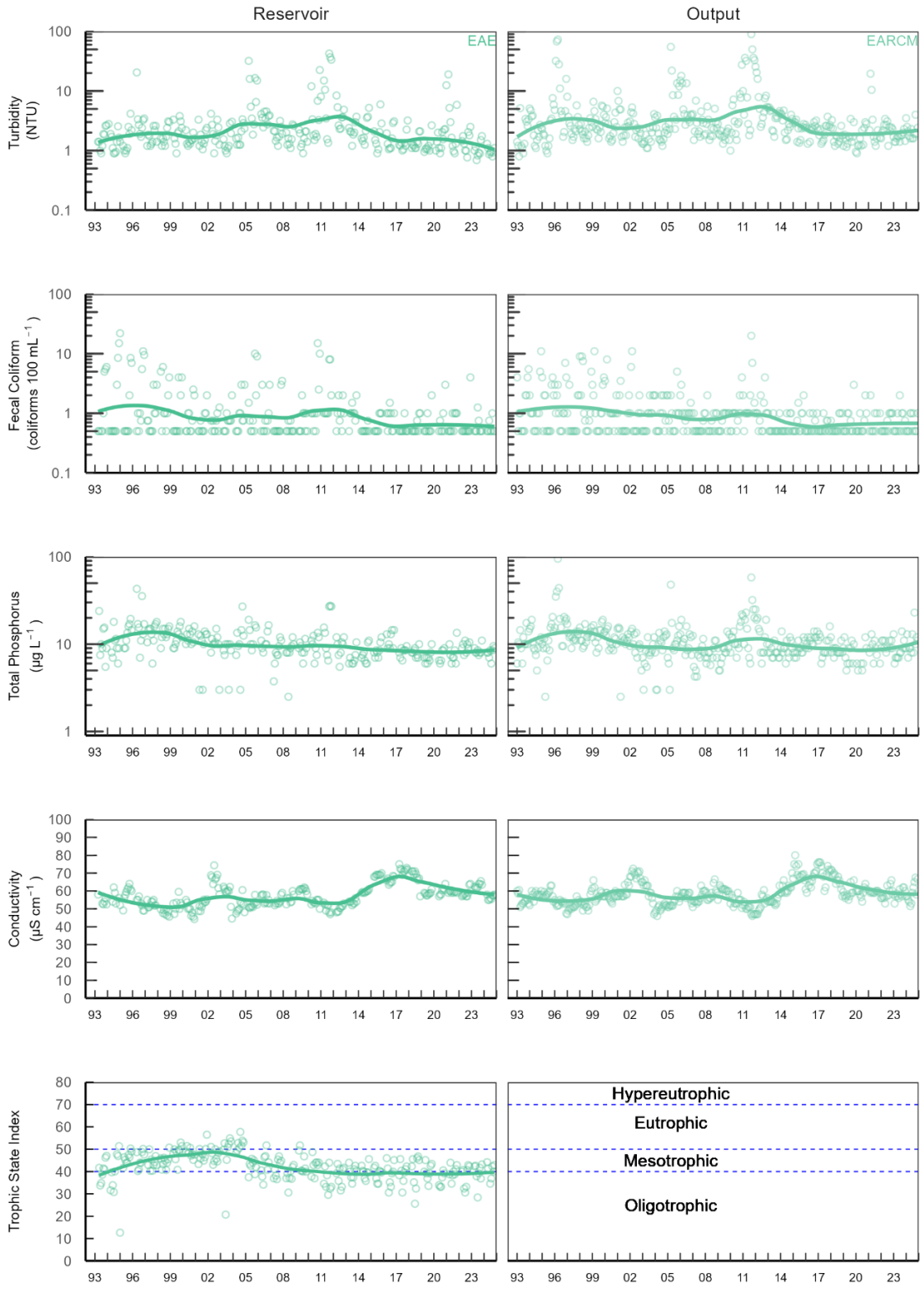


Figure 3.11 Water quality trend plots for the Ashokan Reservoir East Basin (EAE) and the outflow at the Ashokan gatehouse (EARCM).

Table 3.3 Ashokan East Basin trends from 1993-2024 for selected analytes.

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
Ashokan - East	Reservoir	Turbidity	283	***	-0.012	-0.679	Decreasing trend virtually certain
Ashokan - East	Reservoir	Fecal Coliform	276	***	0	0	Decreasing trend virtually certain
Ashokan - East	Reservoir	Total Phosphorus	257	***	-0.167	-1.7544	Decreasing trend virtually certain
Ashokan - East	Reservoir	Conductivity	264	***	0.318	0.5573	Increasing trend virtually certain
Ashokan - East	Reservoir	Trophic State Index	261	***	-0.256	-0.604	Decreasing trend virtually certain
EARCM	Output	Turbidity	380	***	-0.013	-0.5208	Decreasing trend very likely
EARCM	Output	Fecal Coliform	379	***	0	0	Decreasing trend virtually certain
EARCM	Output	Total Phosphorus	373	***	-0.097	-0.9677	Decreasing trend virtually certain
EARCM	Output	Conductivity	380	***	0.192	0.332	Increasing trend virtually certain

[1]The *p*-values for each trend test are symbolized as follows:
NS (Not Significant) = $p \geq 0.20$, * = $p < 0.20$, ** = $p < 0.10$, *** = $p < 0.05$.

3.3.2 Biomonitoring in the Ashokan Watershed

The DEP Stream Biomonitoring Program uses protocols developed by the New York State Department of Environmental Conservation to assess the health of stream macroinvertebrate communities in watershed streams. Stream impairment is assessed via a multi-metric BAP score derived from stream macroinvertebrate assemblages. For full methodology details including headwater adjustment methods as established by NYSDEC in 2018, see Appendix C.

The most recent status of macroinvertebrate communities in the Ashokan basin was evaluated by the analysis of 17 total samples collected from eight streams during 2022 through 2024. During this period, two sites on Esopus Creek (215, 227) were sampled three times each, with two additional sites (213, 255) sampled once each. Esopus tributary sampling included two samples each on Giggle Hollow (229) and Beaver Kill (218, 253), and one sample each on Seneca Hollow (232), Little Beaver Kill (243), Bush Kill (246), and Panther Kill (270). An additional input to the Ashokan, Butternut Creek (203), was sampled once.

Esopus Creek: Esopus Creek is the primary inflow to the Ashokan Reservoir and drains 75% of the basin. Sites 227 (AEWDL) and 215 (E5) are located on Esopus Creek approximately 9.5 and 13 miles upstream of the Ashokan Reservoir. Site 215 was assessed as non-impaired in all three samples from 2022 through 2024. Site 227 was assessed as non-impaired in 2023, but slightly impaired in 2022 and 2024 with BAP scores of 5.83 and 7.29. The in-stream habitat at this site can be deep and difficult to sample due to boulders, sedimentation, and changing flow regimes, so future sampling events will be moved approximately 100 meters upstream to a more stable riffle habitat to obtain samples that are more representative of the reach. Site 255 is in Mount Tremper above the confluence with the Beaver Kill and was assessed as slightly impaired in 2022. Site 213 (E16i) is located at the bridge on Rte. 28A in Boiceville and was assessed as non-impaired in 2024 (Figure 3.12).

Esopus Creek Tributaries and Ashokan Streams: Two sites were assessed as non-impaired on the Beaver Kill in 2024: site 218 (BK) upstream of the confluence with Esopus Creek, and site 253 in the Mink Hollow area of Woodstock. Site 229 (BELLEGIG) on Giggle Hollow was assessed as non-impaired in 2022 and just below non-impaired in 2023. Site 232 (Seneca Hollow was assessed as slightly impaired in 2024 with a headwaters-adjusted BAP score of 6.28, but species richness and percent model affinity metrics were skewed by an abundance of intolerant *Pteronarcys sp.* (*Pteronarcyidae*) stoneflies (n=29) and *Diplonectra sp.* (*Hydropsychidae*) caddisflies (n=35) in the subsample. Sites 243 (LBK) on the Little Beaver Kill, 246 (E10i) on the Bush Kill, and 270 on Panther Kill were assessed as non-impaired in 2024. Site 203 (E12i) on Butternut Creek, located approximately 750 meters upstream of the Ashokan Reservoir in Olive, was assessed as slightly impaired in 2022 with a headwaters-adjusted BAP score of 7.22. This site has been proposed as a future SPDES discharge and will continue to be monitored in future sampling years (Figure 3.12).

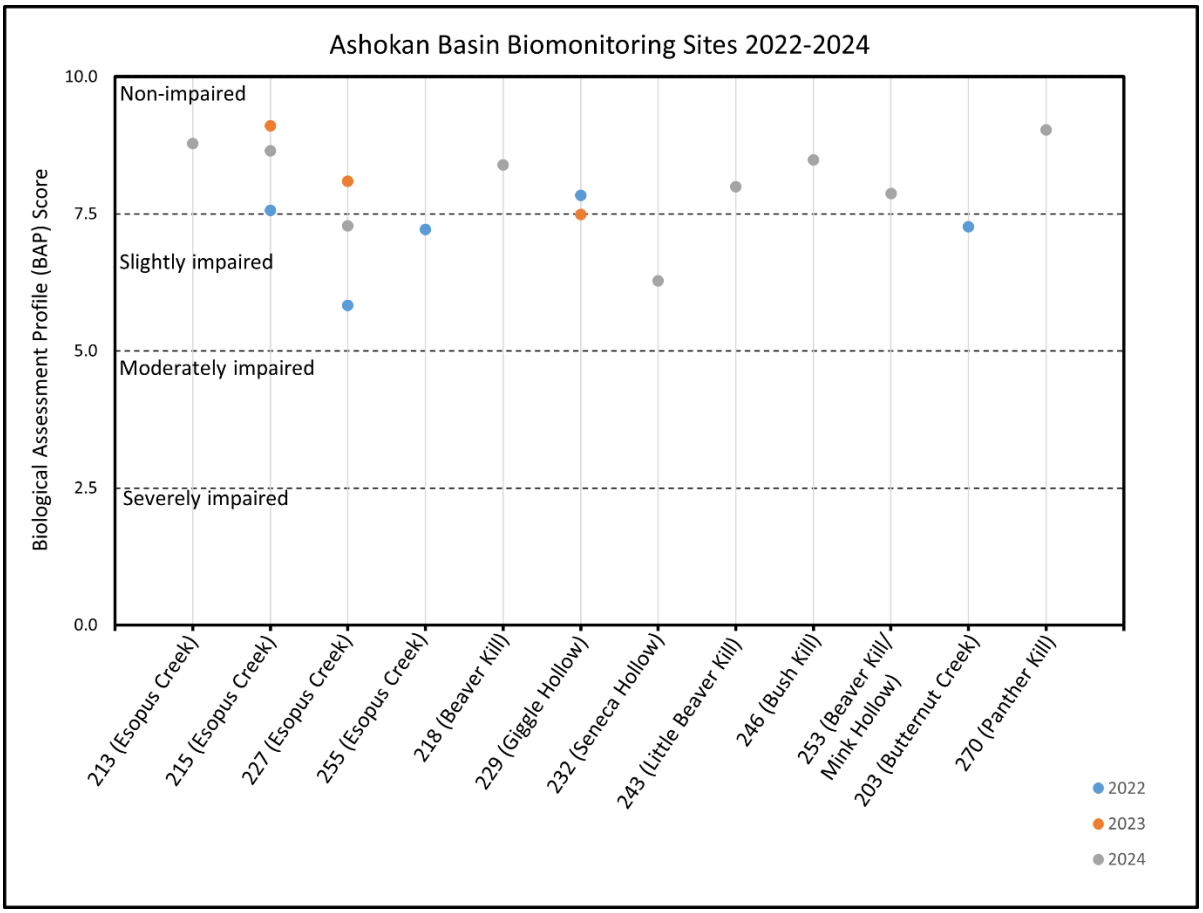


Figure 3.12 Biological Assessment Profile scores for the Ashokan Basin, 2022-2024.

Ashokan Watershed Biomonitoring Trends: Streams in the Ashokan watershed were analyzed for time-series trends in BAP scores based on a site's entire period of record. Long-term trend analysis was focused on main input streams with more than three years of biological assemblage data: sites 213, 215, and 227. All sites average in the non-impaired range over both the periods of record and more recently, since 2014 (Figure 3.13).

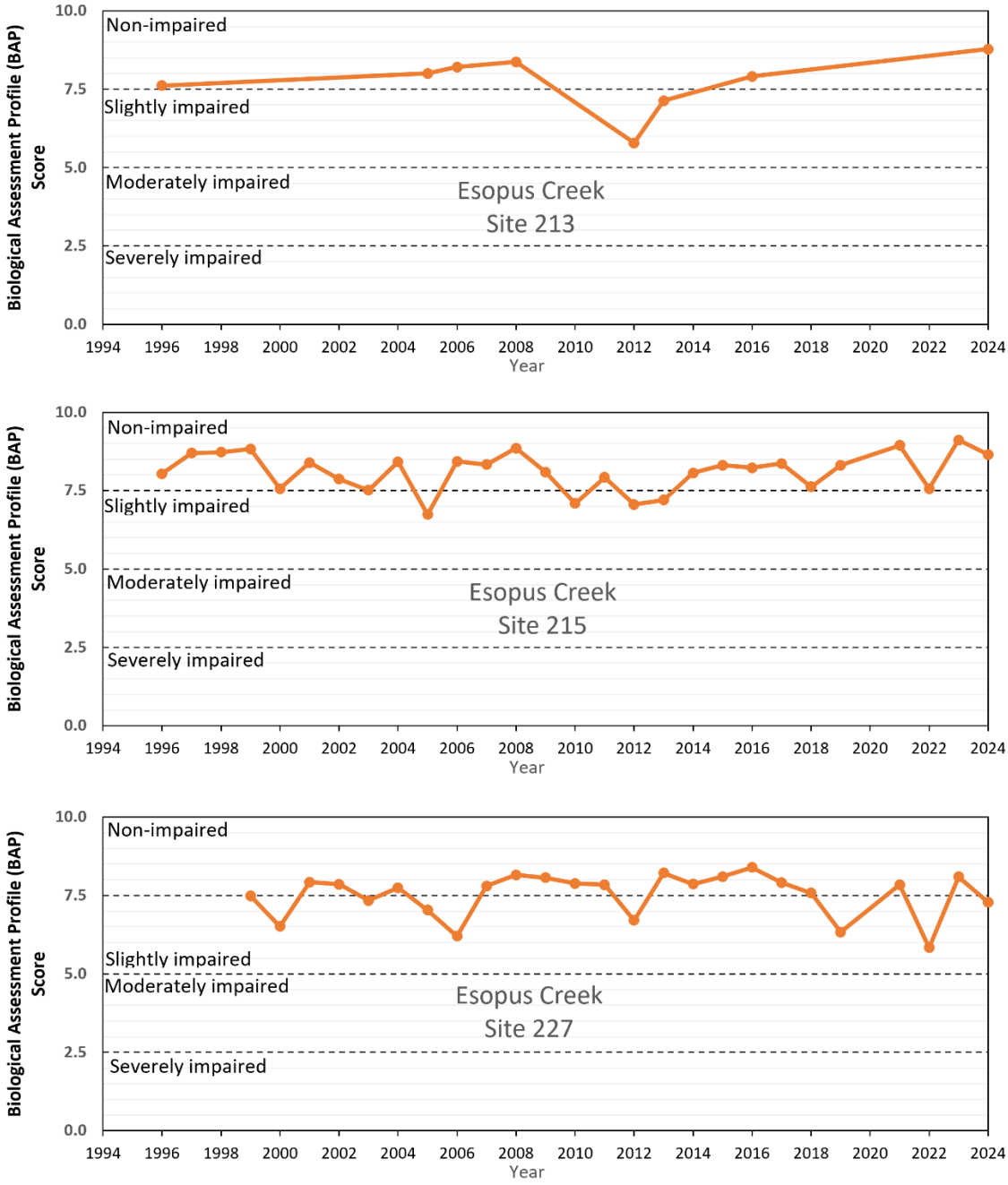


Figure 3.13 Biological Assessment Profile scores for Esopus Creek, 1996-2024.

3.4 Trophic Response of the Catskill Reservoirs

The plots in this assessment period show the most recent five-year period as bold symbols, with all preceding years shown as lightly shaded symbols of the same color. Chlorophyll vs TP in Catskill System reservoirs is plotted in Figure 3.14. In the past, Schoharie Reservoir showed many deviating years on the low side indicating a very low overall response of algal biomass to the phosphorus present. The years with particularly low algal biomass (1996

through 1998 and 2011 to 2012) are associated with high flows and high turbidity. Turbidity can severely diminish light penetration in Schoharie and the West Basin of Ashokan for months at a time, presenting a severe limitation to algal growth. In the most recent five-year period, all three basins' (Schoharie, Ashokan East, and Ashokan West) values tend to cluster within the 80% confidence intervals and have moved closer to the expectation indicated by the OECD standards, with the Schoharie on the low side, most likely due to lower light (shallower Secchi transparency). Schoharie shows the inverse of the expected chlorophyll and TP relationship, this may be due to the shading by clay particles with which the phosphorus is associated.

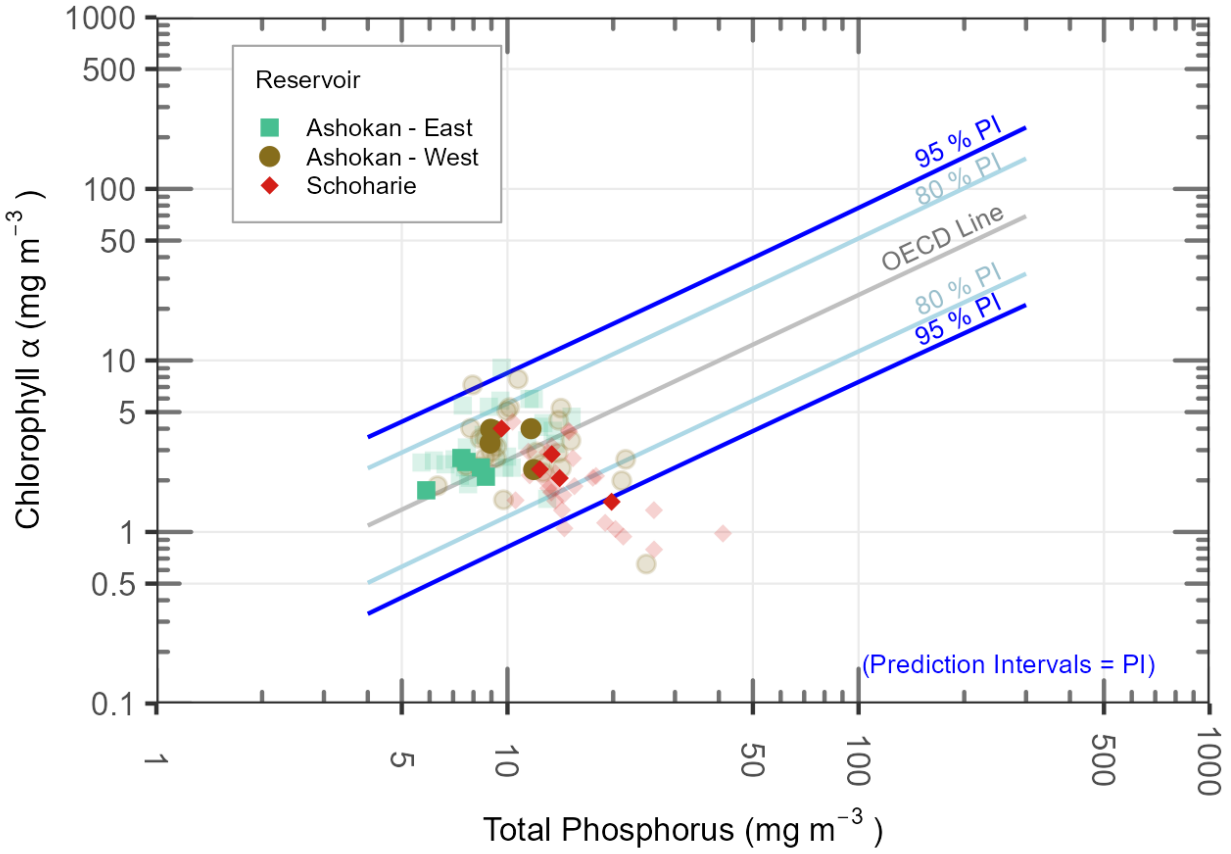


Figure 3.14 Chlorophyll vs TP in Catskill System Reservoirs.

The annual maximum value of chlorophyll vs TP is plotted for each year in Figure 3.15. The chlorophyll maximum reflects the potential for algal biomass development when other factors (light and nutrients) are not limiting. In the most recent period, all three basins tended to cluster around the OECD line. All three basins remained within the 80% prediction interval (PI).

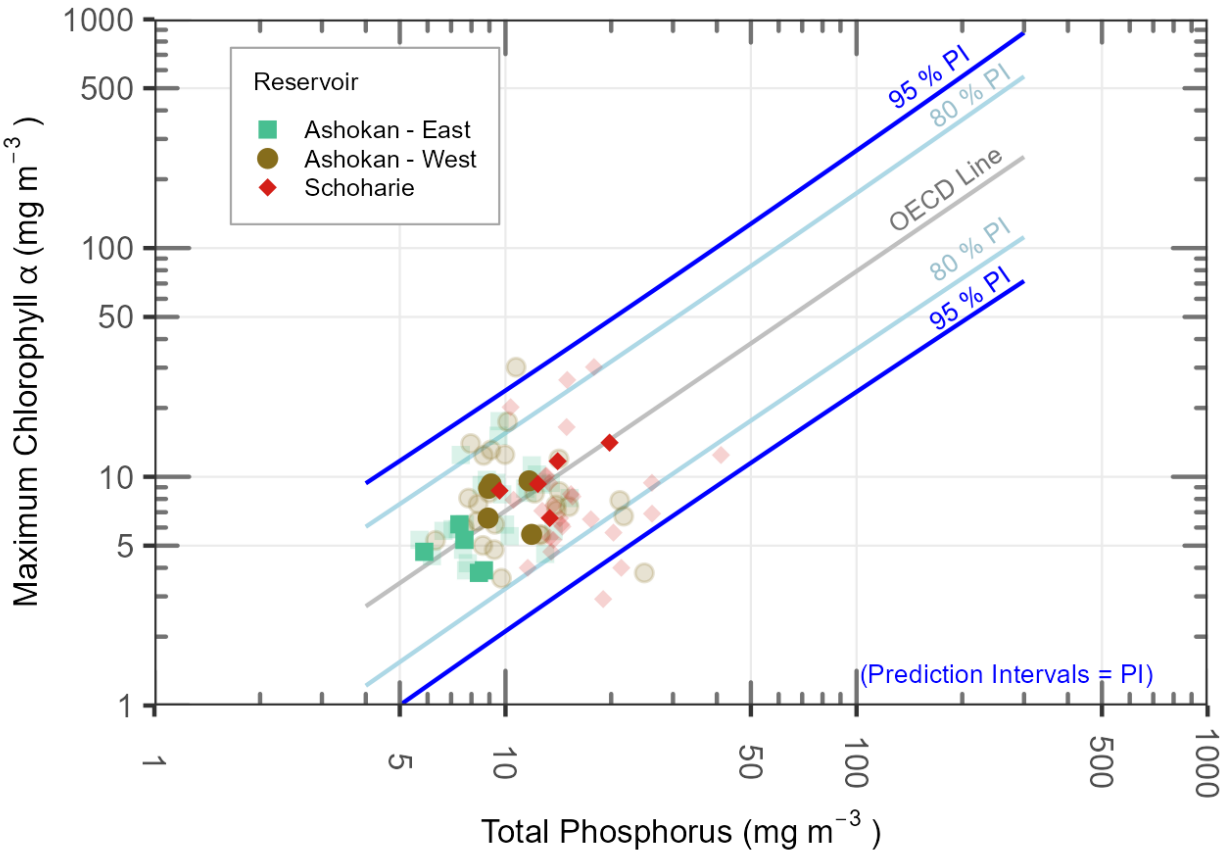


Figure 3.15 Maximum Chlorophyll vs total phosphorus in Catskill System Reservoirs.

Secchi depth vs total phosphorus annual mean values are plotted in Figure 3.16. In past years there are many exceptionally low values (beneath 95% PI) for Schoharie and the Ashokan West Basin. These occurrences coincide with years with floods and turbidity events (1996, 2005, 2011, and 2012), potentially indicating that phosphorus is attached to the glacial clays which create inordinately low transparencies. In the current assessment, the Ashokan East Basin has gravitated toward the OECD line and fell within the 80% PI, unlike Schoharie and the Ashokan West Basin. Factors other than nutrient-induced algal growth may limit transparency in these two basins.

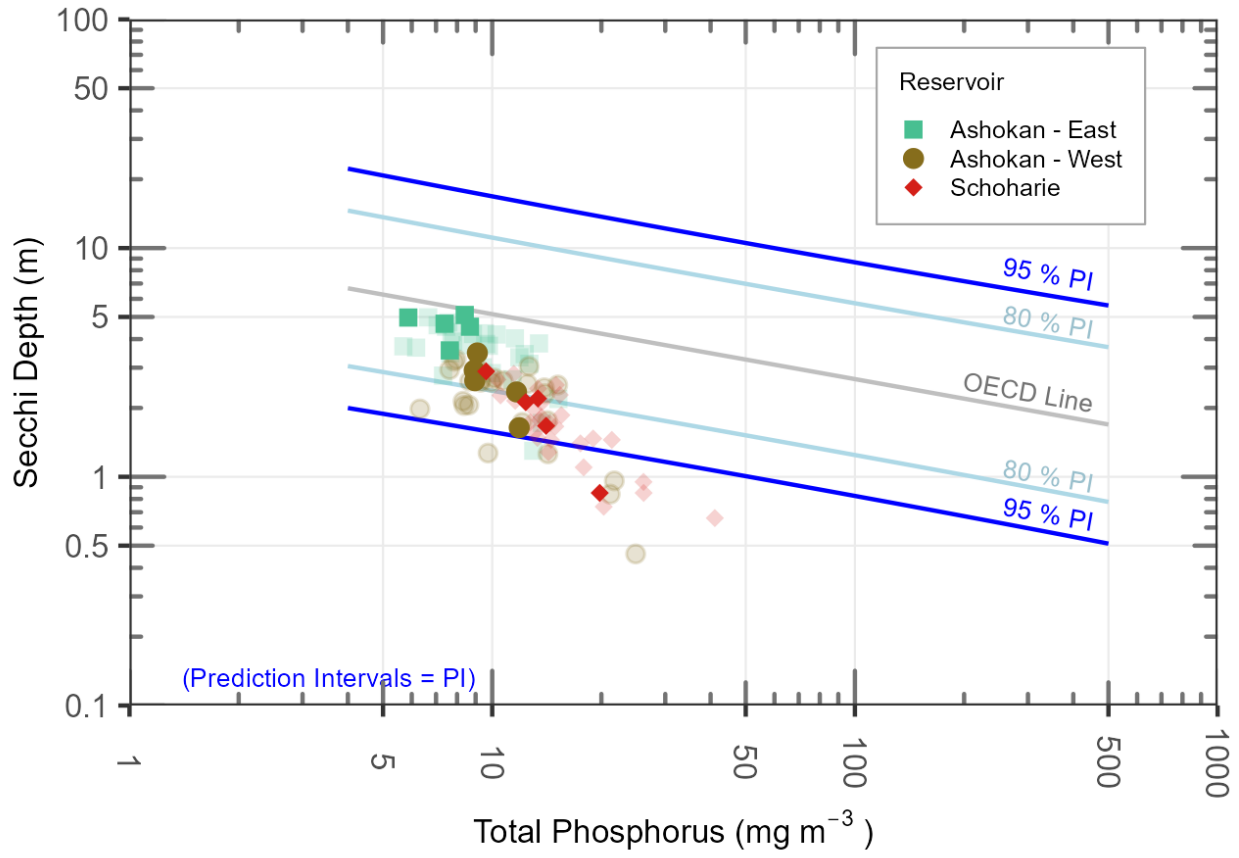


Figure 3.16 Secchi Depth vs. Total Phosphorus in Catskill System Reservoirs.

Secchi depth vs chlorophyll is plotted in Figure 3.17. This plot demonstrates that transparency of the surface water is typically not controlled by algal biomass in Schoharie, nor in the West Basin of Ashokan. Like the reasons for low Secchi depths described in the previous relationship with total phosphorus, transparency is highly limited in years with floods caused by tropical storms and hurricanes, and turbidity events. Secchi depth for Schoharie remains low despite low chlorophyll values indicating other factors, such as suspended particulates, limit transparency.

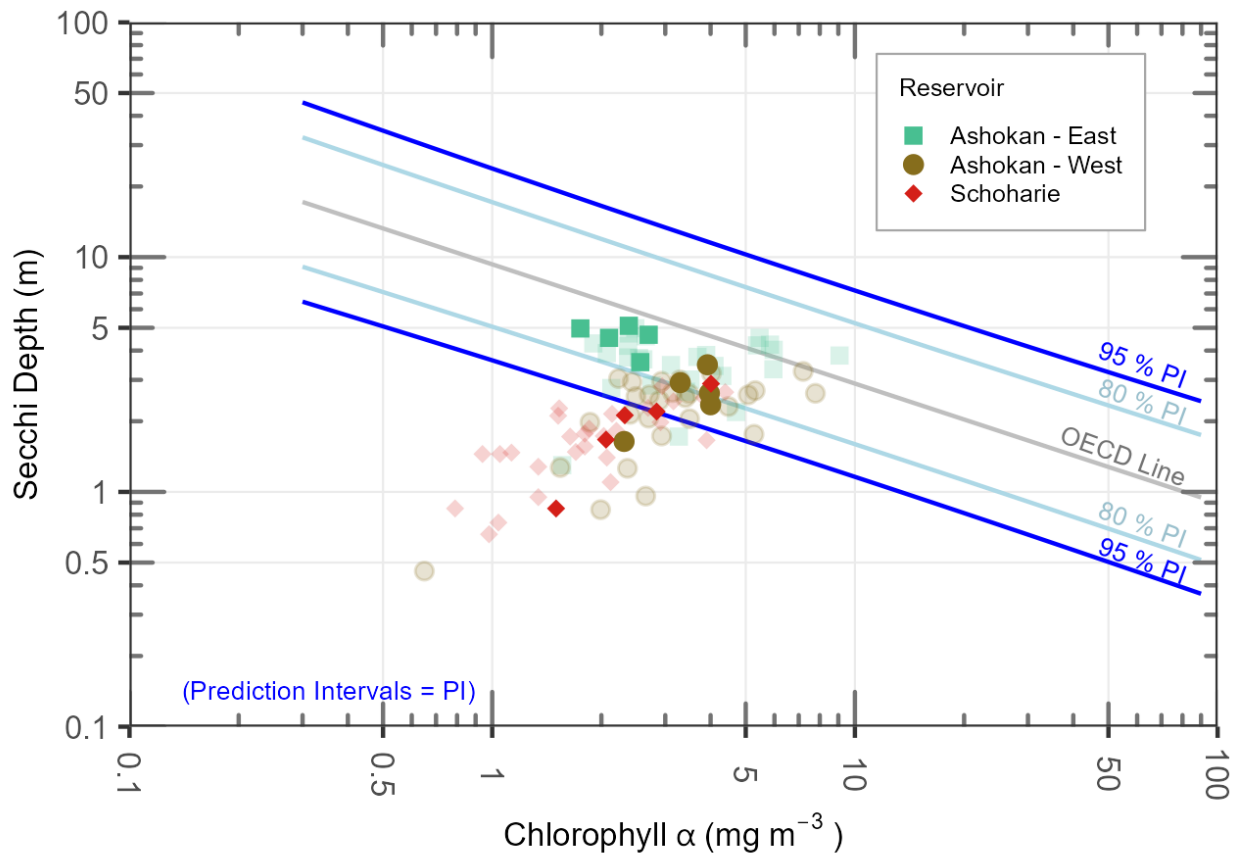


Figure 3.17 Secchi Depth vs. Chlorophyll in Catskill System Reservoirs.

3.5 Water Quality Summary for the Catskill System

Water quality in the Schoharie inflow, reservoir, and outflow from 2022 to 2024 was good overall based on the status of key analytes. Monthly median fecal coliform counts did not exceed benchmarks and both monthly median turbidity and phosphorus concentrations were low overall. Trophic status ranged from oligotrophic to mesotrophic for the status evaluation period.

Long-term upward trends were identified in the Schoharie Basin for turbidity and conductivity, while downward trends were identified for TP. The decline in phosphorus is attributed to recovery from high loads produced by periodic flood events, load reductions associated with the 2001-2002 drought, and from WWTP upgrades. The conductivity increases are likely due to the use of road deicers.

Benthic macroinvertebrate biomonitoring results from 2022 through 2024 indicated that the biological communities of the main inflows to the Ashokan and Schoharie reservoirs (Esopus Creek and Schoharie Creek, respectively) and their sampled tributaries were in good health. Results were derived from assessments made at multiple sites along both stream systems. The mean BAP score for all sites sampled in the region was 7.90, which is above the threshold of 7.50 for the non-impaired category.

Water quality status in the Ashokan West Basin inflow (E16I), both basins (EAW and EAE), and the reservoir outflow at EARCM from 2022 to2024 was good overall based on the status of key analytes. Monthly median fecal coliform counts did not exceed benchmarks and both monthly median turbidity and TP concentrations were low overall. Trophic status was primarily mesotrophic for the evaluation period at EAW and ranged from oligotrophic to mesotrophic at EAE.

Long-term downward trends were evident for TP at Ashokan's inflow, the reservoir itself and the outflow. These reductions are likely due to WWTP construction and to the cumulative effects of watershed protection programs. Downward fecal coliform trends were considered virtually certain at the inflow (E16I), Ashokan East Basin, and the outflow. The decrease can be attributed to landfill closure and to the low frequency of extreme rain events since 2011. Long-term downward turbidity trends were observed in both basins, showing a marked decrease after 2011, most likely due to the lack of extreme rain events. Long-term upward conductivity trends were identified for all sites in the watershed and likely linked to road deicer usage. Long-term TSI decreases were apparent in both reservoir basins. Periods of low water clarity and the long-term decrease in TP are two likely factors

The most recent five-year period shows tight clustering of each basin in the OECD plots indicating a relatively steady-state condition. Turbidity can severely diminish light penetration in Schoharie and the West Basin of Ashokan for months at a time, presenting a severe limitation to algal growth. In the most recent five-year period, all three basins' (Schoharie, Ashokan West, and Ashokan East) values tend to cluster within the 80% confidence intervals and have moved closer to the expectation indicated by the OECD standards. Years associated with high turbidity often have high phosphorus values which indicates that this nutrient is attached to the glacial clays which create inordinately low transparencies and consequently subdued algal growth. So, despite the high phosphorus values in Schoharie, these do not materialize as algal biomass, and this supports the exclusion of Schoharie from the phosphorus-restricted basin list.

4. The Delaware System

4.1 Introduction

4.1.1 The Delaware System Overview

The Delaware System, the most recent of the City's three systems, is comprised of four reservoirs in the West of Hudson region: Neversink Reservoir, Cannonsville Reservoir, Pepacton Reservoir, and Rondout Reservoir. These reservoirs were put into service in the 1950s and 1960s and span Sullivan, Delaware, and Ulster counties, west of the Catskill System. They have a collective total capacity of 338 billion gallons. Water is diverted from Cannonsville, Pepacton, and Neversink reservoirs to Rondout Reservoir via the West Delaware, East Delaware, and Neversink tunnels, respectively. The water residence times for the four reservoir basins in the Delaware System over a 59 year period (1967 to 2025) are depicted in Figure 4.1.

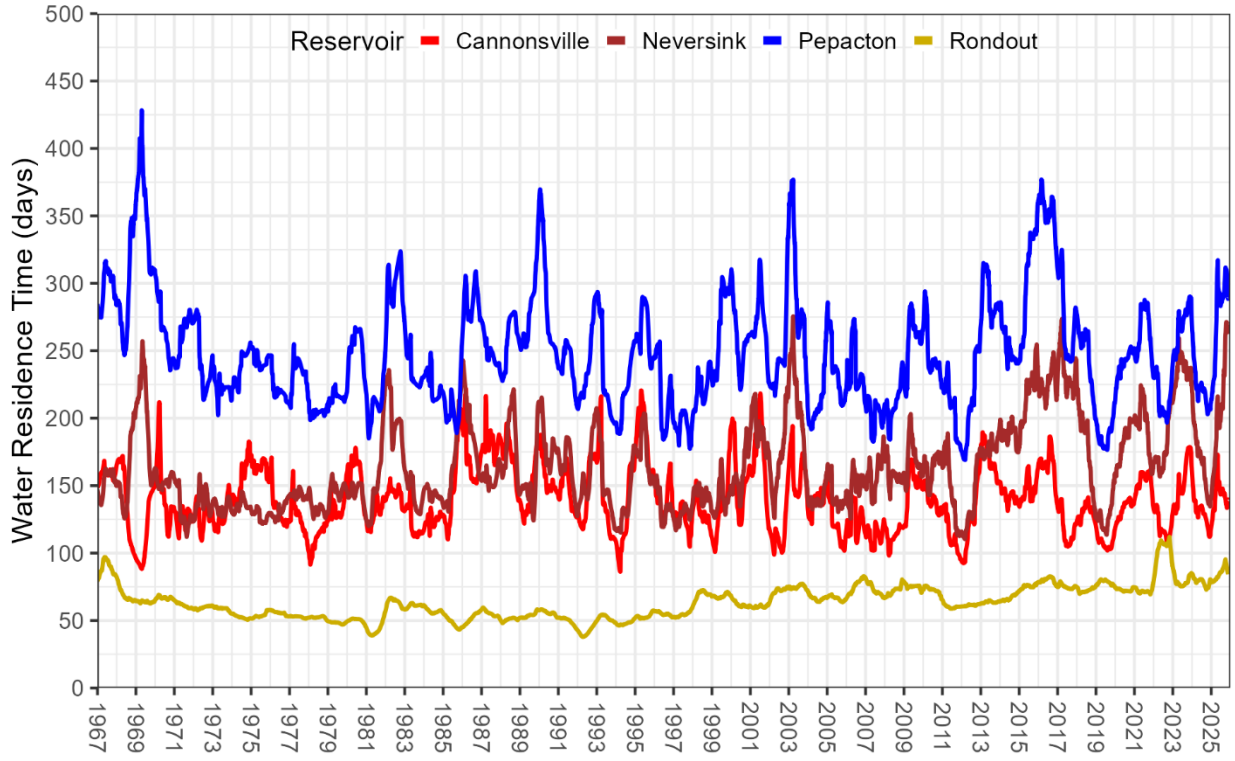


Figure 4.1 Water residence time in the Delaware System Reservoirs, 1967-2025.

Rondout has the shortest and least variable water residence time because of the way the system is operated. It consistently receives a high hydraulic load delivered by the three upstream reservoirs and its residence time averages about 1.5 months. Residence times of Cannonsville and Neversink were historically very similar at about four months, but residence times have increased at Neversink over the past decade to an average closer to six months. Pepacton has the

longest water residence time (averaging about eight to nine months) due to its very large volume. In general, the evolution of a basin to a new steady state takes three times the duration of its water residence time, meaning Rondout would adjust to new nutrient loading levels in about six months, for example, whereas Pepacton would take more than two years to re-equilibrate to a new steady state.

4.1.2 Delaware System Operations

In the Cannonsville, Neversink, and Pepacton reservoirs, the withdrawal elevation and volume of flow from can be adjusted as needed throughout the year to divert the best quality water into Rondout Reservoir. These changes are also made to meet operational needs (e.g., balancing reservoir storage and meeting release targets) and to prevent Rondout from spilling. Where turbidity is the primary water quality driver in managing the Catskill System, disinfection byproduct precursors often dictate operational strategies in the Delaware System. Delaware System operations from 2020 until the end of 2024 are discussed in detail in the subsequent paragraphs.

In the Delaware System in 2020, intake chambers at the four reservoirs were configured for diversion through the mid- or upper-level intakes. Elevation withdrawal changes only occurred at the Rondout Effluent Chamber (REC) and East Delaware Intake Chamber (EDIC) during the year. On March 3, 2020, the intake elevation at the REC was lowered from a surface elevation withdrawal (RR4) to a middle elevation withdrawal (RR3) to allow for continual water quality monitoring during stop shutter and leaf gate cleaning being performed during that timeframe. This mid-depth elevation draw remained throughout the year. On December 31, 2020, following a rainstorm and snowmelt event, the withdrawal elevation at the EDIC was raised from the mid depth (PR2) to a surface draw (PR4) to provide lower turbidity water. Throughout the year, DBPfp surrogates, UV254 and Dissolved Organic Carbon (DOC), helped guide decisions on selecting diversions into Rondout from the three upstream reservoirs.

The late 2020 storms caused an increase in DBPfp as measured by UV254 and DOC at all four Delaware System reservoirs, which continued throughout the spring and into early summer 2021. During late summer, the watershed was inundated by the remnants of two tropical storms, Henri and Ida, which were separated by only 10 days. The addition of these two storms, along with already elevated levels of DOC and UV254, contributed to the most sustained level of DBPfp surrogates across all Delaware System reservoirs since the aftermaths of tropical storms Irene and Lee in 2011 (Figure 4.2).

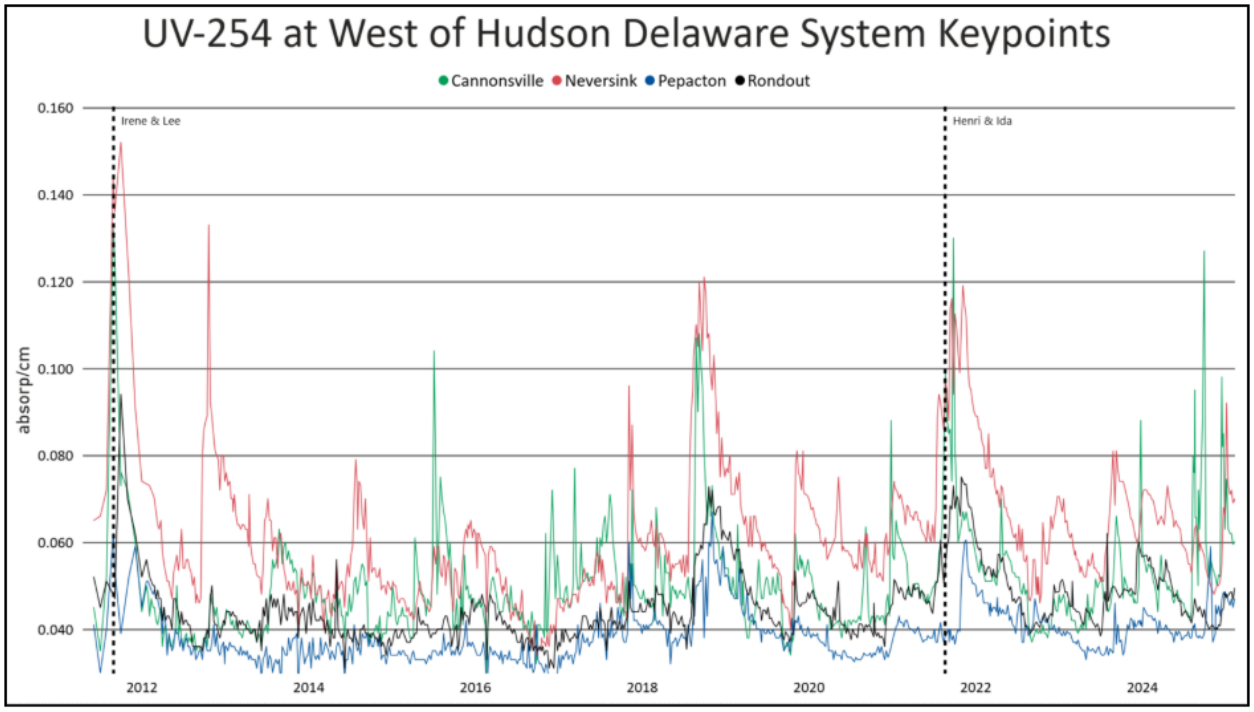


Figure 4.2 UV254 at Delaware System Keypoints.

After experiencing increased levels throughout most of 2021, UV254 in all four Delaware System reservoirs continued to decline in 2022. Consistent with past large storms, it took several months for UV254 levels to return to near pre-storm levels. During this period, DEP minimized the use of Neversink Reservoir which had the highest levels of UV254. There were no significant storms in 2023, and the Delaware System remained near baseline UV254 levels relative to the last 10-year period. DEP decreased use of Neversink Reservoir which had the highest levels of UV254.

For the majority of 2024, water quality in the Delaware System was unremarkable. However, the remnants of Tropical Storm Debby inundated Cannonsville and Pepacton reservoirs in early August. DEP typically minimizes the use of Neversink Reservoir due to elevated UV254, but Neversink was favored over Cannonsville Reservoir throughout the month of August due to lower turbidity and UV254. The intake elevation at Pepacton was changed following the storm to deliver the best quality water into Rondout Reservoir. Cannonsville Reservoir was brought back online at the end of August as water quality improved, with an increase in intake elevation for the best water quality. This configuration was held until the start of the RWBT shutdown in October of 2024.

Diversions into Rondout Reservoir remained offline until mid-November 2024 when the Delaware System was being prepared for restart of the RWBT in response to drought conditions. Rondout Reservoir elevation decreased to 822’ during preparation for the RWBT shutdown with

no impact on water quality. Prior to the restart of the RWBT, the intake elevation at Cannonsville Reservoir was changed from the top to the middle due to decreased usable storage. Water quality remained excellent within Rondout Reservoir during the refill process, and diversions from Rondout Reservoir re-started on December 13, 2024.

4.1.3 Water Quality Trending and Assessment

Water quality trending requires a much longer time period than the current five-year reporting period. Trend assessment in this report includes data from 1993 through 2024 and allows an examination of changes over the past 32 years in the context of changes made through protection programs, as well as through natural variation. Status and trends were assessed at all four of the Delaware System reservoirs, and major inflows and outflows. The current water quality status assessment of each basin uses aggregated data from the last three years of available data (2022-2024). The analytes chosen were those most important for the SWTR and meeting the requirements of the Revised 2017 FAD. The trophic status of each reservoir and the recent biological assessment profile scores for select streams were also assessed using standard criteria. Appendix C provides more detail on statistical and data collection methods.

4.2 The Neversink Basin

Neversink Reservoir is located in Sullivan County, approximately 5 miles northeast of the Village of Liberty and more than 75 miles from New York City. Placed into service in 1954, it was formed by damming the Neversink River, which continues south and eventually drains into the lower Delaware River. The reservoir holds 37.1 billion gallons at total capacity.

Water withdrawn from the reservoir travels six miles in the Neversink Tunnel to the Rondout Reservoir. There it mixes with water from the other two Delaware system reservoirs, Cannonsville and Pepacton, before draining south via the 85-mile-long Delaware Aqueduct, which runs below the Hudson River to West Branch Reservoir in Putnam County and Kensico Reservoir in Westchester.

The Neversink Reservoir's watershed is 93 square miles and includes portions of six towns. The Neversink River is the main tributary supplying the reservoir, providing a 73% of the inflow. Presently there are no WWTPs in the Neversink watershed basin and it is the most heavily forested of any NYC watershed (91.5%). The remaining land use breakdown is 3.0% urban, 1.4% brushland, 2.7% water, and 1.4 % agricultural use with approximately 1,400 acres in Whole Farm Plans.

4.2.1 Water Quality Status and Trends in the Neversink Watershed

Status (Neversink)

The Neversink basin status evaluation is presented as a series of boxplots in Figure 4.3, which compare the main inflow to the reservoir at Neversink River (NCG), the reservoir (NN), and the outflow at Neversink Gatehouse (NRR2CM). A site map, description of the sampling program, and details on data preparation and boxplot interpretation are provided in Appendix C.

For the evaluation period (2022-2024), fecal coliform bacteria remained well below the NYSDEC Stream Guidance Value of 200 fecal coliforms 100 mL^{-1} for the river inflow. Monthly median reservoir fecal coliform levels (SS) were lower than the inflow values. Turbidity in the Neversink Basin is among the lowest in the entire NYC water supply watershed with a median value of 0.9 NTU. Monthly median reservoir TP values were also low, with a median of 6 µg L^{-1}. The TSI values for Neversink Reservoir ranged from oligotrophic to mesotrophic, and conductivity ranges and medians were low at all sites, as in previous assessments.

Trends (Neversink)

Water quality trend plots for the Neversink basin are presented in Figure 4.4 and results of the SKT and TDA analysis are provided in Table 4.1.

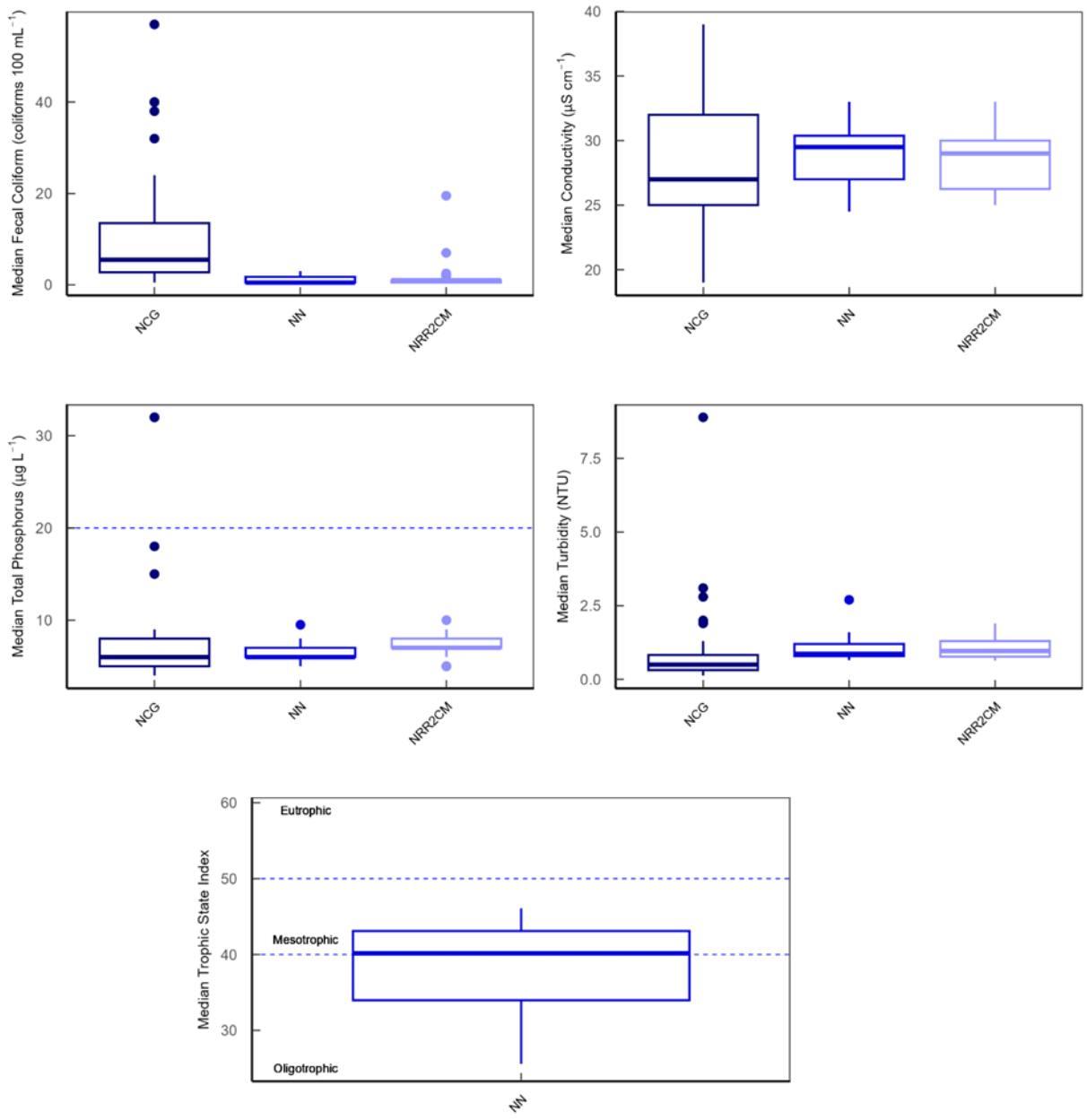


Figure 4.3 Water quality status boxplots using 2022-2024 monthly data for the Neversink basin main inflow at the Neversink River (NCG), Neversink Reservoir (NN), and the outflow at the Neversink gatehouse (NRR2CM).

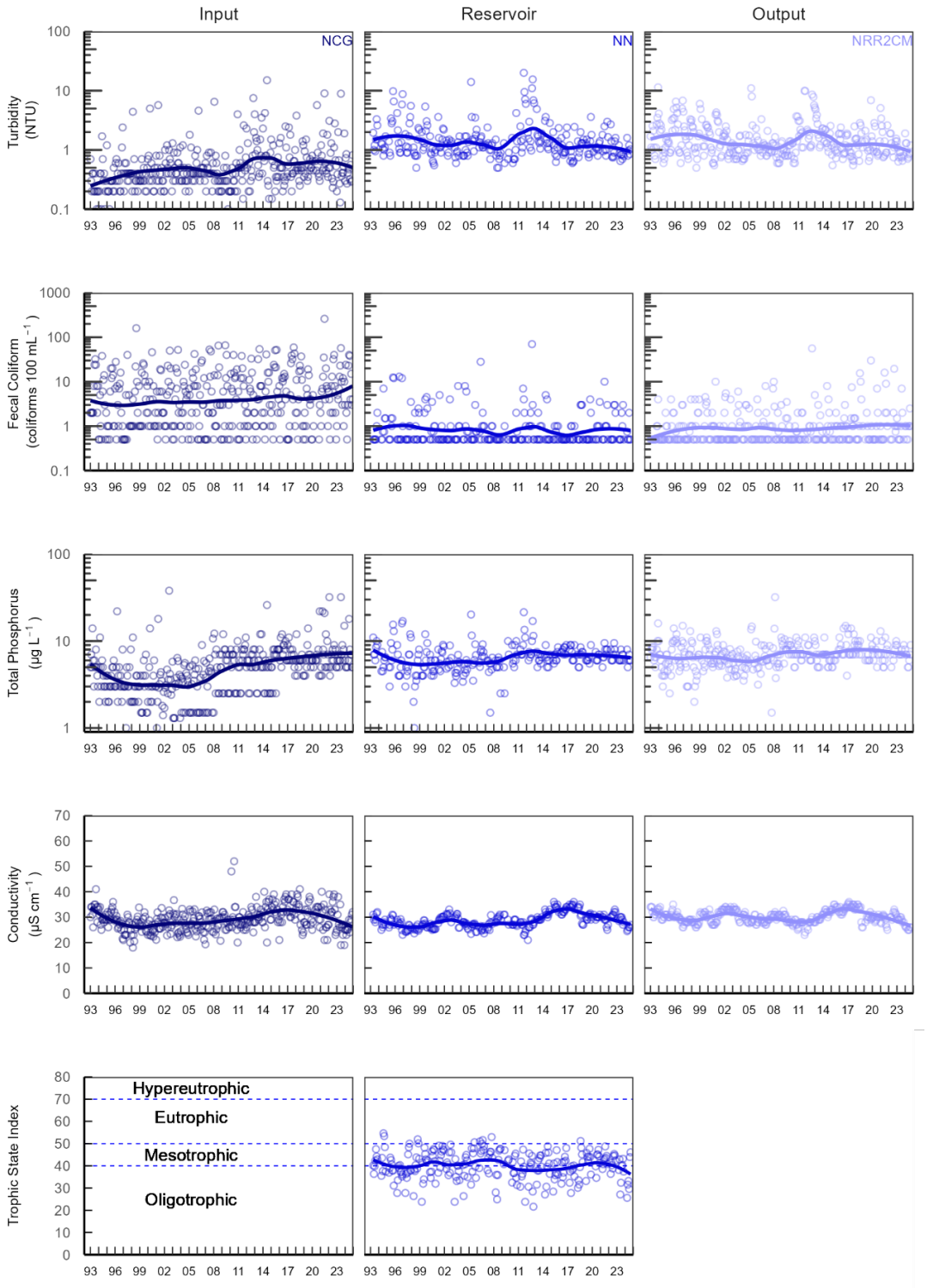


Figure 4.4 Water quality trends for the Neversink basin for the main inflow at the Neversink River (NCG), Neversink Reservoir (NN), and the aqueduct outflow at the Neversink gatehouse (NRR2CM).

Table 4.1 Neversink basin trends from 1993-2024 for selected analytes.

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
NCG	Input	Turbidity	380	***	0.007	1.700	Increasing trend virtually certain
NCG	Input	Turbidity (Flow Adj.)	380	***	0.005	1.3321	Increasing trend virtually certain
NCG	Input	Fecal Coliform	373	***	0	0	Trend exceptionally unlikely
NCG	Input	Fecal Coliform (Flow Adj.)	373	***	0.059	1.4875	Increasing trend virtually certain
NCG	Input	Total Phosphorus	376	***	0.121	2.4105	Increasing trend virtually certain
NCG	Input	Total Phosphorus (Flow Adj.)	376	***	0.118	2.3537	Increasing trend virtually certain
NCG	Input	Conductivity	379	***	0.1	0.3448	Increasing trend virtually certain
NCG	Input	Conductivity (Flow Adj.)	379	***	0.098	0.3385	Increasing trend virtually certain
Neversink	Reservoir	Turbidity	264	***	-0.009	-0.714	Decreasing trend virtually certain
Neversink	Reservoir	Fecal Coliform	264	NS	0	0	Decreasing trend about as likely as not
Neversink	Reservoir	Total Phosphorus	250	***	0.05	0.833	Increasing trend virtually certain

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
Neversink	Reservoir	Conductivity	262	***	0.12	0.414	Increasing trend virtually certain
Neversink	Reservoir	Trophic State Index	253	NS	-0.034	-0.0844	Decreasing trend about as likely as not
NRR2CM	Output	Turbidity	352	***	-0.006	-0.490	Decreasing trend very likely
NRR2CM	Output	Fecal Coliform	346	***	0	0	Trend exceptionally unlikely
NRR2CM	Output	Total Phosphorus	320	***	0.045	0.649	Increasing trend virtually certain
NRR2CM	Output	Conductivity	351	NS	0	0.000	Decreasing trend about as likely as not

*[1]The p-values for each trend test are symbolized as follows: NS (Not Significant) = p ≥ 0.20, * = p < 0.20, ** = p < 0.10, *** = p < 0.05.*

While the Neversink River inflow at site NCG shows strong evidence of upward trends for all analytes of interest when adjusting for flow, Neversink Reservoir and the outflow at Neversink Gatehouse (NRR2CM) remained relatively stable and even showed strong evidence of a modest long-term decreasing trend in turbidity in both the reservoir and the outflow at Neversink Gatehouse.

Turbidity at the NCG inflow has still not returned to its pre-2010 baseline since the extreme runoff events in 2010, tropical storms Irene and Lee in 2011, and another large storm in 2012 which was confined almost exclusively to the Neversink watershed. As previously reported (DEP 2016, DEP 2021), it is likely that storm damage to the watershed altered the flow-turbidity concentration relationship causing flows to produce more turbidity than the pre-extreme period.

There is strong evidence of long-term upward TP and conductivity trends at all sites. The trends are most pronounced at the inflow, while the reservoir and outflow have less than 1% increase per year for both analytes. TP, although increasing, remains low. Interestingly,

conductivity has a recent downward trend at all sites, possibly due to fewer winter storms in recent years. Road deicer usage is the suspected driving force behind conductivity changes.

4.2.2 Biomonitoring in the Neversink Watershed

The DEP Stream Biomonitoring Program uses protocols developed by the New York State Department of Environmental Conservation to assess the health of stream macroinvertebrate communities in watershed streams. Stream impairment is assessed via a multimetric BAP score derived from stream macroinvertebrate assemblages. For full methodology details including headwater adjustment methods as established by NYS DEC in 2018, see Appendix C.

The most recent status of macroinvertebrate communities in the Neversink basin was evaluated by the analysis of five total samples collected from four streams during 2022 through 2024. During this period, one site on each of Neversink River (312), West Branch Neversink River (313), and East Branch Neversink River (314) were sampled, and one site on Aden Brook (307) was sampled twice.

Neversink Basin: Sites 313 (NWBR) and 314 (NEBR) are both located at their respective crossings of Frost Valley Road in Neversink before the streams converge to form the Neversink River. In 2022, site 313 was assessed as non-impaired and 314 was assessed as slightly impaired. Site 312 (NCG) is located on the Neversink River approximately 1.8 miles below the convergence of the east and west branches and was assessed as non-impaired in 2024. Site 307 (NK4) is located on Aden Brook approximately 350 meters upstream of the mouth on the western side of the Neversink Reservoir and was assessed as non-impaired in both 2022 and 2023 as shown in Figure 4.5.

Neversink Watershed Biomonitoring Trends: Streams in the Neversink watershed were analyzed for time-series trends in BAP scores based on a site's entire period of record. For the purposes of this report, long-term trend analysis is focused on main input streams with more than three years of biological assemblage data. Of streams sampled during 2022 through 2024, only Aden Brook (307) has an appropriately long enough sample record for trend analysis. Sites 312, 313, and 314 have traditionally been rotating sites and lack sufficient data for long-term trends. Although BAP scores from Aden Brook have periodically fluctuated into the slightly impaired category across the period of record, scores have averaged in the non-impaired category since 2011(Figure 4.6).

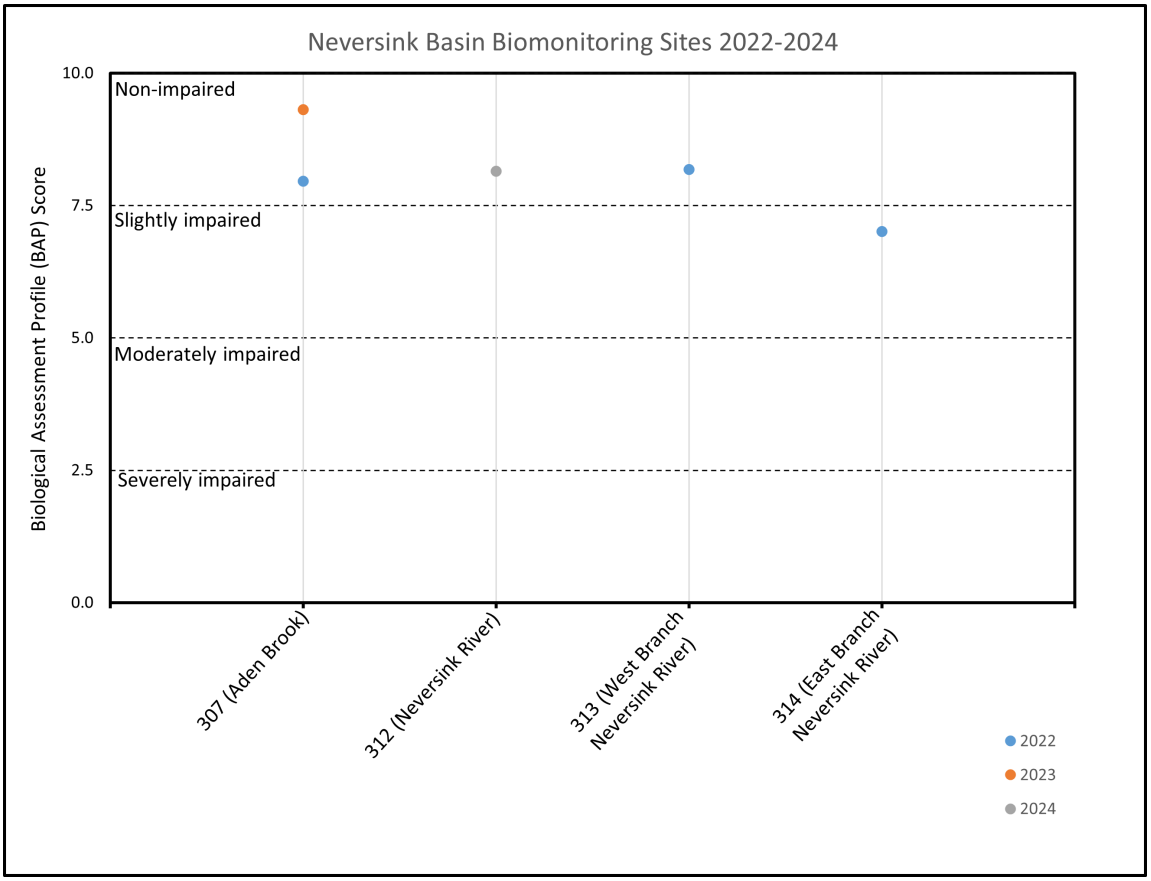


Figure 4.5 Biological Assessment Profile scores for the Neversink Basin, 2022-2024.

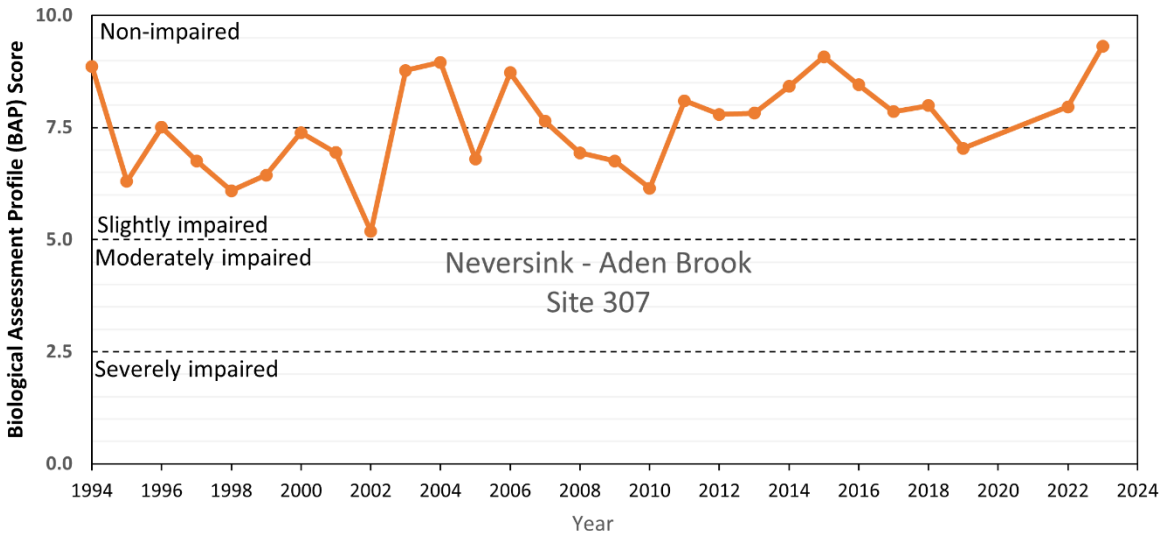


Figure 4.6 Biological Assessment Profile scores for Aden Brook, 1994-2024.

4.3 The Pepacton Basin

Pepacton Reservoir is located in Delaware County along the northern edge of the state's forever wild Catskill Park, 12 miles south of the Village of Delhi and more than 100 miles northwest of New York City. The reservoir was formed by damming the East Branch of the Delaware River, which continues west and joins the lower Delaware River. Placed into service in 1955, Pepacton is approximately 15 miles long, holds 149.8 billion gallons at total capacity, and is the largest reservoir in the City system by volume. Water withdrawn from the Pepacton Reservoir enters the East Delaware Aqueduct and flows southeast for 25 miles into Rondout Reservoir before heading south via the 85-mile long Delaware Aqueduct to West Branch and Kensico reservoirs.

The Pepacton Reservoir's watershed is 371 square miles and includes parts of 13 towns in three counties. Four main tributaries flow into Pepacton: East Branch Delaware River contributes 44%, Platte Kill provides 9.5%, and Tremper Kill and Millbrook Stream provide 9% and 7%, respectively. The Pepacton watershed has a land use breakdown as follows: 77.7% is forested, 6.4% is urban, 6.3% is brushland, 2.6% is water, and 6.9% is in agricultural use. Protection programs in place in the watershed are described in the Watershed Protection Program sections.

4.3.1 Water Quality Status and Trends in the Pepacton Watershed

Status (Pepacton)

The Pepacton basin status evaluation is presented as a series of boxplots in Figure 4.7, which compare the East Branch Delaware River (PMSB), the main inflow to the reservoir, the reservoir (EDP), and the aqueduct outflow (PRR2CM). A site map, description of the sampling program, and details on data preparation and boxplot interpretation are provided in Appendix C.

The monthly median fecal coliform bacteria was above the NYSDEC Stream Guidance Value of 200 fecal coliforms 100 mL^{-1} for the river inflow in December 2023, at 310 fecal coliforms 100 mL^{-1}, following over 2 inches of rain in the watershed the day before sampling. Turbidity in the Pepacton Basin is typically low, and the median monthly turbidity at the outflow for the last three years was 0.9 NTU. Monthly median reservoir TP values were well below the target value of 20 µg L^{-1} (median 9.3 µg L^{-1}). The TSI values for Pepacton Reservoir fell primarily in the mesotrophic range, with excursions into the oligotrophic range. Conductivity, fecal coliform, total phosphorus, and turbidity monthly medians were all greatest at the inflows.

Trends (Pepacton)

Water quality trend plots for the Pepacton basin are presented in Figure 4.8 and results of the SKT and TDA analysis are provided in Table 4.2.

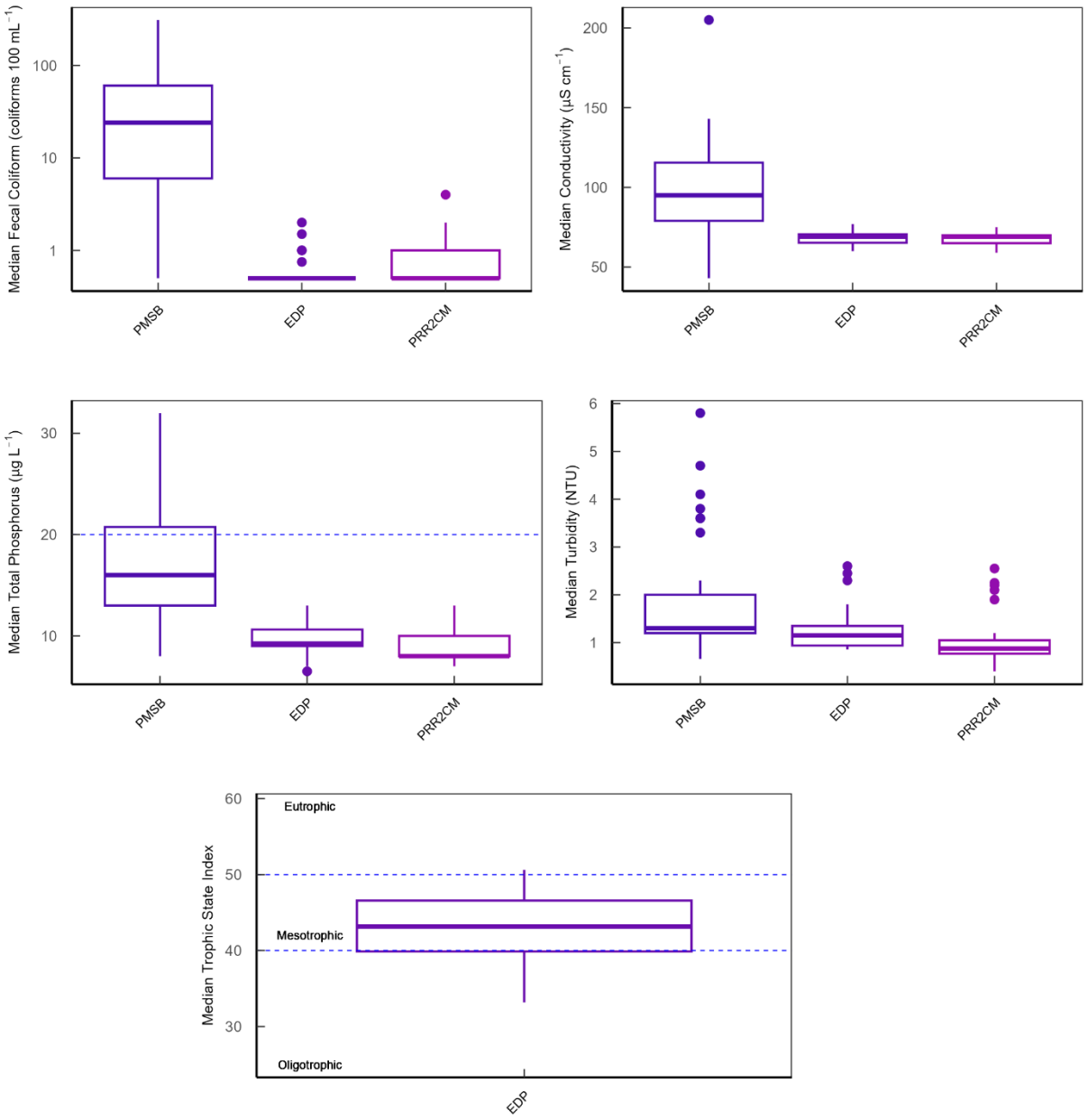


Figure 4.7 Water quality status boxplots using 2022-2024 monthly data for the Pepacton basin main inflow at the East Branch Delaware River (PMSB), Pepacton Reservoir (EDP), and the aqueduct outflow at the Pepacton gatehouse (PRR2CM).

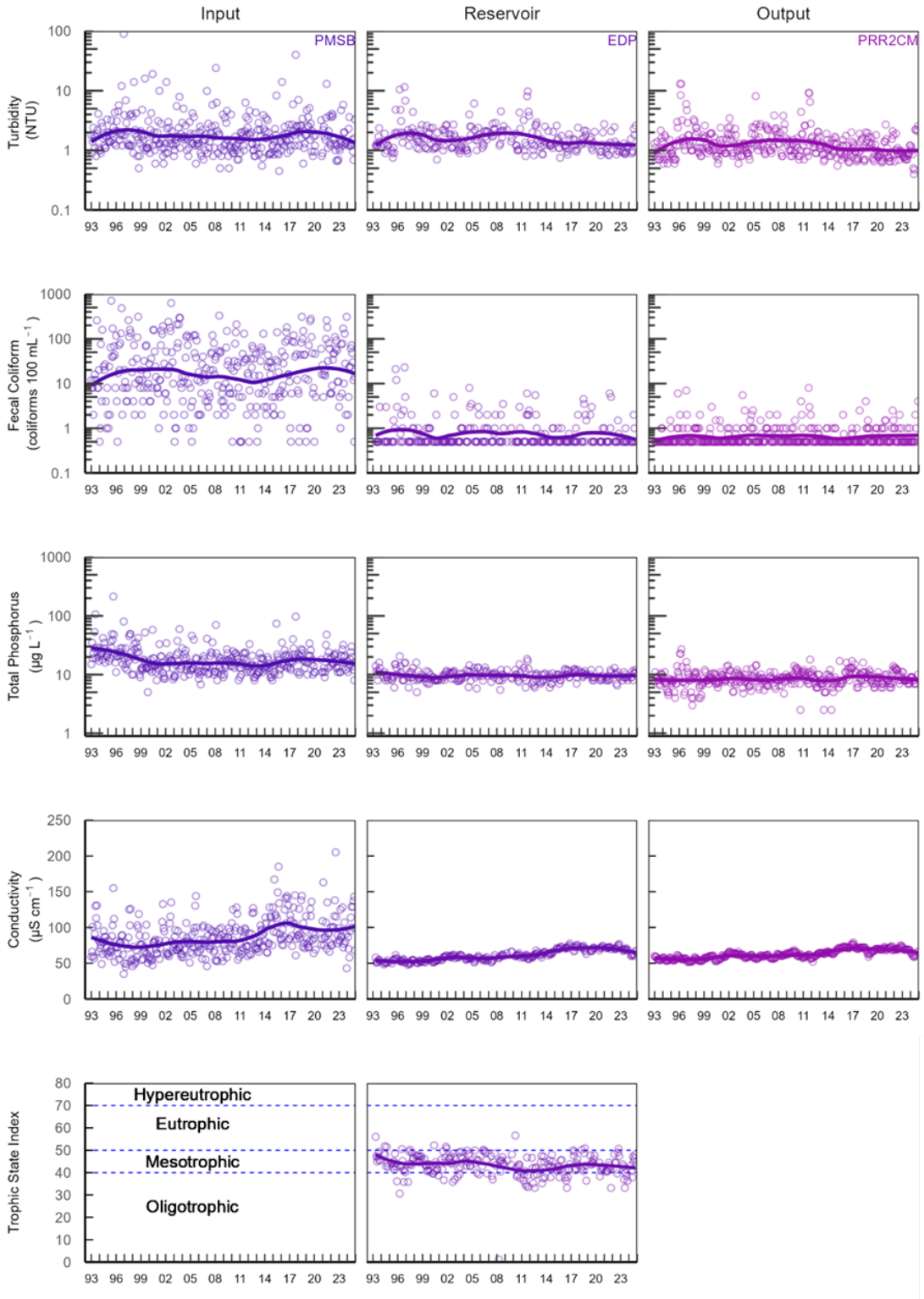


Figure 4.8 Water quality trend plots for the Pepacton basin for the main inflow at the East Delaware River (PMSB), Pepacton Reservoir (EDP), and the outflow at the Pepacton gatehouse (PRR2CM).

Table 4.2 Pepacton basin trends from 1993-2024 for selected analytes.

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
PMSB	Input	Turbidity	374	NS	0	0.000	Decreasing trend possible
PMSB	Input	Turbidity (Flow Adj.)	374	*	-0.006	-0.3542	Decreasing trend possible
PMSB	Input	Fecal Coliform	362	NS	0	0	Trend exceptionally unlikely
PMSB	Input	Fecal Coliform (Flow Adj.)	362	NS	0.008	0.0498	Increasing trend extremely unlikely
PMSB	Input	Total Phosphorus	361	***	-0.095	-0.5952	Decreasing trend virtually certain
PMSB	Input	Total Phosphorus (Flow Adj.)	361	***	-0.088	-0.5471	Decreasing trend very likely
PMSB	Input	Conductivity	371	***	0.955	1.1785	Increasing trend virtually certain
PMSB	Input	Conductivity (Flow Adj.)	371	***	0.961	1.1866	Increasing trend virtually certain
Pepacton	Reservoir	Turbidity	256	***	-0.01	-0.714	Decreasing trend virtually certain
Pepacton	Reservoir	Fecal Coliform	258	*	0	0	Decreasing trend possible
Pepacton	Reservoir	Total Phosphorus	251	NS	0	0.000	Decreasing trend about as likely as not
Pepacton	Reservoir	Conductivity	250	***	0.693	1.155	Increasing trend virtually certain

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
Pepacton	Reservoir	Trophic State Index	249	***	-0.113	-0.2579	Decreasing trend virtually certain
PRR2CM	Output	Turbidity	252	***	-0.021	-1.875	Decreasing trend virtually certain
PRR2CM	Output	Fecal Coliform	248	NS	0	0	Decreasing trend possible
PRR2CM	Output	Total Phosphorus	235	NS	0	0.000	Trend exceptionally unlikely
PRR2CM	Output	Conductivity	252	***	0.667	1.042	Increasing trend virtually certain

[1]The *p*-values for each trend test are symbolized as follows:
NS (Not Significant) = $p \geq 0.20$, * = $p < 0.20$, ** = $p < 0.10$, *** = $p < 0.05$.

The strongest trends for the Pepacton basin were seen in the inflow at the East Branch Delaware River (PMSB). Conductivity had a strong long-term increasing trend while total phosphorus had a strong long-term decreasing trend, which may be attributable to the cumulative effects of the various watershed programs that have been employed in the basin. Increasing conductivity trends were also observed in the reservoir and at the outflow at Pepacton Gatehouse (PRR2CM). Although drought and high flow events certainly produce short-term effects, the primary driver of the upward conductivity trend is likely the use of road deicers.

Decreasing turbidity trends were observed in both the reservoir and outflow. The outflow had a larger rate of change than the reservoir, at 1.9% per year. Although strong fecal coliform trends were not detected in the reservoir, the levels seen in the reservoir and output continued to be an order of magnitude lower than in the inflow.

A long-term downward trend was identified for TSI, which may be related to decreased nutrients associated with watershed programs and WWTP upgrades. Overall, the Pepacton basin values remained relatively steady year over year across analytes, as evidenced by the almost flat LOWESS curves (Figure 4.8). This may be attributed to management of watershed programs and the very large volume of the reservoir.

4.3.2 Biomonitoring in the Pepacton Watershed

The DEP Stream Biomonitoring Program uses protocols developed by the NYSDEC to assess the health of stream macroinvertebrate communities in watershed streams. Stream impairment is assessed via a multimetric BAP score derived from stream macroinvertebrate assemblages. For full methodology details including headwater adjustment methods as established by NYSDEC in 2018, see Appendix C.

The most recent status of macroinvertebrate communities in the Pepacton basin was evaluated by the analysis of 12 total samples collected from eight streams during 2022 through 2024. During this period, two sites on the mainstem East Branch Delaware River (316, 321) and one site on Bush Kill (330) were sampled twice each, and sites on Batavia Kill (323), Platte Kill (324), Tremper Kill (327), Emory Brook (341), and Mill Brook (342) were sampled once each.

East Branch Delaware River: The East Branch Delaware River is the primary inflow to Pepacton Reservoir, draining 45% of the basin. Site 316 (PMSB) in Margaretville is located approximately five miles upstream of Pepacton Reservoir and Site 321 (EDRB) is about 13 miles upstream. Using the most recent samples, site 316 was assessed as non-impaired in 2022 and 2023, and site 321 was assessed as slightly impaired in 2022 and non-impaired in 2023 (Figure 4.9).

East Branch Delaware River Tributaries and Pepacton Streams: Site 330 (PBKG) is located on the Bush Kill approximately 0.6 miles upstream of the confluence with Dry Brook. The confluence is approximately 1.2 miles upstream of where it empties into the East Branch Delaware River. Samples in both 2022 and 2023 were assessed as non-impaired, with large amounts of intolerant EPT taxa in both samples. Two additional tributaries to the East Branch Delaware River in Middletown were sampled in 2024: site 323 (P-50) on the Batavia Kill was assessed as non-impaired; and site 341 on Emory Brook was assessed as slightly impaired using headwater-adjusted metrics. Three additional sites on streams that drain directly into the Pepacton Reservoir were sampled and assessed as non-impaired in 2024: site 324 (P-21) on Platte Kill in Middletown, 327 (P-13) on Tremper Kill in Andes, and 342 (P-60) in Middletown on the southern side of the reservoir (Figure 4.9).

Pepacton Watershed Biomonitoring Trends: Streams in the Pepacton watershed were analyzed for time-series trends in BAP scores based on a site's entire period of record. Long-term trend analysis was focused on main input streams with more than three years of biological assemblage data: 316, 321, and 330. Although both sites 316 (PMSB) and 321 (EDRB) have each fluctuated around the slightly impaired threshold since 2013, the most recent BAP scores scored in the non-impaired range. (Figure 4.10).

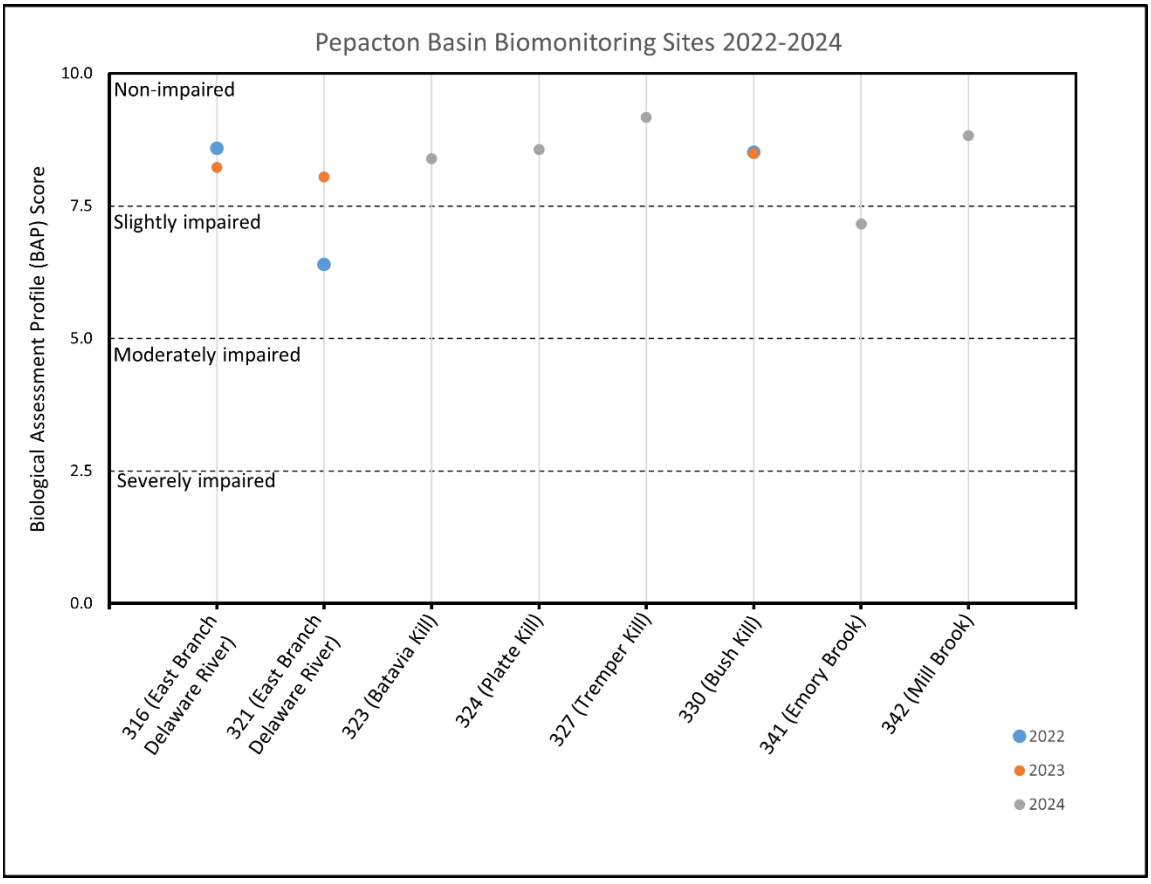


Figure 4.9 Biological Assessment Profile scores for East Branch Delaware River, 2022-2024.

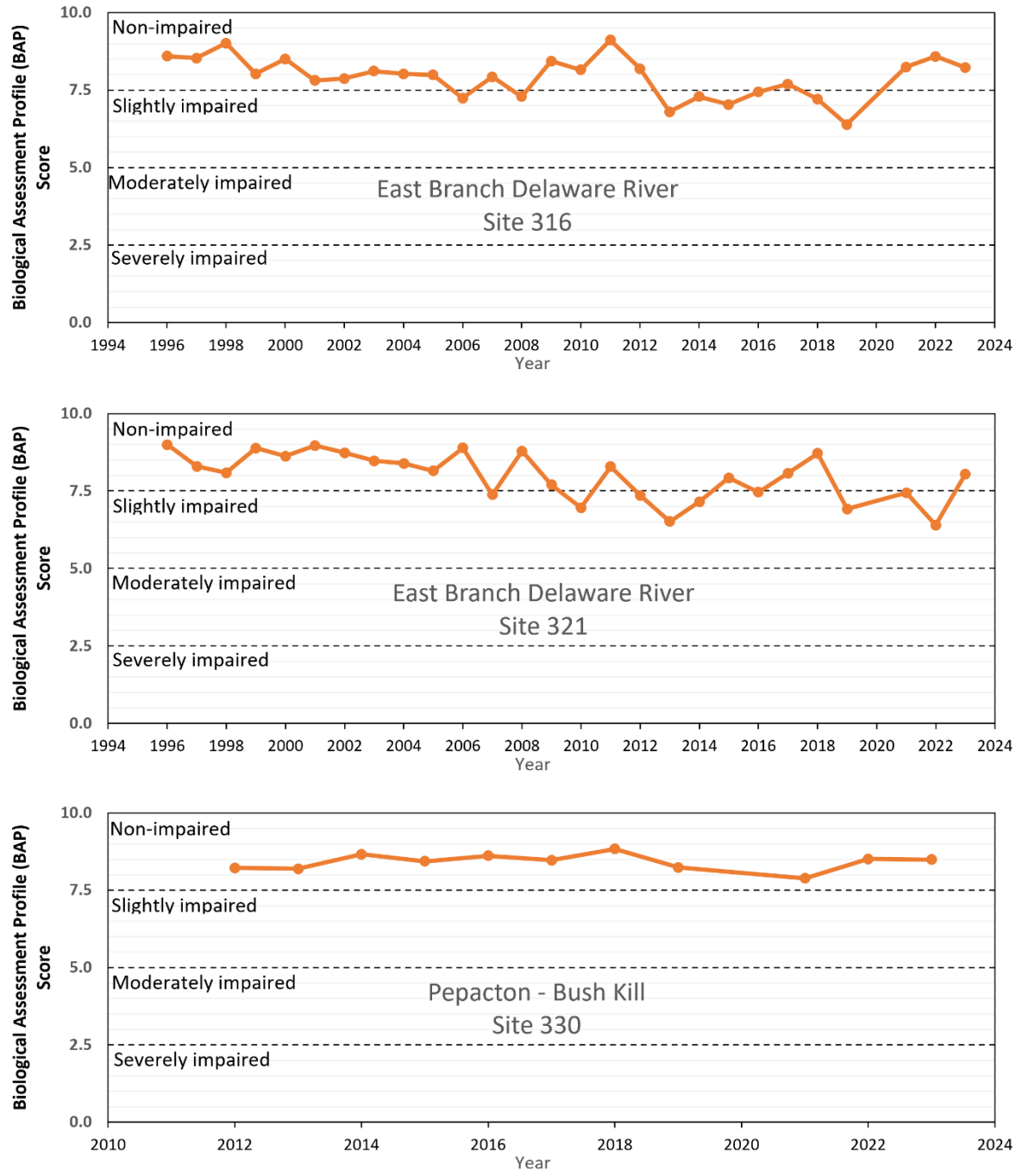


Figure 4.10 Biological Assessment Profile scores for Pepacton basin, 1996-2023.

4.4 The Cannonsville Basin

The Cannonsville Reservoir is located at the western edge of Delaware County, southwest of the Village of Walton and about 120 miles northwest of New York City. It was placed into service in 1964, and it holds 98.6 billion gallons at total capacity. Cannonsville is one of four reservoirs in the City's Delaware system and the most recent in New York City's water supply. Water drawn from Cannonsville enters the West Delaware Tunnel and travels 44 miles to the upper end of Rondout Reservoir. From there, it is carried in the 85-mile-long Delaware Aqueduct under the Hudson River to West Branch and Kensico Reservoirs.

The Cannonsville Reservoir's watershed is 455 square miles, the largest in the City's system, and includes parts of 17 towns, all in Delaware County. Trout Creek and West Branch Delaware River are the two primary tributaries flowing into Cannonsville, the former providing approximately 4.5% and the latter approximately 77%. The Cannonsville watershed land use breakdown is as follows: 63.6% forested, 6.9% urban, 8.1% brushland, 2.1% water, and 19.1% in agricultural use.

Under a 1954 U.S. Supreme Court ruling, New York City can take up to 800 million gallons a day from the Delaware River, provided it releases enough water to insure adequate flow in the lower Delaware for New Jersey and other downstream users. The Office of the Delaware Rivermaster, in conjunction with the NYSDEC, oversee releases from Cannonsville and other Delaware system reservoirs to help manage flow in the lower West Branch Delaware River for the benefit of habitat and water users downstream. Protection programs in place in the watershed are described in the Watershed Protection Program sections.

4.4.1 Water Quality Status and Trends in the Cannonsville Watershed

Status (Cannonsville)

The Cannonsville basin status evaluation is presented as a series of boxplots in Figure 4.11, which compare the main inflow, West Branch Delaware River (CBS), the reservoir (WDC), and the outflow at the West Delaware Tunnel Outlet (WDTOCM). A site map, description of the sampling program, and details on data preparation and boxplot interpretation are provided in Appendix C.

For the evaluation period (2022-2024), fecal coliform bacteria remained below the NYSDEC Stream Guidance Value of 200 fecal coliforms 100 mL^{-1} for the stream inflow site, except for three monthly medians in July and August 2023 and August 2024. Reservoir and outflow fecal coliform levels were low (the median in the reservoir was 0.5 fecal coliforms 100 mL^{-1}, equivalent to non-detect). Turbidity was generally low, with a median at the outflow site (WDTOCM) of 1.8 NTU. Median monthly TP was highest at the inflow (CBS), with a range of 10 to 129 µg L^{-1} and median of 20.5 µg L^{-1}. The reservoir median for TP ranged from 13 to 27 µg L^{-1} with a median of 16 µg L^{-1}. The interquartile range for the TSI values remained in the mesotrophic range, with excursions into both the eutrophic and oligotrophic ranges. Median conductivity was higher (112 µS cm^{-1}) and spanned a wider range (52 to 194 µS cm^{-1}) at the

inflow than the reservoir (WDC) and outflow (WDTOCM) with a median of 91 µS cm^{-1} at both sites.

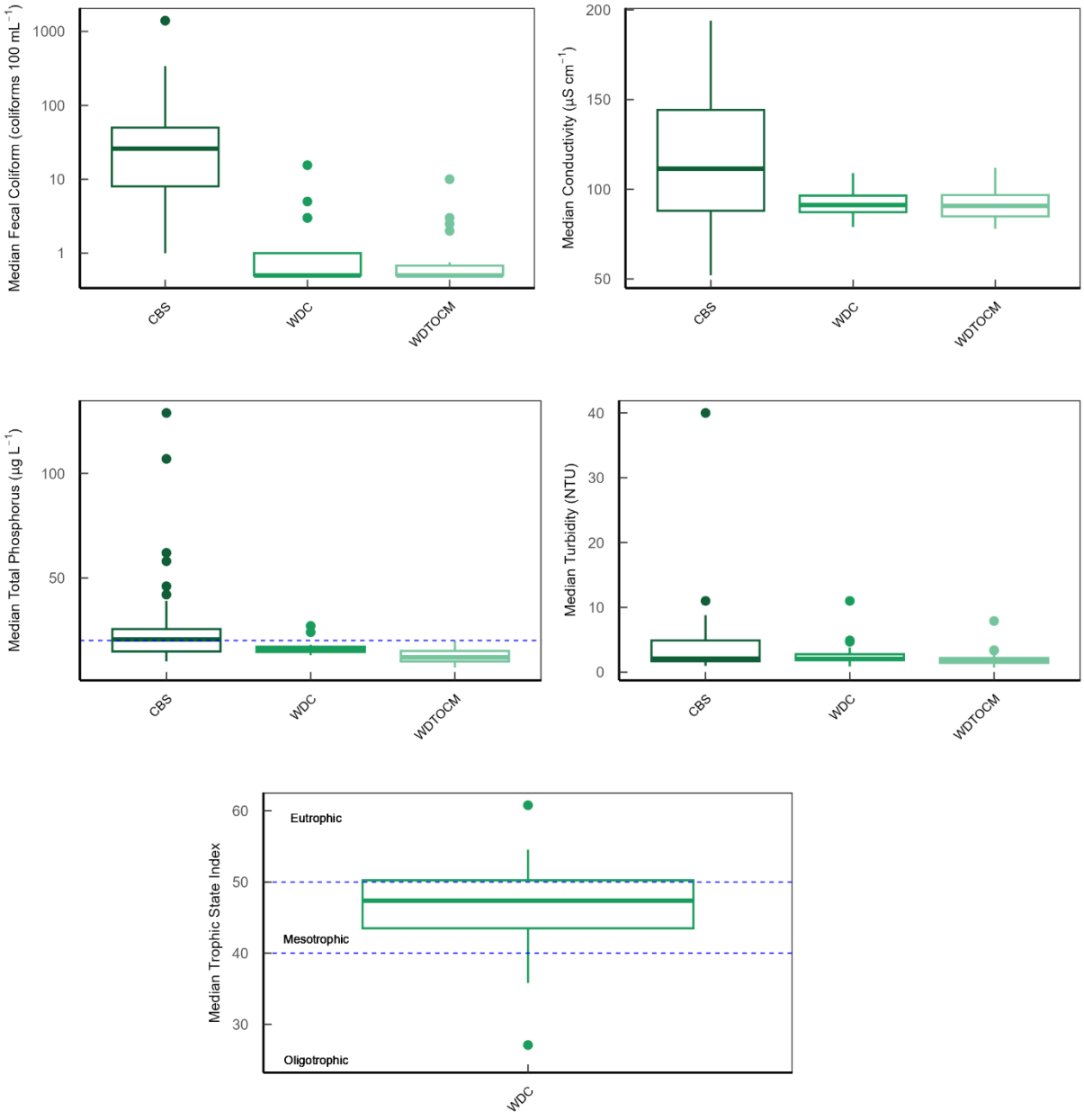


Figure 4.11 Water quality status boxplots using 2022-2024 monthly data for the Cannonsville basin main inflow at the West Branch Delaware River (CBS), Cannonsville Reservoir (WDC), and the outflow at the West Delaware Tunnel Outlet (WDTOCM).

Trends (Cannonsville)

Water quality trend plots for the Cannonsville basin are presented in Figure 4.12 and results of the SKT and TDA analysis are provided in Table 4.3.

Analytes of interest have declined in the reservoir and outflow, except for fecal coliforms in the reservoir (no discernible trend) and conductivity at the reservoir and outflow. Conductivity, as observed in the other Delaware basins, increased with virtual certainty at all sites, likely due to road deicers. Much like the Pepacton basin, fecal coliforms at the inflow were an order of magnitude higher than at the reservoir or outflow.

TP and turbidity at the reservoir and outflow exhibited a strong decreasing long-term trend, as did TSI at the reservoir. This is especially significant for TP (which also had a strong decreasing trend in the inflow), considering the large percentage of agricultural use in the watershed and the large drainage area of the basin. Additionally, while the percent change for Cannonsville Reservoir and the outflow at WDTOCM were modest (both less than -1% change per year), these reductions are notable as the cattle type in the watershed have slowly shifted from dairy to beef, which would typically cause an increase in total phosphorus. Not incidentally, the Cannonsville watershed also has the most implemented BMPs, septics remediated, and agricultural acres with nutrient management plans of all the basins in NYC watershed. While modeling has not shown any trends in total dissolved phosphorus concentrations since 2011 (see Chapter 7), the decreasing trend here may be due to particulate phosphorus. A decrease in particulate phosphorus aligns with the decrease in turbidity observed at the reservoir and outflow.

It is worth noting that there was a sample location change in July 2016 for the inflow at the West Branch Delaware River (CBS). For safety concerns, the site was moved about 500 feet downstream where it could be accessed from the shore by pumping the sample through a pipe submerged in the stream. Paired samples indicated a bias to higher turbidity, fecal coliform, and phosphorus at the new site, and the bias increased at higher flows. This may partially explain the upticks shown in the LOWESS curves for those analytes at CBS since 2016.

A long-term downward trend was identified for TSI in Cannonsville Reservoir. The LOWESS curve revealed that most of the decrease occurred from 1993 to 2012, coinciding with lower TP concentrations. Cannonsville Reservoir has the advantage of shady areas in the reservoir and lower residence time compared to the other Delaware reservoirs, which can help offset TSI increases due to increased clarity. However, increased surface temperatures may be responsible for the short term-peak in TSI around 2018.

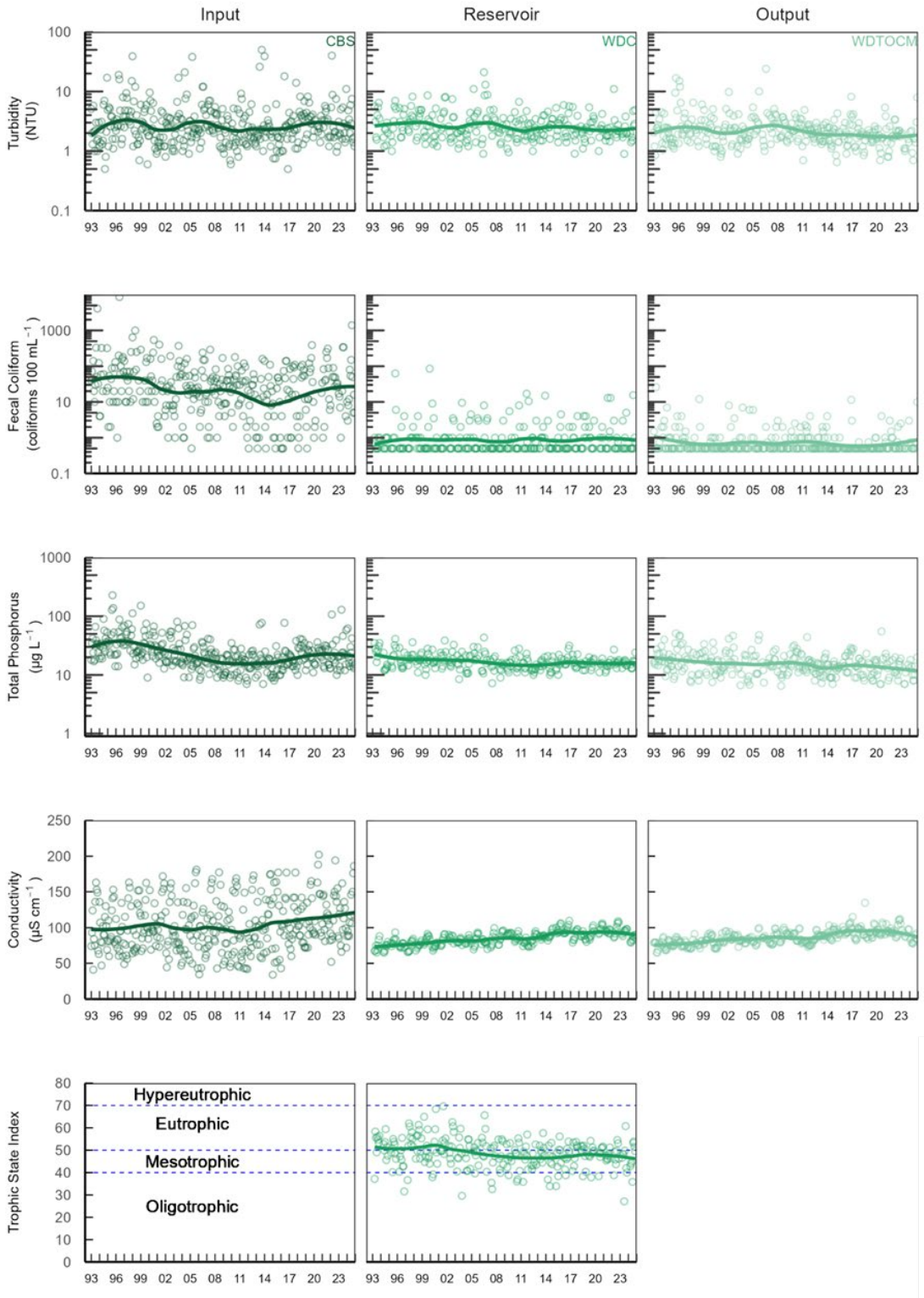


Figure 4.12 Water quality trend plots for the Cannonsville basin main inflow at the West Branch Delaware River (CBS), Cannonsville Reservoir (WDC), and the outflow at the West Delaware Tunnel Outlet (WDTOCM).

Table 4.3 Cannonsville Basin trends for selected variables from 1993 to 2024.

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
CBS	Input	Turbidity	377	NS	0	0.000	Trend unlikely
CBS	Input	Turbidity (Flow Adj.)	377	NS	0.002	0.0835	Increasing trend unlikely
CBS	Input	Fecal Coliform	338	***	-0.25	-1.0204	Decreasing trend virtually certain
CBS	Input	Fecal Coliform (Flow Adj.)	338	NS	0.235	0.9609	Increasing trend about as likely as not
CBS	Input	Total Phosphorus	375	***	-0.435	-2.0704	Decreasing trend virtually certain
CBS	Input	Total Phosphorus (Flow Adj.)	375	***	-0.352	-1.6782	Decreasing trend virtually certain
CBS	Input	Conductivity	377	***	0.593	0.6109	Increasing trend virtually certain
CBS	Input	Conductivity (Flow Adj.)	377	***	0.738	0.7608	Increasing trend virtually certain
Cannonsville	Reservoir	Turbidity	265	***	-0.018	-0.735	Decreasing trend virtually certain
Cannonsville	Reservoir	Fecal Coliform	263	NS	0	0	Trend exceptionally unlikely
Cannonsville	Reservoir	Total Phosphorus	249	***	-0.11	-0.689	Decreasing trend virtually certain

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
Cannonsville	Reservoir	Conductivity	261	***	0.7	0.824	Increasing trend virtually certain
Cannonsville	Reservoir	Trophic State Index	255	***	-0.149	-0.3047	Decreasing trend virtually certain
WDTOCM	Output	Turbidity	318	***	-0.025	-1.250	Decreasing trend virtually certain
WDTOCM	Output	Fecal Coliform	317	***	0	0	Decreasing trend very likely
WDTOCM	Output	Total Phosphorus	286	***	-0.143	-0.952	Decreasing trend virtually certain
WDTOCM	Output	Conductivity	318	***	0.643	0.748	Increasing trend virtually certain

*[1]The p-values for each trend test are symbolized as follows: NS (Not Significant) = p ≥ 0.20, * = p < 0.20, ** = p < 0.10, *** = p < 0.05.*

4.4.2 Biomonitoring in the Cannonsville Watershed

The DEP Stream Biomonitoring Program uses protocols developed by the New York State Department of Environmental Conservation to assess the health of stream macroinvertebrate communities in watershed streams. Stream impairment is assessed via a multimetric BAP score derived from stream macroinvertebrate assemblages. For full methodology details including headwater adjustment methods as established by NYSDEC in 2018, see Appendix C.

The most recent status of macroinvertebrate communities in the Cannonsville basin was evaluated by the analysis of 12 total samples collected from five streams in 2022 through 2024. During this period, three sites on the mainstem West Branch Delaware River (301, 304, 320) were sampled twice each, along with two additional sites on the river (302, 336) sampled once

each. Sites on Trout Creek (325), Loomis Brook (326), Third Brook (339), and Coulter Brook (349) were sampled once each.

West Branch Delaware River: The West Branch of the Delaware River is the primary inflow to Cannonsville Reservoir, draining 77% of the basin. Site 320 (WDBN) in Beerston lies approximately 1.5 miles upstream of Cannonsville Reservoir. Sites 304 (WSPB) and 301 (WDHOA) are situated about five and 42 miles, respectively, upstream of the reservoir. Site 320 was assessed as non-impaired in 2022 and 2023, and sites 301 and 304 were each assessed as slightly impaired in 2022 and 2023. Both 301 and 304 are located a short distance downstream of SPDES outflows. Two additional sites on the West Branch Delaware River were assessed in 2024: site 302 (DTPA) in Delhi was non-impaired, while site 336 (WDSTA) was moderately impaired (Figure 4.13). Site 336 is in the headwaters of the West Branch Delaware River and is located at the northeastern edge of the Cannonsville basin. Its headwater-adjusted BAP score of 3.61 in 2022 was driven by low species richness and EPT taxa, as well as inconsistencies with both Percent Model Affinity and Percent Model Affinity – Functional Feeding Group metrics. The site is located downstream of an impoundment, and lower than usual flows may have influenced sampling efficacy. DEP will sample different areas of the headwaters in future sampling events.

West Branch Delaware River Tributaries and Cannonsville Streams: Two tributaries to the West Branch Delaware River were sampled in 2022. Both sites 339 (CTB) on Third Brook in Walton and 349 (CCBHG), the headwaters of Coulter Brook in Bovina, were assessed as non-impaired. Sites 325 (C-7) on Trout Creek and 326 (C-8) on Loomis Brook in Walton are located approximately 1.0 miles and 0.5 miles, respectively, from the northern section of the Cannonsville Reservoir. Both were assessed as non-impaired in 2022 (Figure 4.13).

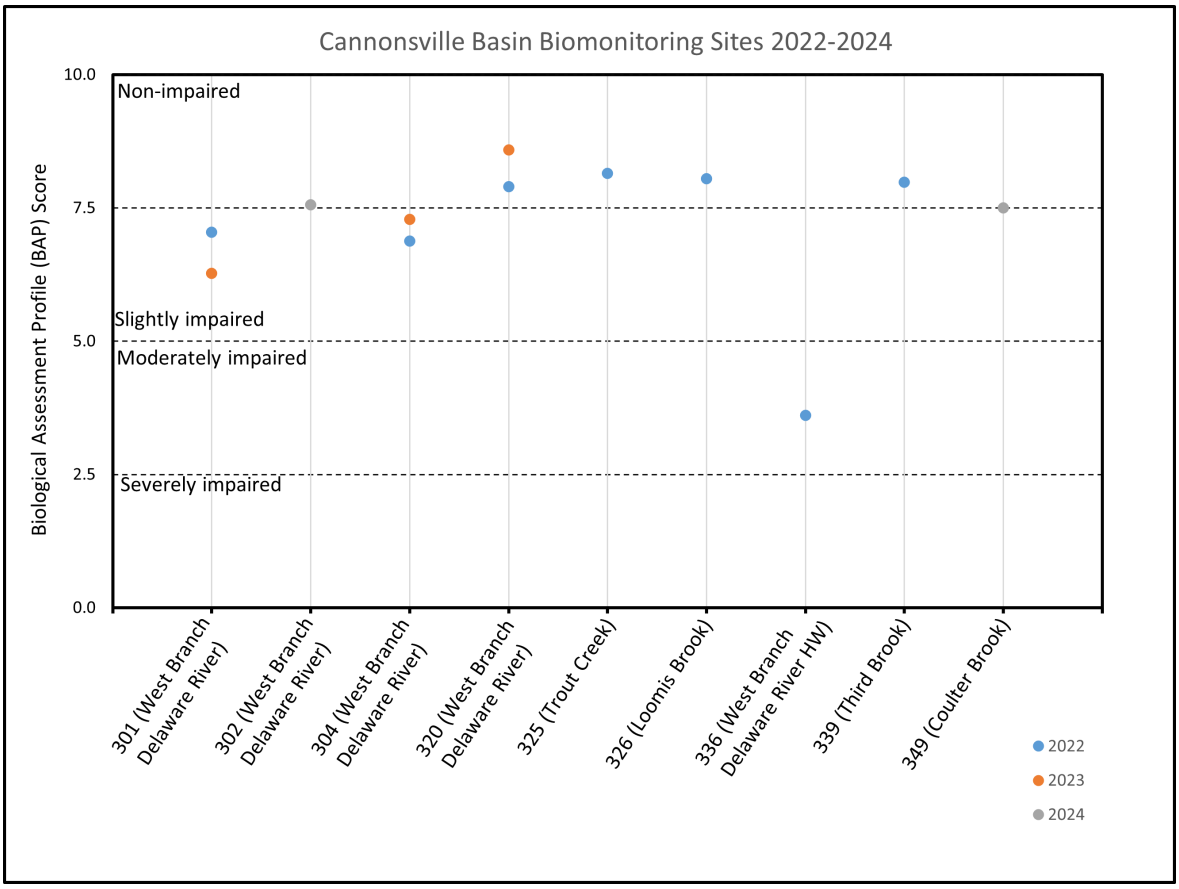


Figure 4.13 Biological Assessment Profile scores for West Branch Delaware River, 2022-2024.

Cannonsville Watershed Biomonitoring Trends: Streams in the Cannonsville watershed were analyzed for time-series trends in BAP scores based on a site's entire period of record. Long-term trend analysis was focused on main input streams with more than three years of biological assemblage data: 301, 302, 304, and 320. Both 301 (WDHOA) and 304 (WSPB) have exhibited slight downward trends over the period of record, but mean BAP scores (6.74 and 7.27, respectively) since 2014 are in the slightly impaired range (Figure 4.14). However, both sites contained sensitive Ephemeroptera taxa in recent sampling years, suggesting that habitat rather than water quality may be a limiting factor reflected by Species Richness and EPT metrics.

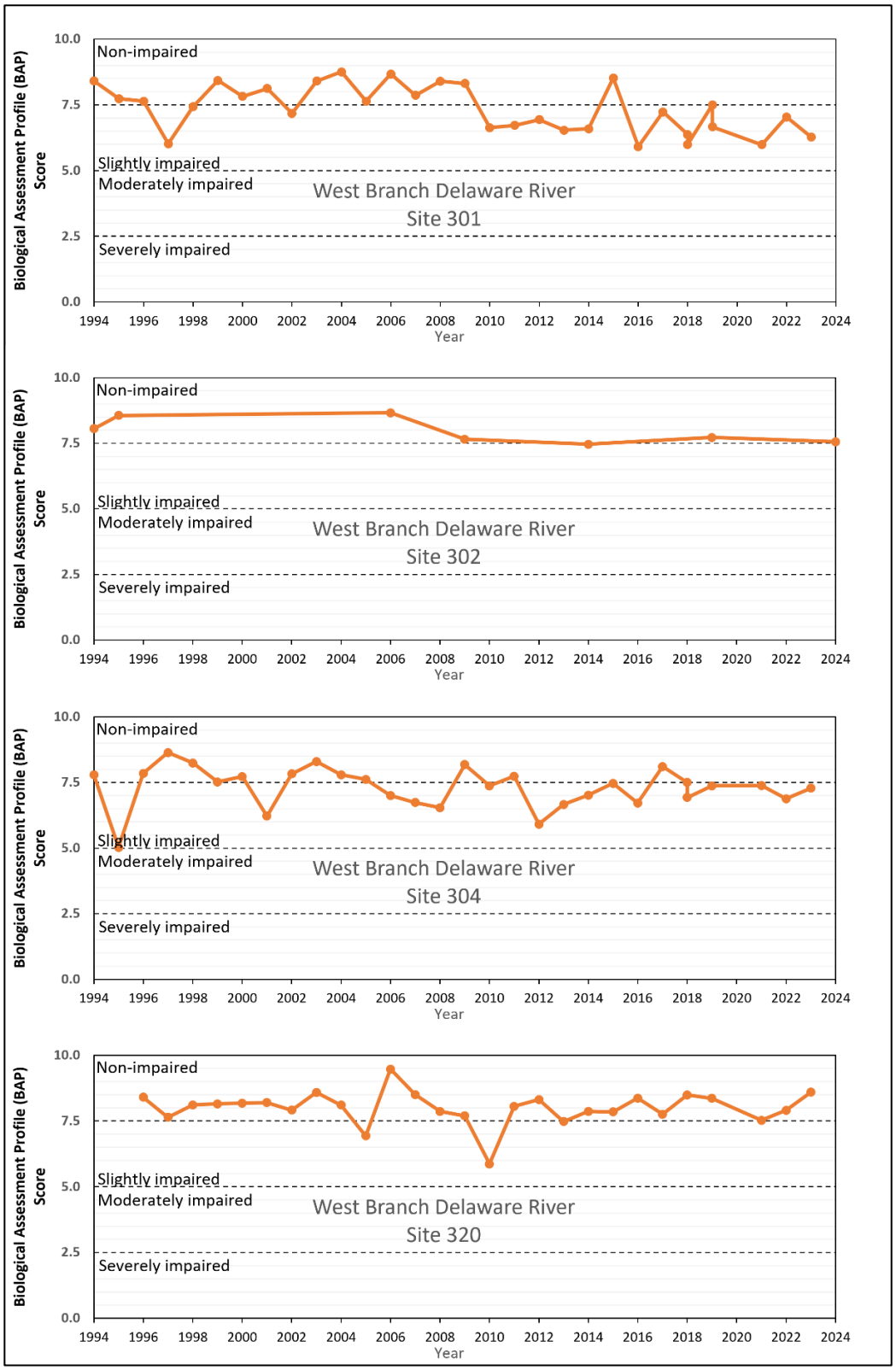


Figure 4.14 Biological Assessment Profile scores for West Branch Delaware River, 1994-2024.

4.5 The Rondout Basin

The Rondout Reservoir is located on the southern edge of the Catskill Park, approximately 65 miles northwest of New York City. Placed into service in 1950, it was formed by damming Rondout Creek, which continues southeastward and drains into the Hudson River at Kingston. The reservoir consists of one basin, almost 6.5 miles long, which holds 52.4 billion gallons at total capacity.

The Rondout Reservoir is one of four reservoirs in the Delaware System and it serves as the central collecting reservoir for water from Pepacton, Cannonsville, and Neversink reservoirs. Rondout plays a critical role in the City's overall water supply system due to the large volume of water it contributes to daily consumption. Water from Rondout Reservoir is diverted southeast into the 85-mile-long Delaware Aqueduct, which runs below the Hudson River to West Branch Reservoir and then to Kensico Reservoir.

Rondout Reservoir's watershed area is 95 square miles and includes parts of seven towns. Four main tributaries flow directly into Rondout Reservoir, with Rondout Creek supplying 40% of flow while Chestnut Creek provides 22%. Sugarloaf and Sawkill brooks deliver another 8.4% and6.6% of flow, respectively. The Rondout Reservoir's watershed land use breakdown is as follows: 86.1% is forested, 5.2% is urban, 1.9% is brushland, 3.6% is water, and 3.3% is in agricultural use. Protection programs in place in the watershed are described in the Watershed Protection Program sections.

4.5.1 Water Quality Status and Trends in the Rondout Watershed

Status (Rondout)

The Rondout basin status evaluation is presented as a series of boxplots in Figure 4.15, which compare the inflows, reservoir, and the outflow. Inflows include water diverted from Neversink Reservoir (NRR2CM), Pepacton Reservoir (PRR2CM), Cannonsville Reservoir (WDTOCM), and Rondout Creek (RDOA). The reservoir is designated as RR and the outflow is designated as RDRRCM. A site map, description of the sampling program, and details on data preparation and boxplot interpretation are provided in Appendix C.

For the evaluation period (2022-2024), analyte levels at the reservoir and outflow continued to reflect the average of the inflows. Fecal coliform bacteria remained well below the NYSDEC Stream Guidance Value of 200 fecal coliforms 100 mL^{-1} for aqueduct inflow sites (NRR2CM, PRR2CM, and WDTOCM). The principal river inflow to Rondout Reservoir, Rondout Creek (RDOA), had a wider range of fecal coliforms, with two high outliers (100 fecal coliforms 100 mL^{-1} in July 2023 and 60 fecal coliforms 100 mL^{-1} in August 2023), but all values fell below the NYSDEC guidance value. Reservoir (RR) and outflow (RDRRCM) fecal coliform levels were low, with only a few outlier values above the detection limit. Turbidity was generally low at all sites, with a median monthly turbidity of 0.64 NTU at the outflow (RDRRCM). Median monthly TP for the reservoir was 8.5 µg L^{-1}, well below the target value of 15 µg L^{-1}.

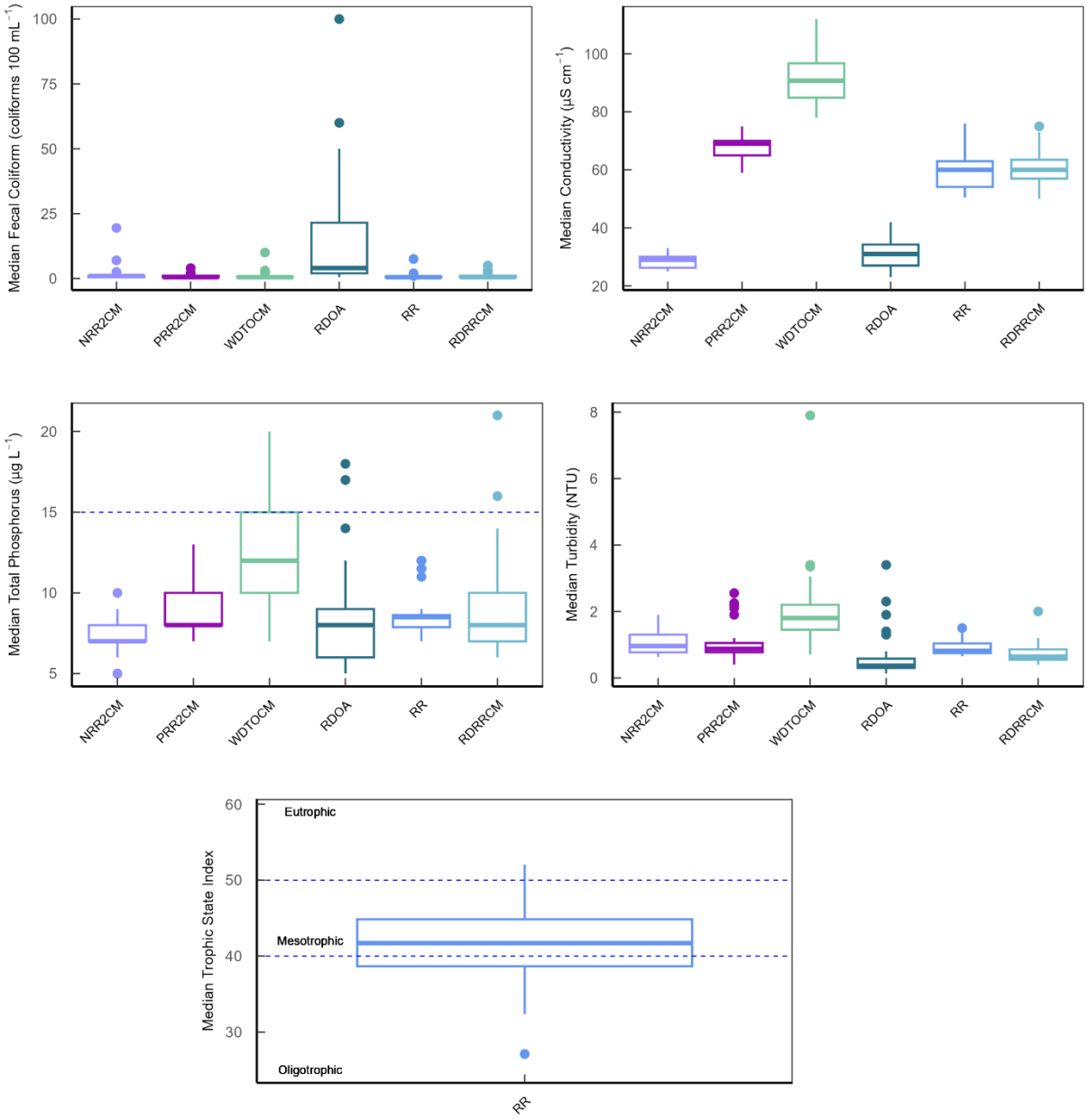


Figure 4.15 Water quality status boxplots using 2022-2024 monthly data for the Rondout basin inflows from Cannonsville (WDTOCM), Pepacton (PRR2CM), and Neversink (NRR2CM) reservoirs and from the main stream inflow at Rondout Creek (RDOA); Rondout Reservoir (RR); and the outflow at the Rondout gatehouse (RDRRCM).

The TSI values for Rondout Reservoir fell primarily within the mesotrophic range, with a median of 42. Conductivity medians were highest at the inflow from Cannonsville (WDTOCM) and lower in the reservoir (RR) and outflow (RDRRCM), with medians of 60 µS cm^{-1} at both sites.

Trends (Rondout)

Water quality trend plots for the Rondout basin are presented in Figure 4.16 and results of the SKT and TDA analysis are provided in Table 4.4.

Trend interpretation is difficult for Rondout Reservoir since it receives water from four major sources (diversions from Neversink, Cannonsville, and Pepacton reservoirs as well as from Rondout Creek (RDOA)), and since diversions are chosen to maximize the water quality sent to Rondout Reservoir. Further operational details are provided in Section 4.1.2.

Downward long-term turbidity trends were observed for all the reservoir inflows except for Rondout Creek, which showed strong evidence of an upward trend. However, the LOWESS curve for turbidity at Rondout Creek has been decreasing since about 2019. Since this inflow only accounts for about 11% of the total flow to the reservoir, diversions from the upstream reservoirs offset the input from Rondout Creek resulting in strong evidence for a decreasing trend in both the reservoir and outflow.

Moderate to strong decreasing fecal coliform trends were detected at the inflow at WDTOCM, Rondout Reservoir, and the outflow at the Rondout Gatehouse (RDRRCM), but all with Sen slopes of zero due to the many point-to-point ties from the non-detect values. The inflow at Rondout Creek (RDOA) showed signs of an increasing trend since 2017 according to the LOWESS curve. While this inflow had higher fecal coliform levels than the other inputs, its low flow contribution to the reservoir minimized impacts to the reservoir, which showed a decrease in the LOWESS within the last five years. Similar to other Delaware basins, the low reservoir and outflow fecal coliform concentrations relative to the inflow at RDOA illustrate the reservoir's capacity to attenuate pathogens through processes such as die-off and sedimentation.

Despite a likely upward TP trend of 0.16% year at Rondout Reservoir, no total phosphorus trend was detected at the outflow. Upward trends were detected at NRR2CM and RDOA, while WDTOCM showed a decreasing trend, possibly due to WWTP upgrades and agricultural BMPs.

Upward conductivity trends were identified in the reservoir and outflow, coinciding with increases in all inflows except RDOA and NRR2CM. However, the LOWESS curves for the reservoir, outflow, and WDTOCM show a decreasing trend since approximately 2017. Shorter-term conductivity trends appear to be controlled by precipitation patterns. In wet years (e.g., 2003-2011) dilution causes conductivity to decrease. During drier periods (e.g., 1998-2001 and 2012-2016), base flow becomes a larger portion of the inflow causing conductivity to increase.

Increasing chloride concentrations from road salt is likely the primary driver of the long-term trend.

A long-term downward TSI trend was identified for Rondout Reservoir at a modest rate of -0.18% per year, and the period of record ending in 2024 hovered on the border of mesotrophic and oligotrophic. Decreasing TSI trends were also detected in the upstream reservoirs, except for Neversink.

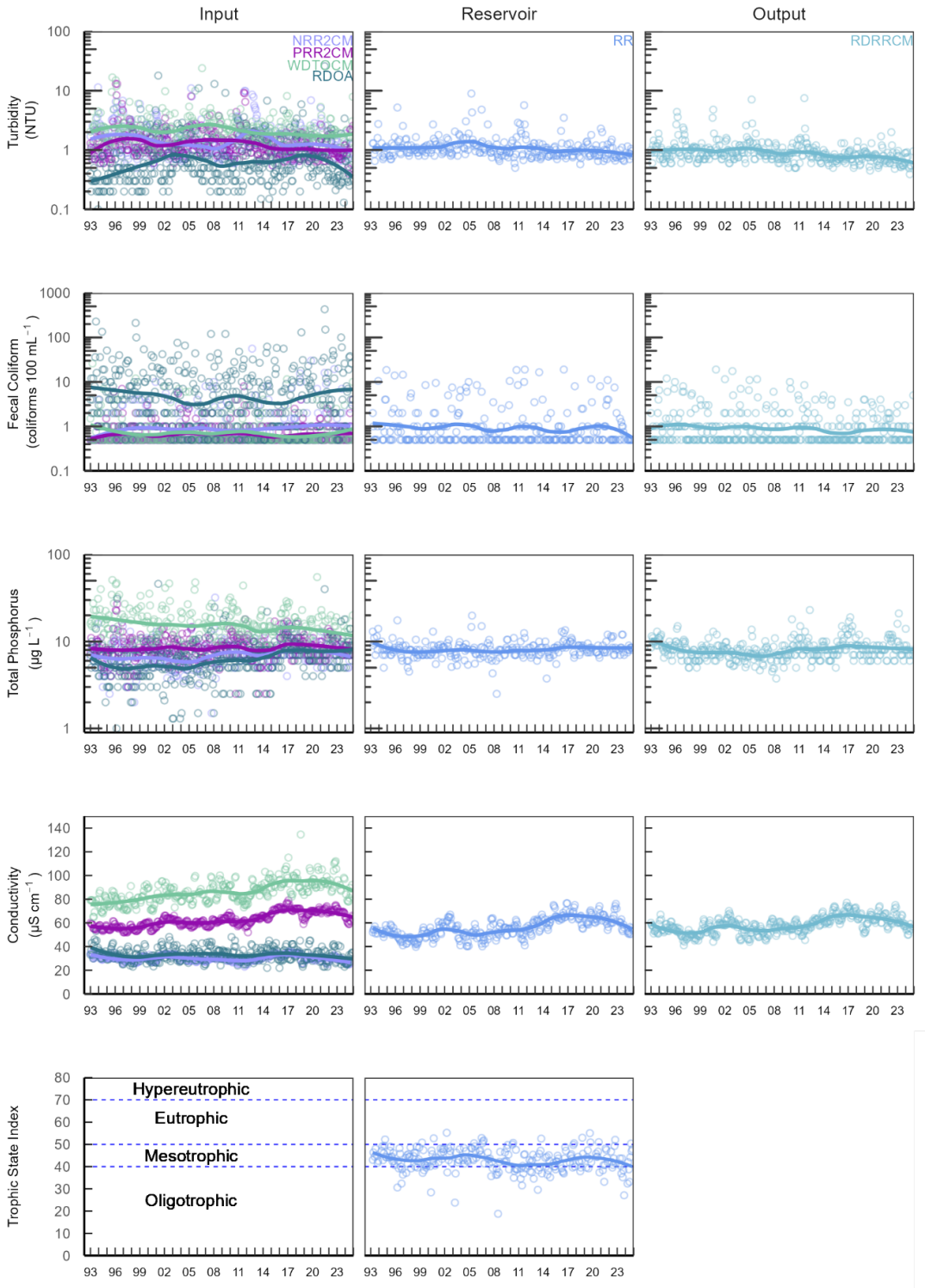


Figure 4.16 Water quality trend plots for the Rondout basin inflows from Cannonsville (WDTOCM), Pepacton (PRR2CM), and Neversink (NRR2CM) reservoirs and the main stream inflow, Rondout Creek (RDOA); Rondout Reservoir (RR); and the outflow at the Rondout gatehouse (RDRRCM).

Table 4.4 Rondout Basin trends for selected analytes from 1993 to 2024.

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
NRR2CM	Input	Turbidity	352	***	-0.006	-0.490	Decreasing trend very likely
NRR2CM	Input	Fecal Coliform	346	***	0	0	Trend exceptionally unlikely
NRR2CM	Input	Total Phosphorus	320	***	0.045	0.6494	Increasing trend virtually certain
NRR2CM	Input	Conductivity	351	NS	0	0	Decreasing trend about as likely as not
PRR2CM	Input	Turbidity	252	***	-0.021	-1.875	Decreasing trend virtually certain
PRR2CM	Input	Fecal Coliform	248	NS	0	0	Decreasing trend possible
PRR2CM	Input	Total Phosphorus	235	NS	0	0	Trend exceptionally unlikely
PRR2CM	Input	Conductivity	252	***	0.667	1.0417	Increasing trend virtually certain
WDTOCM	Input	Turbidity	318	***	-0.025	-1.250	Decreasing trend virtually certain
WDTOCM	Input	Fecal Coliform	317	***	0	0	Decreasing trend very likely

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
WDTOCM	Input	Total Phosphorus	286	***	-0.143	-0.952	Decreasing trend virtually certain
WDTOCM	Input	Conductivity	318	***	0.643	0.748	Increasing trend virtually certain
RDOA	Input	Turbidity	381	***	0.002	0.4762	Increasing trend very likely
RDOA	Input	Turbidity (Flow Adj.)	381	*	0.002	0.469	Increasing trend possible
RDOA	Input	Fecal Coliform	375	NS	0	0	Decreasing trend about as likely as not
RDOA	Input	Fecal Coliform (Flow Adj.)	375	NS	0.007	0.142	Increasing trend unlikely
RDOA	Input	Total Phosphorus	372	***	0.095	1.587	Increasing trend virtually certain
RDOA	Input	Total Phosphorus (Flow Adj.)	372	***	0.102	1.701	Increasing trend virtually certain
RDOA	Input	Conductivity	376	***	-0.055	-0.170	Decreasing trend very likely
RDOA	Input	Conductivity (Flow Adj.)	376	***	-0.056	-0.174	Decreasing trend very likely
Rondout	Reservoir	Turbidity	290	***	-0.008	-0.769	Decreasing trend virtually certain

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
Rondout	Reservoir	Fecal Coliform	287	***	0	0.000	Decreasing trend very likely
Rondout	Reservoir	Total Phosphorus	257	**	0.012	0.156	Increasing trend likely
Rondout	Reservoir	Conductivity	286	***	0.522	0.940	Increasing trend virtually certain
Rondout	Reservoir	Trophic State Index	254	***	-0.079	-0.184	Decreasing trend very likely
RDRRCM	Output	Turbidity	382	***	-0.009	-1.038	Decreasing trend virtually certain
RDRRCM	Output	Fecal Coliform	382	***	0	0.000	Decreasing trend virtually certain
RDRRCM	Output	Total Phosphorus	376	NS	0	0.000	Trend exceptionally unlikely
RDRRCM	Output	Conductivity	382	***	0.406	0.699	Increasing trend virtually certain

[1]*The p-values for each trend test are symbolized as follows:*
*NS (Not Significant) = p ≥ 0.20, * = p < 0.20, ** = p < 0.10, *** = p < 0.05.*

4.5.2 Biomonitoring in the Rondout Watershed

The DEP Stream Biomonitoring Program uses protocols developed by the NYSDEC to assess the health of stream macroinvertebrate communities in watershed streams. Stream impairment is assessed via a multimetric BAP score derived from stream macroinvertebrate assemblages. For full methodology details including headwater adjustment methods as established by NYSDEC in 2018, see Appendix C.

The most recent status of macroinvertebrate communities in the Neversink basin was evaluated by the analysis of four total samples collected from four streams during 2022 through 2024. During this period, one site on each of Chestnut Creek (315), Red Brook (328), Sawkill Creek (335), and Sugarloaf Brook (347) were sampled.

Rondout Basin: Sites 315 (RGB), and 347 (RD2) were assessed as non-impaired in 2023. Sites 328 (RK) and 335 (RD4) were assessed as non-impaired in 2024 (Figure 4.17). All sites sampled during this period have traditionally been rotating sites and lack sufficient data for long-term trend analysis.

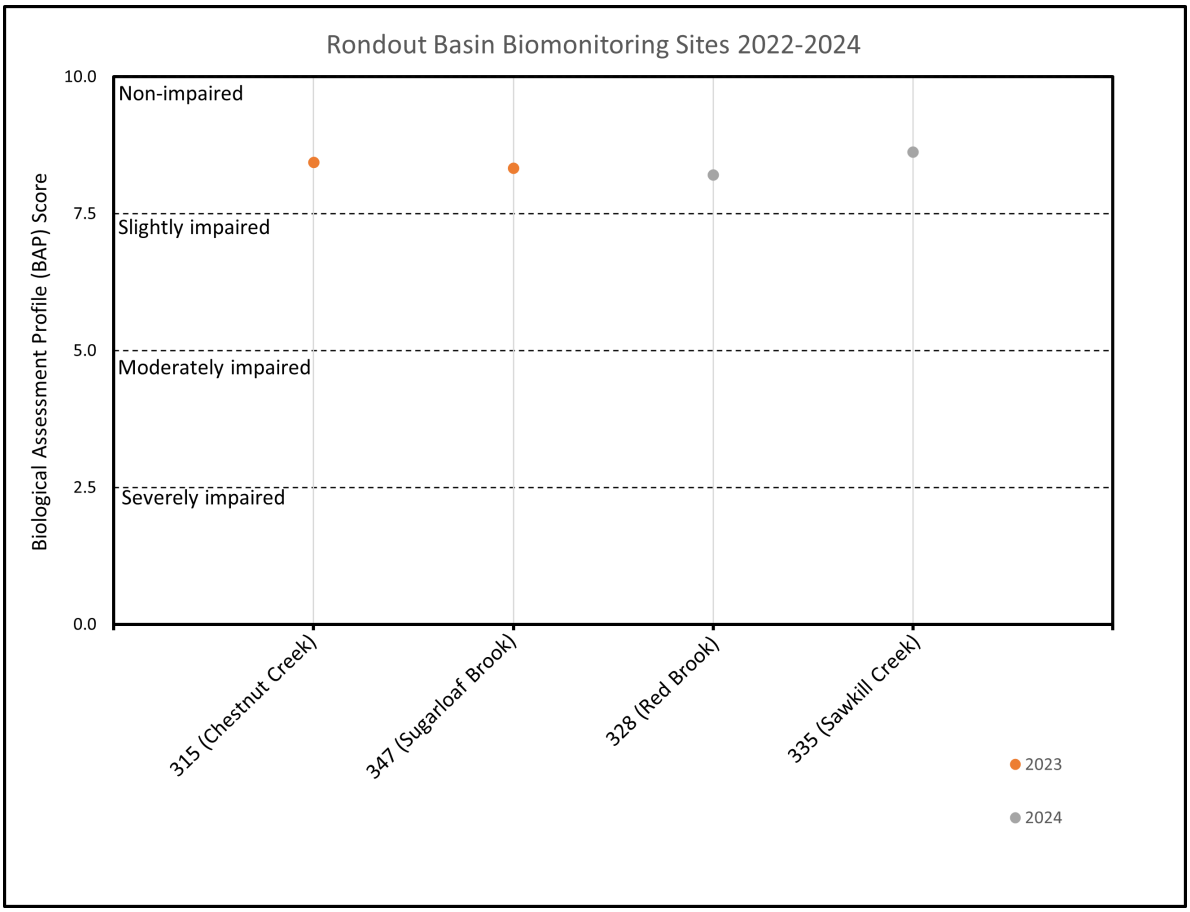


Figure 4.17 Biological Assessment Profile scores for Rondout basin, 2023-2024.

4.6 Trophic Response of Delaware Reservoirs

A series of four plots were used to examine the trophic response of Delaware System reservoirs. Annual geometric means of chlorophyll vs TP are plotted in Figure 4.18. Most points lie at or above the standard OECD line, including for the last five years. Several factors may contribute to this effect. The data points represent the growing season, rather than the entire year, and may tend to be higher than the regression for that reason. More sensitive laboratory measurement methods may have been used for chlorophyll than for the data used to calculate the

regression. Field collection methods may have also differed. Nonetheless, all four reservoirs are well aligned and show a decrease in biomass in line with a decrease in phosphorus levels. In decreasing order, Cannonsville, Pepacton, and Neversink each cluster around a characteristic biomass level set by their nutrient contents. As a blend of the other three reservoirs, Rondout is in an intermediate position. This indicates that phosphorus is controlling the level of algal standing crop and eutrophication continues to be controlled through phosphorus concentrations at their reduced levels.

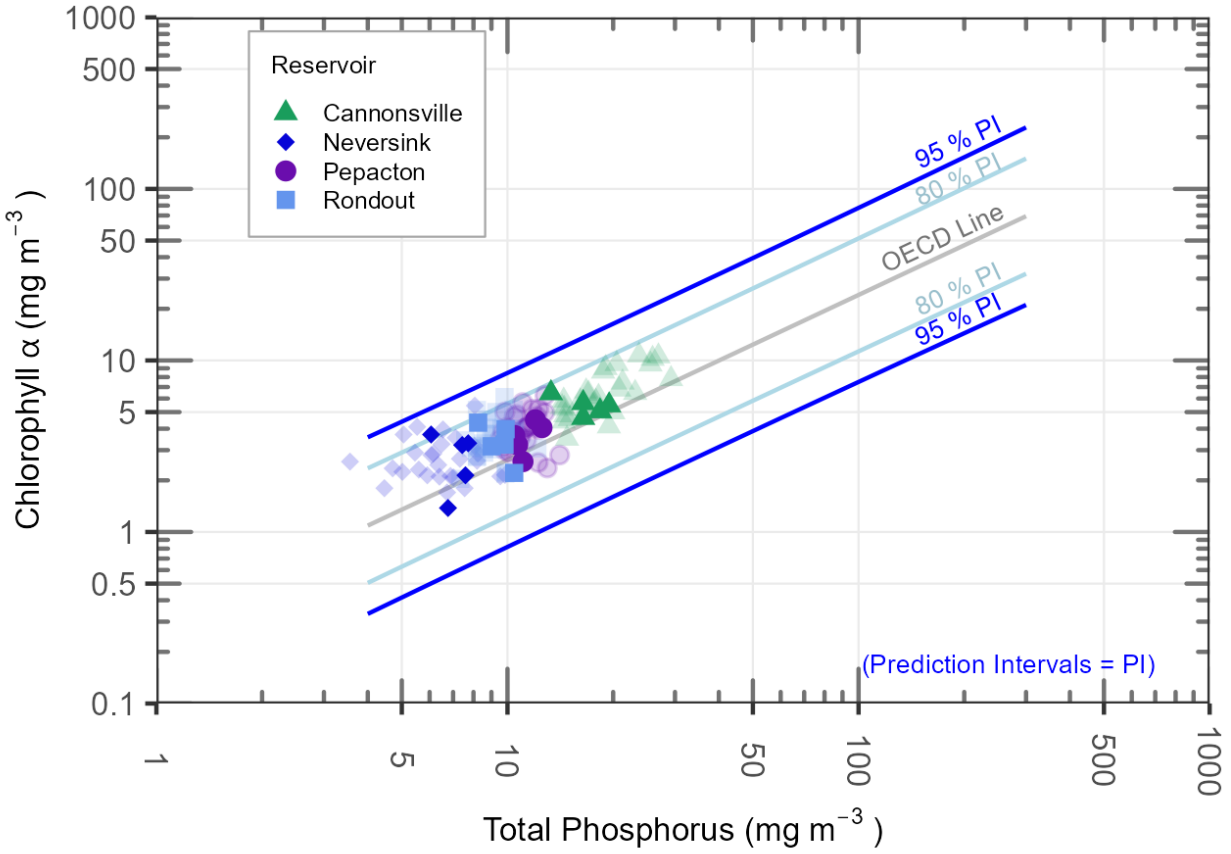


Figure 4.18 Chlorophyll vs total phosphorus for Delaware System reservoirs.

Maximum chlorophyll is plotted vs TP in Figure 4.19. Again, the chlorophyll concentrations are consistently above the standard regression line, so the same methodological differences may play a role as in the previous plot. The variation is greater in the maximum than for annual mean chlorophyll, with some values exceeding the upper 95% PI, particularly for Cannonsville and Pepacton reservoirs. The maximum values may not always be captured due to low frequency of sampling, and maxima may not always be attained if other factors depress the standing crop. The last five years of data show good alignment with the OECD line for Rondout and Neversink reservoirs. The least variation occurs in Rondout. This may be related to the short, nearly constant water residence time of about 1.5 months. The constant flow through this

reservoir may tend to flush nutrients and phytoplankton downstream before there is sufficient time for maximum growth. As expected, reservoirs retain their same relative positions as in the plot of annual mean chlorophyll values.

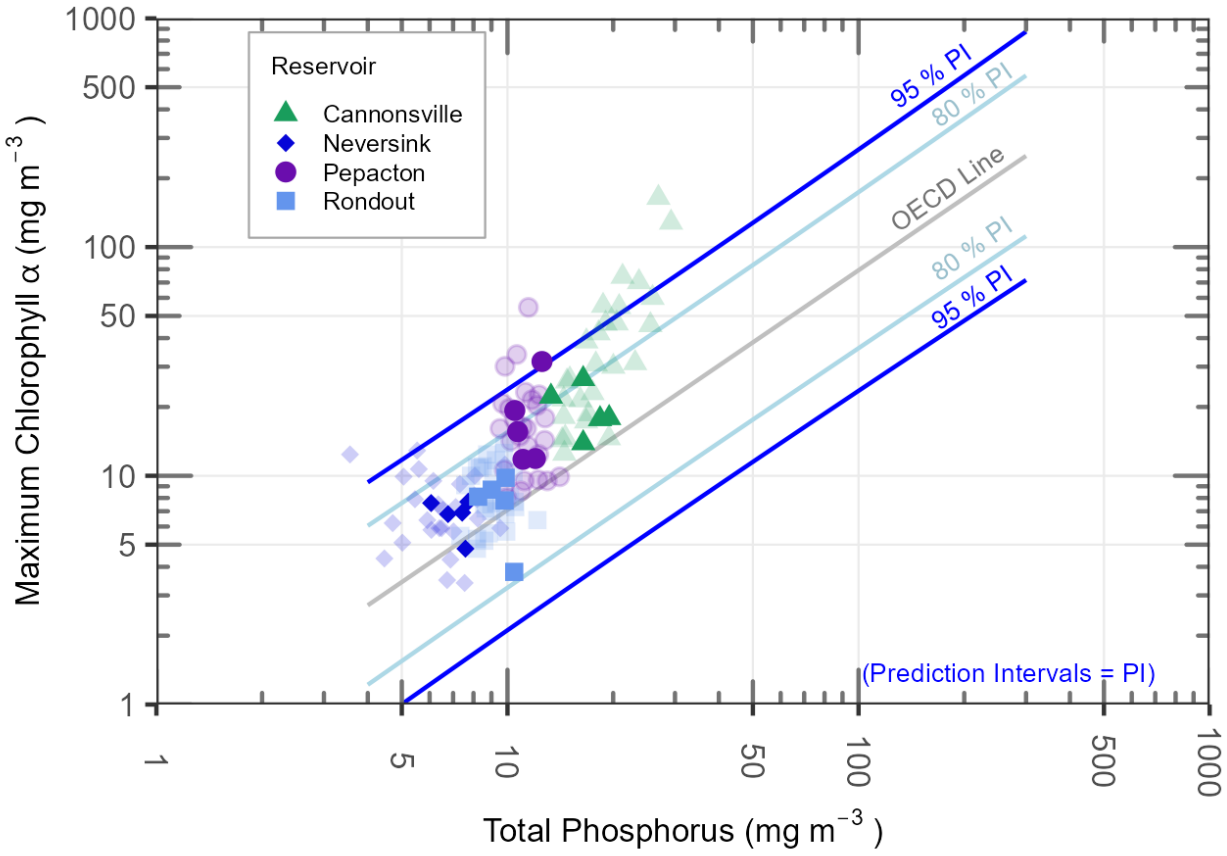


Figure 4.19 Maximum chlorophyll vs TP in Delaware System reservoirs.

Secchi depth vs TP is plotted in Figure 4.20. Secchi depths are consistently lower than expected at the reported concentrations of phosphorus, especially for Cannonsville Reservoir, but well aligned with the standard line, and with relatively low variation. In the most recent five years, Pepacton and Rondout are most tightly clustered and closest to agreement with the OECD line. Since all the relationships tend to lie below the OECD line, it can be concluded that factors in addition to chlorophyll (algal biomass) may limit light penetration in a consistent manner.

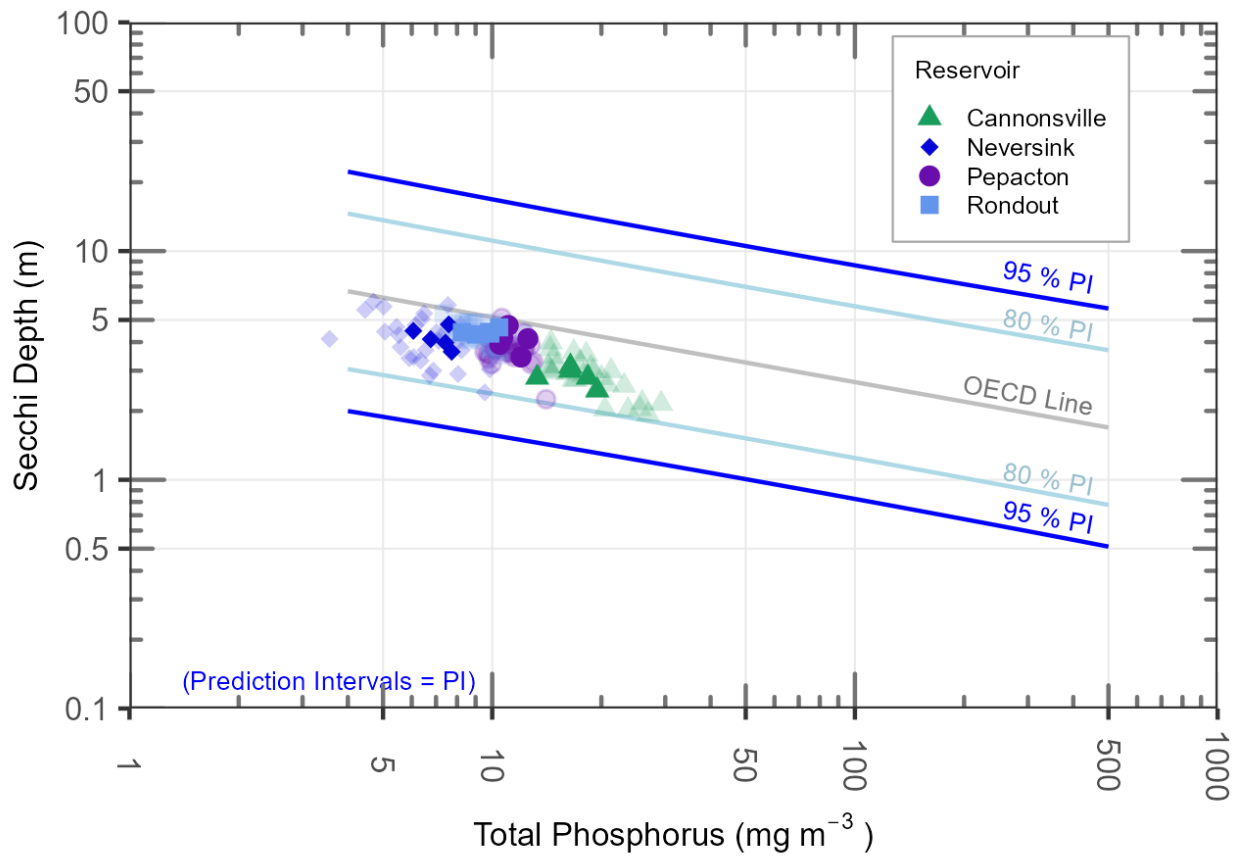


Figure 4.20 Secchi depth vs TP for Delaware System reservoirs.

Secchi depth vs chlorophyll is plotted in Figure 4.21. The observed Secchi depths are less than expected at the reported concentrations of chlorophyll. As was concluded above, the limitation of transparency is evidently influenced by factors in addition to algal biomass in all the Delaware System reservoirs.

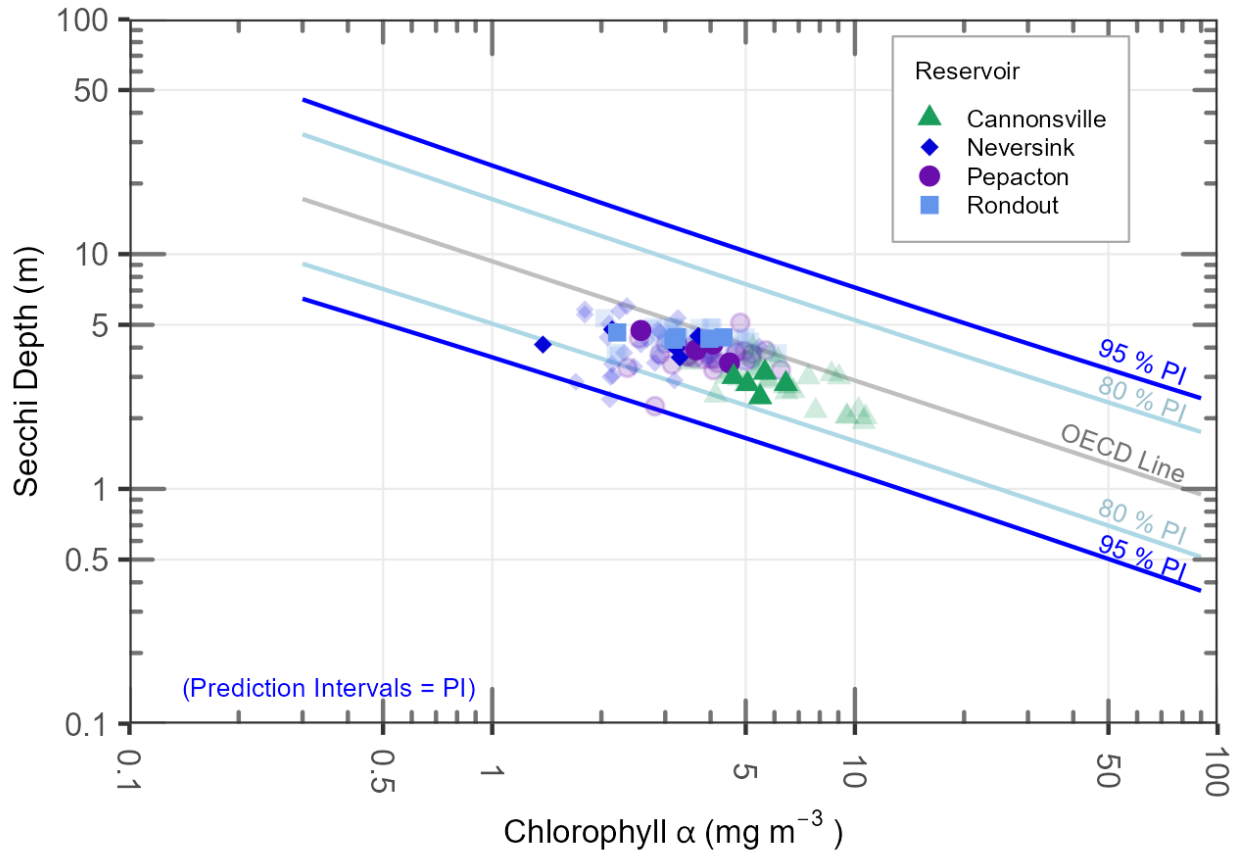


Figure 4.21 Secchi depth vs chlorophyll in Delaware System reservoirs.

Examining time series over the past 31 years (also see Appendix C) for geometric mean phosphorus (Figure 4.22), mean chlorophyll, maximum chlorophyll (Figure 4.23), and Secchi depth (Appendix C, Figure 11), it is obvious that there have been vast improvements in Cannonsville Reservoir where the greatest phosphorus load reduction has been achieved. More subtle changes have taken place in the other reservoirs. (The full set of these plots is provided in Appendix C.)

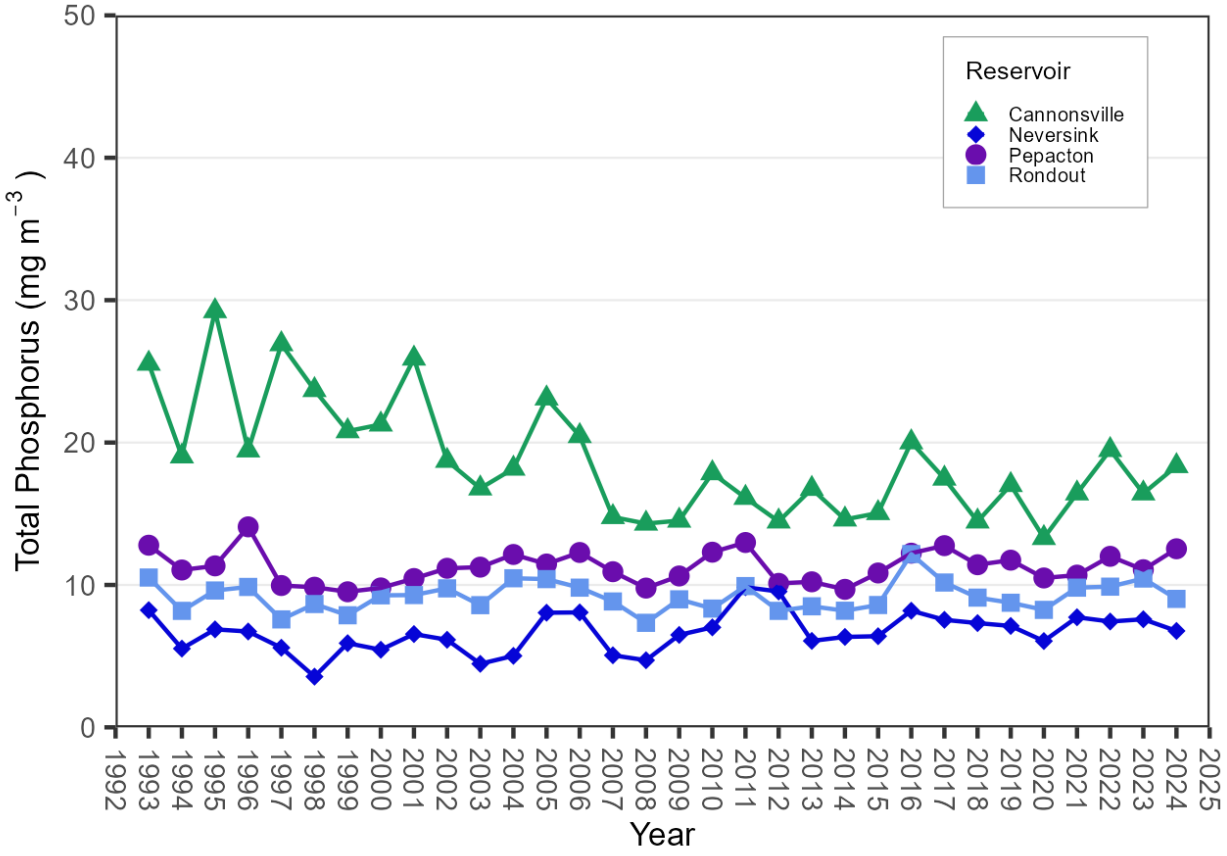


Figure 4.22 Annual geometric means for total phosphorous at Delaware reservoirs (1993 – 2024).

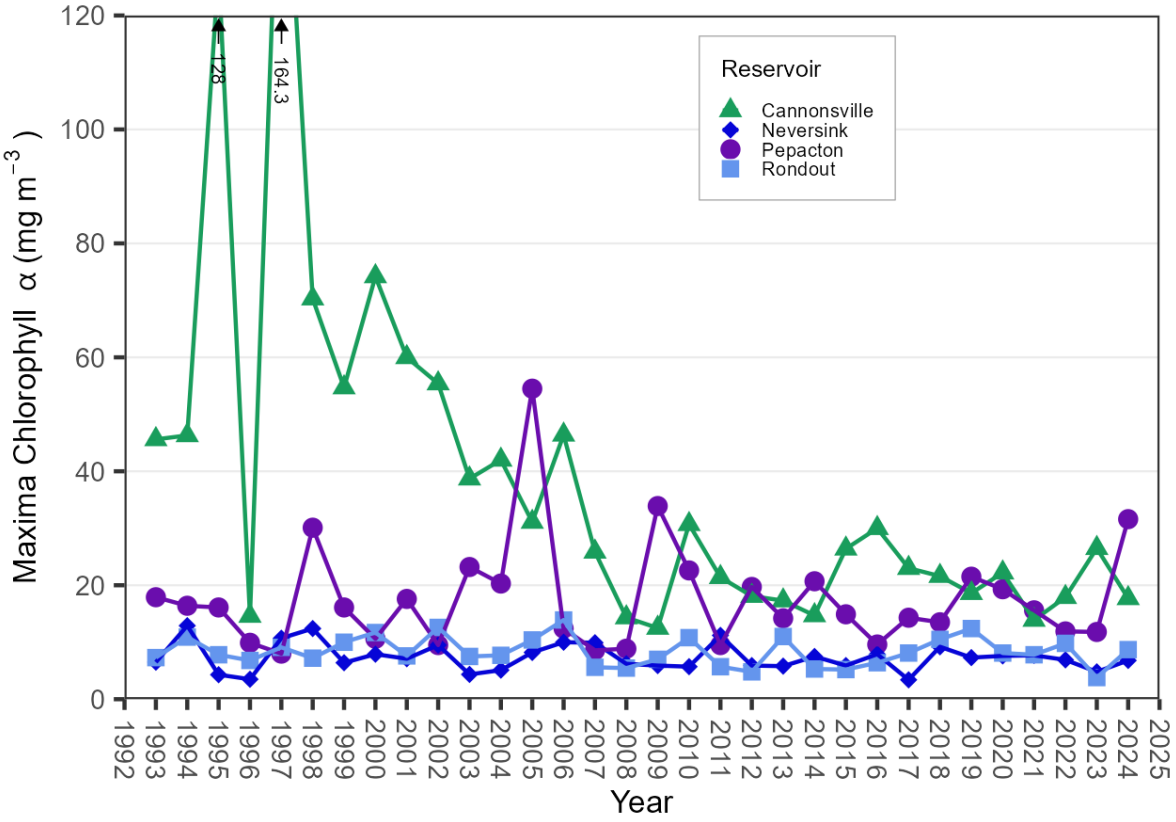


Figure 4.23 Annual maxima for Chlorophyll a at Delaware reservoirs (1993 – 2024).

4.7 Water Quality Summary for the Delaware System

Overall, the water quality status of all four Delaware System basins for the 2022-2024 assessment period continues to be very good, which is a reflection in part of the ongoing investment in watershed protection. Monthly median fecal coliform counts were generally low for all reservoirs and their outflows, with median values for the three-year period all non-detect except for at the Neversink outflow (1 fecal coliform 100 mL^{-1}). Monthly median turbidity was low throughout the system, with a median of 0.6 NTU and corresponding median phosphorus value of 8 µg L^{-1} for the outflow from Rondout Reservoir (RDRRCM), the terminal reservoir in the Delaware System.

Long-term trend analysis for the Delaware System continues to show a decline in TP and TSI for all basins with the exception of Neversink, which had an unclear trend. These long-term decreases are largely due to the cumulative effects of various watershed protection programs. The TP decreases in the Cannonsville basin despite the large and shifting agricultural presence are of particular note. Long-term conductivity increases were ubiquitous throughout the system and likely the result of road deicer usage. The LOWESS curves show a decrease of conductivity at Rondout Reservoir and its outflow at RDRRCM since approximately 2017, which may be due

to fewer storms requiring deicers during that time period. Fecal coliforms within Delaware System reservoirs continue to show a strong attenuation, typically an order of magnitude or lower than the stream inflows.

From 2022 to 2024, DEP conducted benthic macroinvertebrate biomonitoring on two sites on the primary river inflow to the Pepacton Reservoir (East Branch Delaware River), five sites on the primary river inflow to the Cannonsville Reservoir (West Branch Delaware River), and three sites on the inflows to Neversink Reservoir (West and East Branch Neversink Rivers, and Neversink River). The mean BAP scores across all sites sampled for each region indicated non-impaired status for the Pepacton (8.22), Neversink (8.06), and Rondout (8.40) basins, with the Cannonsville basin scoring on the higher end of slightly impaired (7.23).

The four reservoirs of the Delaware system are well aligned with the OECD standards, showing a decrease in biomass in line with a decrease in phosphorus levels. In decreasing order, Cannonsville, Pepacton, and Neversink each cluster around a characteristic biomass level set by their nutrient contents. As a blend of the other three reservoirs, Rondout is in an intermediate position. This indicates that phosphorus is controlling the level of algal standing crop and eutrophication continues to be controlled through reduced phosphorus concentrations. Variation is greater in the maximum chlorophyll than annual mean chlorophyll. The maximum values may not always be captured due to low frequency of sampling, and maxima may not always be attained if other factors depress the standing crop. Since all the Secchi depth relationships tend to lie below the OECD line, it can be concluded that factors in addition to chlorophyll limit light penetration in all the Delaware System reservoirs. Time series of the changes in central tendencies over the past 25 years show that there have been vast improvements in reducing the trophic condition of Cannonsville Reservoir where greatest phosphorus load reduction has been achieved, in agreement with the long-term trending using LOWESS curves and TDA.

5. East of Hudson Catskill/Delaware Basins

5.1 Introduction

5.1.1 East of Hudson Catskill/Delaware System Overview

The East of Hudson Catskill/Delaware System includes West Branch, Boyd Corners, and Kensico reservoirs, located in Putnam and Westchester counties. West Branch Reservoir typically receives most of its water from the Delaware System via the RWBT. Inflows from the Boyd Corners release and other non-Delaware (Croton streams) sources also contribute to West Branch Reservoir. Kensico Reservoir, the final reservoir in the Cat/Del System, receives both Catskill and Delaware System water inflows via the Catskill and Delaware aqueducts at CATALUM and DEL17, respectively. These contributions make up the majority of the water in Kensico Reservoir, with the remainder coming from streams within the watershed.

5.1.2 East of Hudson Catskill/Delaware System Operations

West Branch Reservoir can be operated in several ways, including reservoir mode, float mode, and bypass mode. In reservoir mode, the water from the Delaware Aqueduct is diverted directly into the reservoir and eventually flows out of the reservoir and back into the aqueduct at DEL10. In this scenario, residence time is shortened and Rondout water would make up most of the inflows into West Branch. In float mode, DEL9 at the upstream end of the reservoir remains closed while DEL10 remains open, allowing water from West Branch to enter the Delaware Aqueduct at DEL10 at a very low rate. Usually, more time spent in float mode means a longer reservoir residence time, resulting in a higher proportion of water coming in from local streams. In bypass mode, West Branch Reservoir is bypassed altogether and receives no water from the Delaware Aqueduct, and the local streams become the exclusive source of water to the reservoir. Local stream inflows at West Branch Reservoir can be quite influential depending on the current reservoir operational mode.

During the first five years of the data record West Branch was essentially operated as an extension of the Delaware Aqueduct, thus minimizing the influence of inflows from local sources. During most of the last 32 years, West Branch has been operated in such a way that can often increase the relative contributions of the local, Croton stream inflows like the Boyd Corners release and Horse Pound Creek. The effect on water quality can be best illustrated by the long-term trends in reservoir conductivity. For the most recent reporting period (2020-2024), West Branch has been operated intermittently in reservoir and float modes, and seldom in by-pass mode. Float mode was typically used in anticipation of wet and windy weather events to prevent turbidity spikes, or to support maintenance activities.

DEP closely monitors weather forecasts at Kensico Reservoir to allow for operational changes prior to wind and wave action that could increase turbidity near the Delaware Shaft 18 intake (DEL18). If sustained easterly or northeasterly winds are predicted, especially if they are

predicted over 15 mph, the operating mode at Delaware Aqueduct Shaft 18 may be changed from a reservoir-only withdrawal to a float or bypass mode withdrawal to prevent resuspended shoreline sediments from entering the intake. During float mode, water from Rondout and/or West Branch Reservoirs are delivered via a bypass tunnel directly to the down-take at DEL18. Flow may be supplemented by water drawn from Kensico Reservoir when demand exceeds the capacity of the bypass tunnel.

In 2020, influent turbidity and fecal coliform at Delaware Shaft 17 (DEL17) and the Pleasantville Alum Plant (CATALUM) were generally low. There was a brief increase in turbidity associated with the restart of the Catskill Aqueduct after a 10-week shutdown to remove algal growth within the aqueduct, but the impact was mitigated by alum treatment. Between mid-June and November 2020, DEP selectively diverted higher turbidity water from Ashokan West Basin to create a West Basin void. There were no operational changes made to address fecal coliform results, where higher counts coincided with runoff events in the watersheds of upstream reservoirs Rondout and West Branch. Kensico Reservoir was operated in float mode in anticipation of strong winds 10 times (for all or part of 27 days) in 2020. The Kensico Shoreline Stabilization Project continued in 2020 with a goal of reducing sediment resuspension and the resulting turbidity risk.

In preparation for the shutdown of the RWBT, work on the Kensico shoreline stabilization project continued in 2021. Because of the proximity of this work to Delaware Shaft 18, and as a precautionary measure, Kensico was operated in float mode for most of 2021 to minimize the potential for turbidity excursions. This required vigilant monitoring of continuous, robotic, and laboratory water quality data to mitigate the impacts of storm related increases in turbidity, fecal coliforms, and natural organic matter (NOM). For example, DEP limited the amount of water leaving the Kensico basin during the 2021 tropical storms Henri and Ida. While this was successful in mitigating turbidity impacts from within the Kensico watershed, it resulted in periods of increased coliform counts and higher than normal levels of NOM leaving Kensico for an extended period. Fecal coliform levels peaked at 82 CFU/100 mL aL18DT on September 2, 2021, with four hits over 20 CFU/100 mL over the next four days. This required a change from float mode to bypass mode at West Branch to reduce fecal coliform levels at the source water monitoring location. In addition to constraints related to ongoing shoreline work, DEP was unable to divert low-NOM water from Ashokan to Kensico from early October through mid-December due to the shutdown of the Catskill Aqueduct for the CAT-RR project. This eliminated DEP's ability to reduce the DBPfp entering Kensico which ultimately contributed to the fourth quarter 2021 violation of the Stage 2 Disinfection By-Product Rule. When the CAT-RR shutdown ended in mid-December 2021, DEP began to maximize the use of Ashokan water to lower the levels of NOM in Kensico Reservoir.

In summary, the combination of water quality factors and operational constraints contributed to exceedance of the Locational Running Annual Average (LRAA) for haloacetic acids (HAA5) at three distribution system locations in the fourth quarter of 2021 and one

location in the first quarter of 2022, resulting in a violation of the Stage 2 Disinfection By-Products rule. The main contributing factors were an increase in NOM in the water supply due to significant rain events and higher than normal chlorine targets needed to address increased NOM and coliform levels in the distribution system. As operational conditions and infrastructure projects allowed, DEP began addressing the HAA5 levels by lowering chlorine targets and by ensuring that the water delivered to Kensico Reservoir had the lowest possible concentrations of NOM. Specifically, DEP limited diversions from Neversink Reservoir into Rondout Reservoir, and maximized the delivery of Ashokan water to Kensico.

In preparation for the 2023 shutdown of the RWBT, work on the Kensico shoreline stabilization project continued in 2022. This project required ongoing monitoring of continuous, robotic, and laboratory water quality data to mitigate the impacts of storm-related increases in turbidity, fecal coliforms, and NOM. With the CAT-RR Project largely complete, DEP was able to divert more Ashokan water into Kensico Reservoir. This allowed DEP to reduce the DBPfp entering Kensico which ultimately contributed to the system regaining compliance with the Stage 2 Disinfection By-Product Rule in the second quarter of 2022.

In preparation for the 2024 shutdown of the RWBT, and with written approval from the NYSDOH, the Croton Falls and Cross River pump stations were utilized during two separate dewatering exercises of the tunnel. The first exercise was executed March 6 through March 13, 2023, diverting up to 75 MGD from Cross River Pump Station and 186 MGD from Croton Falls Pump Station. Under the NYSDOH approval, the use of the pump stations must be discontinued prior to operating Kensico Reservoir in float or bypass mode to prevent unfiltered Croton System water from entering the distribution system. Using specific conductance data from this exercise, DEP evaluated the time needed for Cross River and Croton Falls water to completely discharge into Kensico Reservoir following pump station shutdown. The time was determined to be approximately eight and one-half hours, and this information was used as a guide during the 2024 shutdown.

The second dewatering exercise and associated pump station activation occurred October 16 through November 5, 2023, diverting up to 180 MGD from Croton Falls Pump Station and 69 MGD from Cross River Pump Station. Use of the pump stations during these exercises were summarized in after action reports and submitted accordingly to NYSDOH.

In addition, Kensico Reservoir was placed into float mode on four occasions in 2023. The first instance was related to a small aircraft crash in early January, where DEP placed the reservoir into float mode until the plane was determined to be on land. The remaining instances were as a precaution due to an inclement weather system in early March 2023, an effort to move colder water into the distribution system to mitigate total coliform counts in mid-July 2023, and as a precaution due to an inclement weather system in mid-September 2023.

As part of the 2024 shutdown of the RWBT, and with written approval from the NYSDOH, the Croton Falls and Cross River pump stations were operated. Croton Falls was used

from October 1, 2024 to December 12, 2024. Cross River Pump Station was used from October 1, 2024 to November 21, 2024. The pump stations diverted up to 180 MGD from Croton Falls Pump Station and 60 MGD from Cross River Pump Station. Use of the pump stations during these exercises was summarized in an after-action report and submitted to NYSDOH.

In addition, Kensico Reservoir was operated in float mode on a few occasions in 2024: once in January to facilitate the installation of turbidity curtains around a section of the cove where construction activity had the potential to disturb soils, and once in March 2024 and twice in April 2024 in anticipation of high winds.

5.1.3 Water Quality Trending and Assessment

Water quality trending requires a much longer time period than the current five-year reporting period. Trend assessment in this report includes data from 1993 through 2024 and allows an examination of changes over the past 32 years in the context of changes made through protection programs, as well as through natural variation. Status and trends were assessed at West Branch and Kensico reservoirs, and major inflows and outflows. The current water quality status assessment of each basin used aggregated data from the last three years of available data (2022-2024). The analytes chosen were those most important for the SWTR and meeting the requirements of the 2017 revised Filtration Avoidance Determination. Trophic status of both reservoirs and the recent biological assessment profile scores at select streams were also assessed using standard criteria. In addition to the analytes assessed for the Catskill and Delaware System basins in Chapter 3 and 4, an analysis of pathogen inflows and outflow is provided in this chapter for Kensico Reservoir. In accordance with DEP's mandate to meet regulatory requirements downstream, the focus is on the pathogenic protozoans *Cryptosporidium* and *Giardia*. Appendix C provides more detail on statistical and data collection methods.

5.2 The West Branch Basin

The West Branch Reservoir is located in Putnam County approximately 35 miles from New York City. It was formed by damming the West Branch of the Croton River, which continues south to the Croton Falls Reservoir and consists of two basins, separated by Route 301. The reservoir holds ten billion gallons at total capacity and was placed into service in 1895 initially as part of the City's Croton water supply system.

The West Branch functions primarily as part of the Delaware water supply system, serving as a supplementary settling basin for the water from Rondout Reservoir, which enters West Branch via the Delaware Aqueduct. West Branch Reservoir also receives water from its own small watershed and the Boyd Corners Reservoir. The Boyd Corners Reservoir is 1.5 miles in length and holds 1.7 billion gallons at total capacity. First placed into service in 1873, the dam, spillway and outlet works were rebuilt in 1990 as part of the City's complete overhaul and modernization of the 19 reservoirs in its water supply system. Water from West Branch flows via the Delaware Aqueduct into the Kensico Reservoir.

Land use in the West Branch watershed is as follows: 67.2% is forested, 19.3% is urban, 1.2% is brushland or successional forest, 11.3% is water, and 0.8% is in agricultural use. The Boyd Corners watershed drainage basin is 22 square miles. Land use breakdown in the Boyd Corners watershed is as follows: 79.2 % is forested, 12.5% is urban, 1.6% is brushland or successional forest, 6% is water, and 0.7% is in agricultural use. Protection programs in place in the watershed are described in the Watershed Protection Program sections.

5.2.1 Water Quality Status and Trends in the West Branch Watershed

Status (West Branch)

The West Branch Basin status evaluation is presented as a series of boxplots in Figure 5.1. The inflows include water diverted from Rondout Reservoir (DEL9), Boyd Corners release (BOYDR), and Horse Pound Brook (HORSEPD12). The reservoir is designated as CWB and the outflow is designated as WESTBRR. A site map, description of the sampling program, and details on data preparation and boxplot interpretation are provided in Appendix C.

For the status evaluation period (2022-2024), fecal coliform bacteria remained below the NYSDEC Stream Guidance Value of 200 fecal coliforms 100 mL^{-1} for all inflows, with a monthly median of 12 fecal coliforms 100 mL^{-1} and five values that exceeded the guidance value. Reservoir fecal coliform levels were comparatively low, with only one outlier of 24 fecal coliforms 100 mL^{-1} in September 2023. Turbidity in the West Branch Basin is typically low, as was the case for the 2022-2024 assessment period with a reservoir (CWB) monthly median turbidity of 0.9 NTU. Monthly median reservoir TP values were below the target value of 15 µg L^{-1} with one exception in November 2023, when median TP was 17 µg L^{-1}. The TSI values ranged from oligotrophic to eutrophic, with a median of 43, in the mesotrophic range. Conductivity medians were higher from local inflows (BOYDR median 193 µS cm^{-1} and HORSEPD12 median 259 µS cm^{-1}). Low-ionic strength water from Rondout Reservoir (DEL9) had a monthly median of 59 µS cm^{-1} and the West Branch Reservoir (CWB) monthly median conductivity was 73 µS cm^{-1} for the evaluation period.

Trends (West Branch)

Water quality trend plots for the West Branch basin are presented in Figure 5.2and results of the SKT and TDA analysis are provided in Table 5.1.

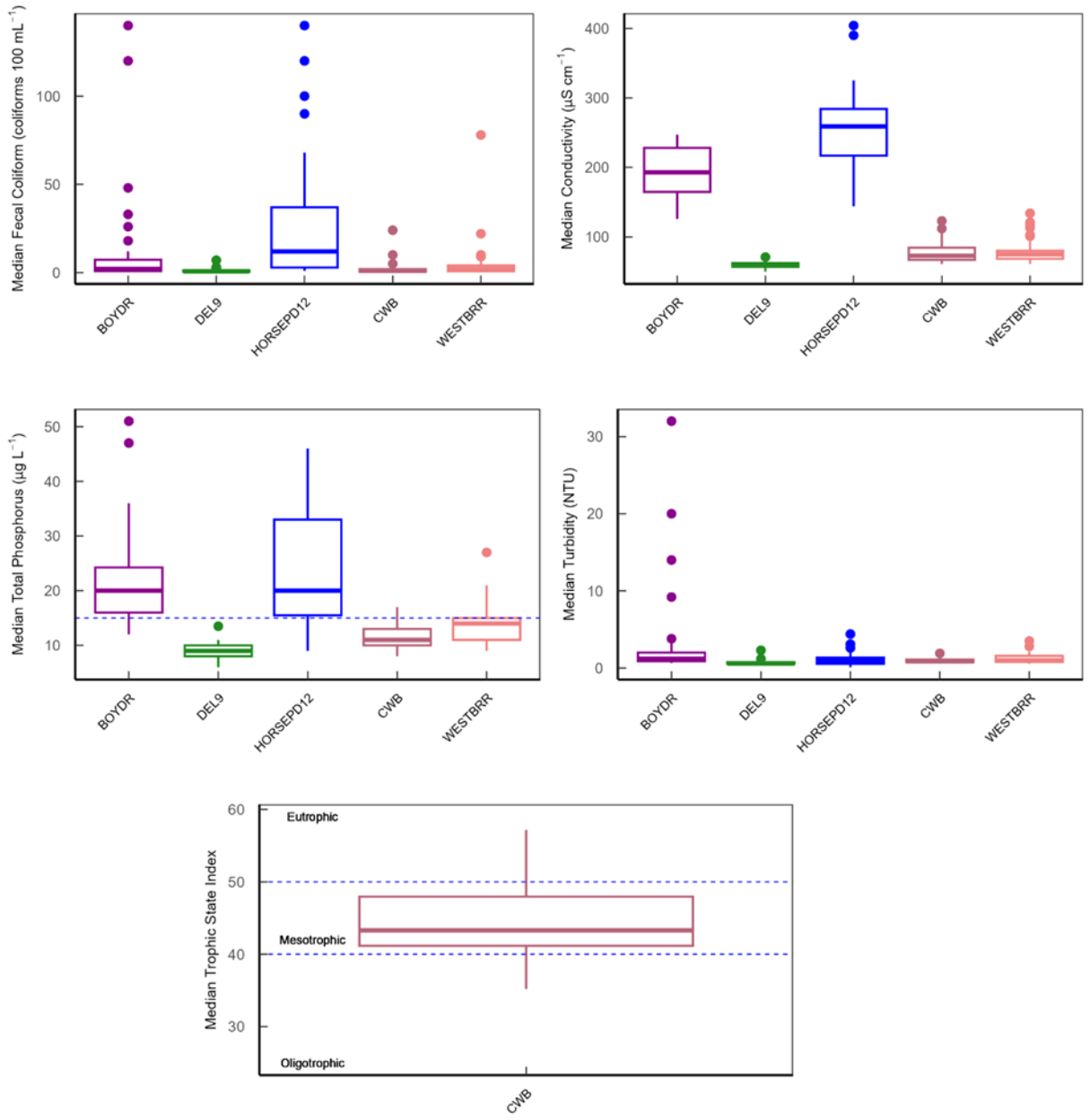


Figure 5.1 Water quality status boxplots using 2022-2024 monthly data for the West Branch basin for the inflows from Rondout Reservoir (DEL9), the main stream inflows at Boyd Corners Reservoir release (BOYDR) and Horse Pound Brook (HORSEPD12), West Branch Reservoir (CWB), and West Branch Reservoir Release (WESTBRR).

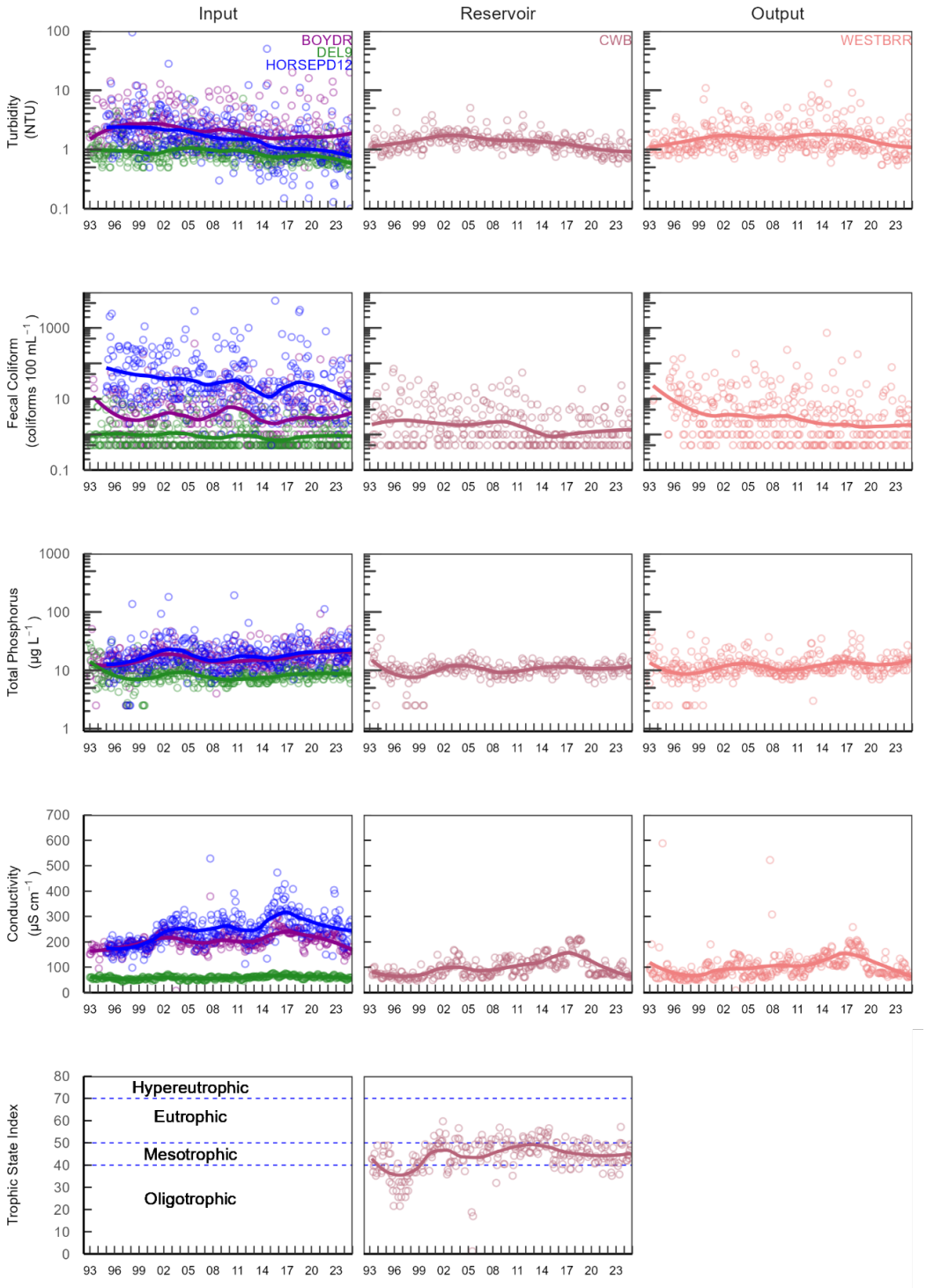


Figure 5.2 Water quality trend plots for the West Branch basin for the inflow from Rondout Reservoir (DEL9), the main stream inflows at Boyd Corners Reservoir release (BOYDR), and Horse Pound Brook (HORSEPD12); West Branch Reservoir (CWB); and the outflow at the West Branch Release (WESTBRR).

Table 5.1 West Branch inflow, reservoir, and outflow trends from 1993 to 2024.

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
BOYDR	Input	Turbidity	375	***	-0.03	-1.694	Decreasing trend virtually certain
DEL9	Input	Turbidity	382	***	-0.007	-0.8929	Decreasing trend virtually certain
HORSEPD12	Input	Turbidity	345	***	-0.048	-3.4483	Decreasing trend virtually certain
HORSEPD12	Input	Turbidity (Flow Adj.)	333	***	-0.048	-3.437	Decreasing trend virtually certain
BOYDR	Input	Fecal Coliform	348	NS	0	0	Decreasing trend about as likely as not
DEL9	Input	Fecal Coliform	380	***	0	0	Decreasing trend very likely
HORSEPD12	Input	Fecal Coliform	324	***	-0.72	-3.6024	Decreasing trend virtually certain
HORSEPD12	Input	Fecal Coliform (Flow Adj.)	313	***	-1.252	-6.2613	Decreasing trend virtually certain
BOYDR	Input	Total Phosphorus	360	***	0.167	1.042	Increasing trend virtually certain
DEL9	Input	Total Phosphorus	369	NS	0	0	Trend exceptionally unlikely
HORSEPD12	Input	Total Phosphorus	334	***	0.167	0.980	Increasing trend virtually certain
HORSEPD12	Input	Total Phosphorus (Flow Adj.)	322	***	0.141	0.830	Increasing trend virtually certain
BOYDR	Input	Conductivity	371	***	1.235	0.6158	Increasing trend virtually certain

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
DEL9	Input	Conductivity	382	***	0.303	0.510	Increasing trend virtually certain
HORSEPD12	Input	Conductivity	341	***	3.667	1.5089	Increasing trend virtually certain
HORSEPD12	Input	Conductivity (Flow Adj.)	329	***	3.432	1.384	Increasing trend virtually certain
West Branch	Reservoir	Turbidity	293	***	-0.014	-1.099	Decreasing trend virtually certain
West Branch	Reservoir	Fecal Coliform	293	***	0	0.000	Decreasing trend virtually certain
West Branch	Reservoir	Total Phosphorus	253	***	0.038	0.366	Increasing trend very likely
West Branch	Reservoir	Conductivity	284	***	1.091	1.247	Increasing trend virtually certain
West Branch	Reservoir	Trophic State Index	257	***	0.159	0.353	Increasing trend virtually certain
WESTBRR	Output	Turbidity	365	NS	0	0.000	Decreasing trend possible
WESTBRR	Output	Fecal Coliform	335	***	-0.071	-3.571	Decreasing trend virtually certain
WESTBRR	Output	Total Phosphorus	351	***	0.1	0.909	Increasing trend virtually certain
WESTBRR	Output	Conductivity	361	***	1.375	1.503	Increasing trend virtually certain

[1]The p-values for each trend test are symbolized as follows:
*NS (Not Significant) = p ≥ 0.20, * = p < 0.20, ** = p < 0.10, *** = p < 0.05.*

The water comprising West Branch Reservoir is derived mainly from the Delaware System's Rondout Reservoir via the Delaware Aqueduct (DEL9) and from its primary local inflows, the Boyd Corners Reservoir release (BOYDR) and Horse Pound Brook (HORSEPD12). The relative contributions from these sources are dependent on the operational status of the

Delaware Aqueduct. As discussed below these operational changes cause fluctuations in water quality, which can influence trend calculations and complicate interpretation.

Strong evidence of a downward turbidity trend was indicated by TDA analysis for the reservoir and all inflows, while a downward trend of low magnitude was identified for the reservoir outflow. Stormwater remediation projects have been completed in both the West Branch and Boyd Corners watersheds and may have contributed to the observed turbidity downtrends.

Downward fecal coliform trends were evident for all sites except for the Boyd Corners release. The inflow at HORSEPD12 was especially strong when adjusted for flow. Less frequent large rain events and low rainfall totals in most years since 2011 as well as the aforementioned local stormwater remediation projects are likely factors contributing to the long-term downturn.

Increasing TP and conductivity trends were considered virtually certain at most local Croton inflows, as well as at West Branch Reservoir and its outflow, likely due to the greater influence of local Croton water than water from DEL9, which did not exhibit a strong trend.

The increasing trend in TSI values can be ascribed to rising reservoir surface water temperatures and to the TP contribution from local sources during the latter part of the data record. In part, these changes are related to operational changes, which control the blend of waters that comprise West Branch Reservoir.

5.2.2 Biomonitoring in the West Branch Watershed

The DEP Stream Biomonitoring Program uses protocols developed by the NYSDEC to assess the health of stream macroinvertebrate communities in watershed streams. Stream impairment is assessed via a multi-metric BAP score derived from stream macroinvertebrate assemblages. For full methodology details including headwater adjustment methods as established by NYSDEC in 2018, see Appendix C.

The most recent status of macroinvertebrate communities in the West Branch and Boyd Corners watershed was evaluated by the analysis of five total samples collected from four streams in 2022 through 2024. One sample was collected from the Boyd Corners basin during this period, on West Branch Croton River (145). For the West Branch Reservoir basin during this period, one site on Horse Pound Brook (146) was sampled twice, along with one sample each on Gypsy Trail Brook (131) and Long Pond Stream (133).

West Branch and Boyd Corners Watershed: Site 145 on the West Branch Croton River in Putnam Valley was assessed as non-impaired in 2023. Site 146 (HORSEPD12) on Horse Pound Brook in Kent is located approximately 1.7 miles north of the West Branch Reservoir and was assessed as non-impaired in 2022 and 2023. Site 131 (GYPSYTRL1) is located on Gypsy Trail Brook just before the stream enters the West Branch Reservoir and was assessed as non-impaired in 2024. Site 133 (LONGPD1) is located on Long Pond Stream before it enters the southern branch of West Branch Reservoir and was assessed as non-impaired in 2024 (Figure 5.3).

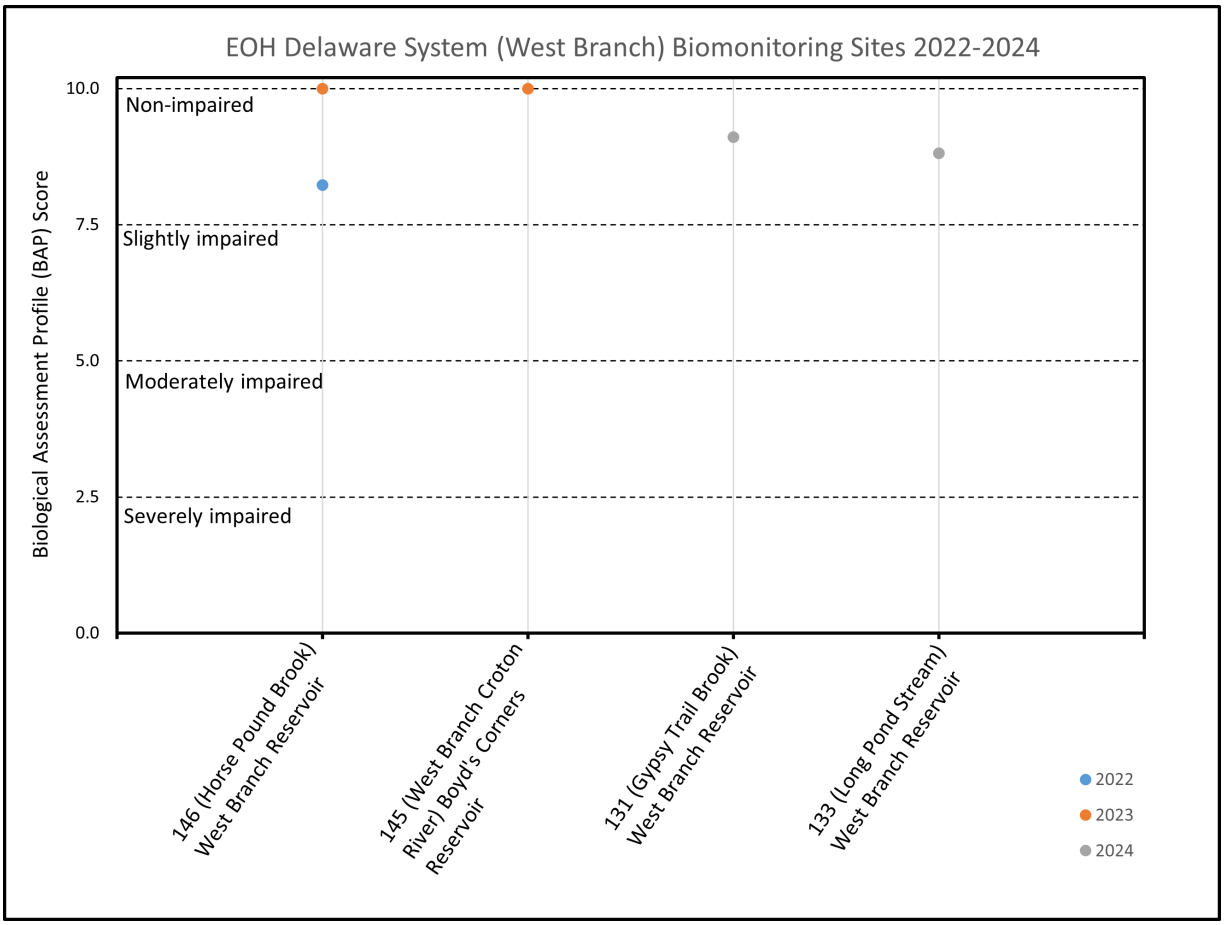


Figure 5.3 Biological Assessment Profile scores for EOH Delaware system, 2022-2024.

West Branch and Boyd Corners Biomonitoring Trends: Streams in the West Branch and Boyd Corners watershed were analyzed for time-series trends in BAP scores based on a site's entire period of record. For the purposes of this report, long-term trend analysis is focused on main input streams with more than three years of biological assemblage data. Only site 146 on Horse Pound Brook has sufficient historical data for long-term analysis. A 1.3x modifier was applied to all previous samples, as the stream fits the NYS DEC headwater designation for the Croton region by having a drainage under 16km^2. Horse Pound Brook has consistently been scored as non-impaired from 1994-2024 (Figure 5.4).

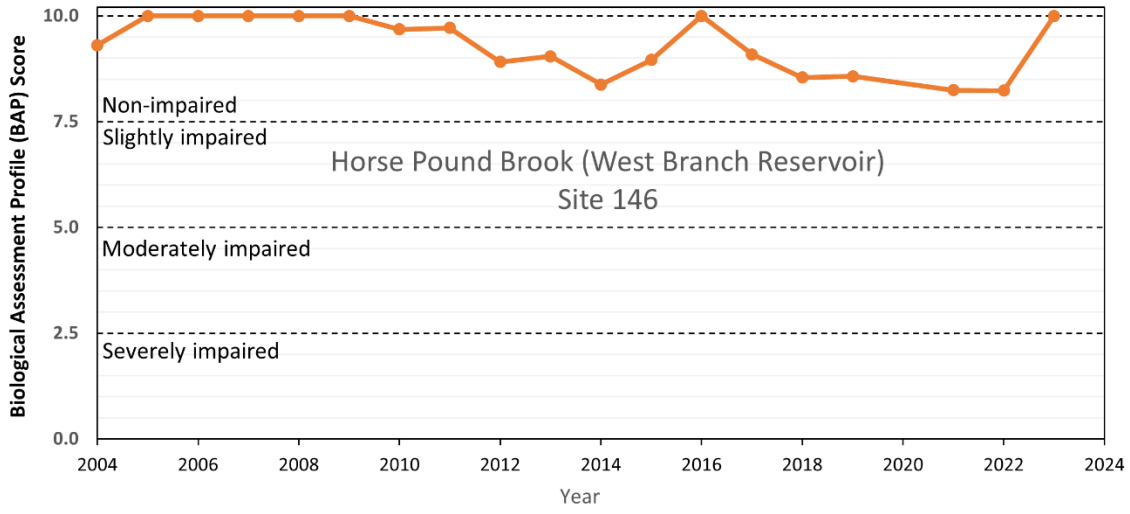


Figure 5.4 Biological Assessment Profile scores for Horse Pound Brook, 2004-2023.

5.3 The Kensico Basin

The Kensico Reservoir is located in Westchester County, about 15 miles north of New York City limits. Although formed by the damming of the Bronx River, it receives most of its water from reservoirs west of the Hudson through the Catskill and Delaware aqueducts. Kensico consists of a western main basin that receives Catskill Aqueduct water and an eastern Rye Lake portion that receives Delaware Aqueduct water. These mix in the main basin before entering the Delaware Aqueduct at Shaft 18. The Catskill Aqueduct, south (or downstream) of Kensico Reservoir, is currently offline until work is completed to pressurize the flow to the UV Plant. Kensico Reservoir holds 41.2 billion gallons at total capacity and was placed into service in 1915. As the final reservoir in the Catskill/Delaware system before water enters the distribution network, Kensico Reservoir is subject to federal water quality standards for coliforms and turbidity under the SWTR.

The Kensico Reservoir's watershed is 13 square miles. The land use breakdown for the Kensico watershed is as follows: 42.7% is forested, 28.2% is urban, 2.4% is brushland or successional forest, 26.0% is water, and 0.5% is agricultural use.

DEP watershed protection programs have been effective in preserving the high quality of the water in the Kensico Reservoir. More than 97% of the water in the Reservoir is delivered via the Catskill or Delaware aqueduct. Kensico was one of the earliest focal points of DEP's watershed protection activities and is certainly the most intensely studied basin in the system. Those study efforts have led to implementation of targeted controls to address localized threats to water quality.

A cumulative total of 45 stormwater and erosion abatement facilities have been installed in the Kensico basin since 1997, significantly reducing the turbidity and fecal coliforms entering

the Reservoir. To further reduce turbidity entering Kensico from two streams near the Catskill Effluent Chamber, DEP installed a back-up turbidity curtain completed in 2009.

5.3.1 Water Quality Status and Trends in the Kensico Basin

Status (Kensico)

The Kensico Basin status evaluation is presented as a series of boxplots in Figure 5.5. The inflows include Rondout Reservoir via West Branch Reservoir (DEL17, i.e., the Delaware Aqueduct), and the diversion from Ashokan Reservoir (CATALUM, i.e., the Catskill Aqueduct). The reservoir is designated as BRK and the outflow is designated as DEL18DT. A site map, description of the sampling program, and details on data preparation and boxplot interpretation are provided in Appendix C.

For the evaluation period (2022-2024), reservoir fecal coliform levels were below the SWTR limit of 5 fecal coliforms 100 mL^{-1}, except for October 2023 (12 fecal coliforms 100 mL^{-1}) from an approximate six-inch storm event that took place at the end of September 2023. Turbidity in the Kensico Basin is typically low, and continued to be low during the status assessment period. Monthly median reservoir TP values were well below the target value of 15 µg L^{-1} with a median of 9 µg L^{-1}. The TSI values for Kensico Reservoir fell primarily in the mesotrophic range, with some values in the oligotrophic range. Conductivity was relatively low in the reservoir (BRK) with a median of 75 µS cm^{-1}, reflecting the character of Catskill/Delaware inflows.

Trends (Kensico)

Water quality trend plots for the Kensico basin are presented in Figure 5.6 and results of the SKT and TDA analysis are provided in Table 5.2. As previously reported, the CDUV plant was brought on-line in September 2012; as a result, all water leaving Kensico since 2012 is through the Delaware outflow and is sampled at DEL18DT.

In contrast to results reported in the last FAD evaluations (DEP 2016 and DEP 2021), there was strong evidence for long-term turbidity downward trends in the Delaware Aqueduct inflow (DEL17), in the reservoir, the Delaware outflow (DEL18DT), and the Catskill Aqueduct inflow (CATALUM). Note that during times of excessive turbidity, alum is applied just downstream of the Catskill inflow sampling site; as a result, the turbidity levels entering Kensico Reservoir are much lower, generally being reduced to <1 NTU before traveling very far in the reservoir. It is for this reason that the periodic turbidity peaks shown for the Catskill inflow are absent from the reservoir.

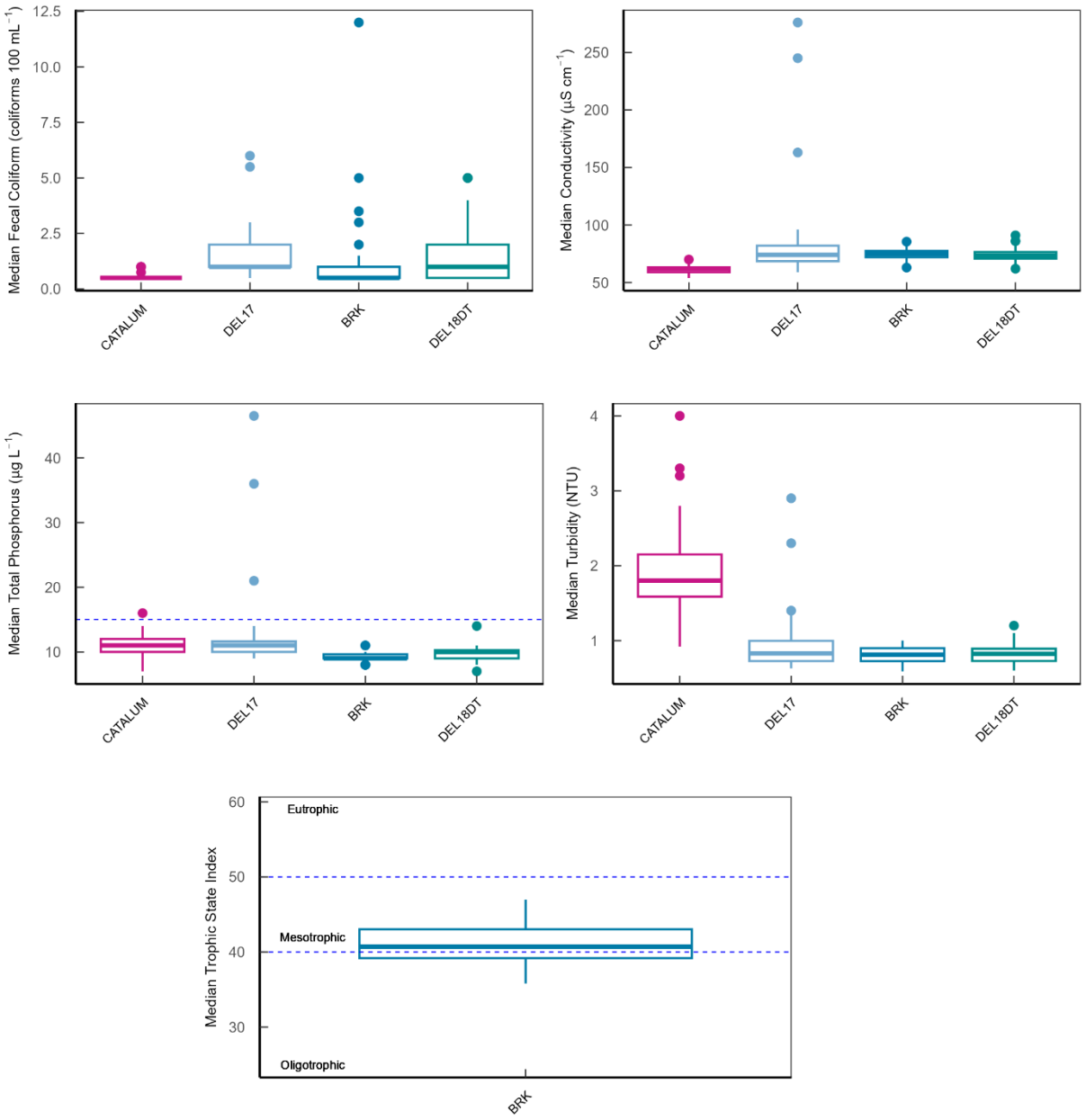


Figure 5.5 Water quality status boxplots using 2022-2024 monthly data for the Kensico basin inflows from the Catskill Aqueduct (CATALUM) and the Delaware Aqueduct (DEL17), Kensico Reservoir (BRK), and the outflow at the Kensico Reservoir gatehouse (DEL18DT).

Although the slope estimator test produced a long-term change of zero for fecal coliforms at all sites in the Kensico basin, the TDA analysis indicated that a downward trend was virtually certain at all sites. The Sen Slope estimate is not accurate when the data being analyzed has

many tied values (e.g. fecal coliforms). See Appendix C for a more detailed description of slope values of zero. Additional evidence of the decline and its magnitude is indicated by examination of the LOWESS curves at these sites. As reported previously, the downward trend in the reservoir can also be attributed to the waterfowl management program in place at Kensico since 1993. Prior to that year, samples often exceeded 20 fecal coliforms 100 mL^{-1}. Since then, most of the monthly median counts have been 1 fecal coliform 100 mL^{-1} or less than the detection limit, with the highest monthly median counts reaching 5 fecal coliforms 100 mL^{-1} in most years.

A long-term increasing TP trend was detected at DEL17, and starting in 2012, the LOWESS curves indicate an increasing trend at all other sites. Although some recent TP increases have been observed in the Delaware System, the water quality of the Delaware inflow was also influenced by operational changes. The Delaware inflow is dominated by water from Rondout Reservoir, which is a blend of water from the Cannonsville, Pepacton, and Neversink reservoirs and Rondout Creek, and the West Branch, Cross River, and Croton Falls reservoirs, depending upon system operations. A portion of the TP increase in the Delaware inflow from Rondout is from decreasing usage of the comparatively low TP Neversink Reservoir and the periodic increase of higher TP water from Cannonsville.

Upward conductivity trends were identified for all sites in the Kensico basin and were likely due to greater usage of road deicers throughout the Catskill/Delaware System. Delaware inflow conductivities had a median of 74 µS cm^{-1} and are likely associated with usage of water from West Branch, Croton Falls and Cross River reservoirs where median conductivity ranged from 75 to 336 µS cm^{-1} in recent years.

Peak TSI occurred 2001-2003, coinciding with the productivity increase (from increased clarity) noted for Ashokan Reservoir (DEP 2006). Low values in 2005 were associated with two rounds of alum treatment in April and October, which, in addition to reducing turbidity, decreased available nutrients in the reservoir. TSI has been declining since approximately 2011, despite increasing TP during the same time period.

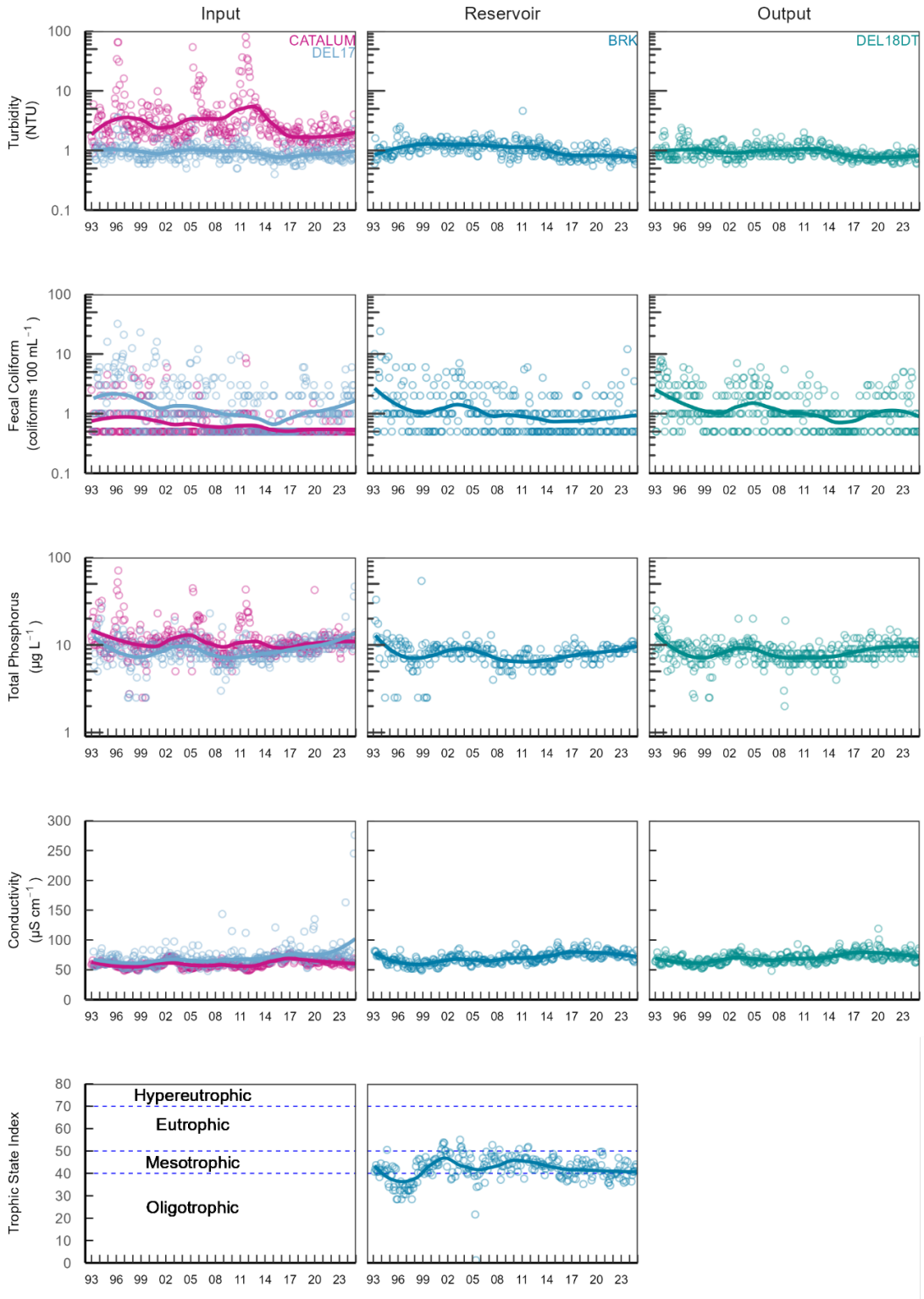


Figure 5.6 Water quality trend plots for the Kensico basin inflows from the Delaware Aqueduct (DEL17) and the Catskill Aqueduct (CATALUM), Kensico Reservoir (BRK), and the outflows at the Kensico Reservoir gatehouses (DEL18DT).

Table 5.2 Kensico Basin inflow, reservoir, and outflow trends from 1993 to 2024.

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
CATALUM	Input	Turbidity	381	***	-0.026	-1.141	Decreasing trend virtually certain
DEL17	Input	Turbidity	381	***	-0.004	-0.4762	Decreasing trend virtually certain
CATALUM	Input	Fecal Coliform	381	***	0	0	Decreasing trend virtually certain
DEL17	Input	Fecal Coliform	381	***	0	0	Decreasing trend virtually certain
CATALUM	Input	Total Phosphorus	379	NS	0	0	Decreasing trend possible
DEL17	Input	Total Phosphorus	379	***	0.05	0.5556	Increasing trend virtually certain
CATALUM	Input	Conductivity	381	***	0.217	0.3611	Increasing trend virtually certain
DEL17	Input	Conductivity	381	***	0.469	0.6996	Increasing trend virtually certain
Kensico	Reservoir	Turbidity	320	***	-0.014	-1.427	Decreasing trend virtually certain
Kensico	Reservoir	Fecal Coliform	319	***	0	0	Decreasing trend virtually certain
Kensico	Reservoir	Total Phosphorus	263	NS	0	0.000	Decreasing trend about as likely as not
Kensico	Reservoir	Conductivity	313	***	0.55	0.791	Increasing trend virtually certain

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
Kensico	Reservoir	Trophic State Index	267	NS	0	0.0000	Decreasing trend unlikely
DEL18DT	Output	Turbidity	384	***	-0.006	-0.694	Decreasing trend virtually certain
DEL18DT	Output	Fecal Coliform	384	***	0	0	Decreasing trend virtually certain
DEL18DT	Output	Total Phosphorus	381	NS	0	0.000	Decreasing trend exceptionally unlikely
DEL18DT	Output	Conductivity	384	***	0.484	0.693	Increasing trend virtually certain

[1]The p-values for each trend test are symbolized as follows:
NS (Not Significant) = $p \geq 0.20$, * = $p < 0.20$, ** = $p < 0.10$, *** = $p < 0.05$.

5.3.2 Biomonitoring in the Kensico Watershed

The DEP Stream Biomonitoring Program uses protocols developed by the NYSDEC to assess the health of stream macroinvertebrate communities in watershed streams. Stream impairment is assessed via a multi-metric BAP score derived from stream macroinvertebrate assemblages. For full methodology details including headwater adjustment methods as established by NYSDEC in 2018, see Appendix C.

The most recent status of macroinvertebrate communities in the Kensico watershed was evaluated by the analysis of one sample collected from site 117 (WHIP) on Whippoorwill Creek just before it reaches the Kensico Reservoir. The BAP score of 6.42 places the site in the slightly impaired category, and lower than the mean of 7.66 for the period of record (Figure 5.7). A 1.3x modifier was applied to all previous samples as the stream fits the NYS DEC headwater designation for the Croton region by having a drainage under 16 km^2. A decrease in Species Richness and an inconsistency with Percent Model Affinity compared to previous samples were the main drivers of the score in 2024. The current sampling site on Whippoorwill Creek contains some appropriate riffle habitat, but the embeddedness of the substrate on the restored streambed, lack of canopy cover, and narrow channel are not ideal for macroinvertebrate sampling. The DEP Stream Biomonitoring Program will seek alternate sites on Whippoorwill Creek that may be more representative of the stream in future sampling years. Note, however, that the influence of

this stream on reservoir water quality is small because the largest inputs are from the Catskill and Delaware reservoirs via the aqueducts.

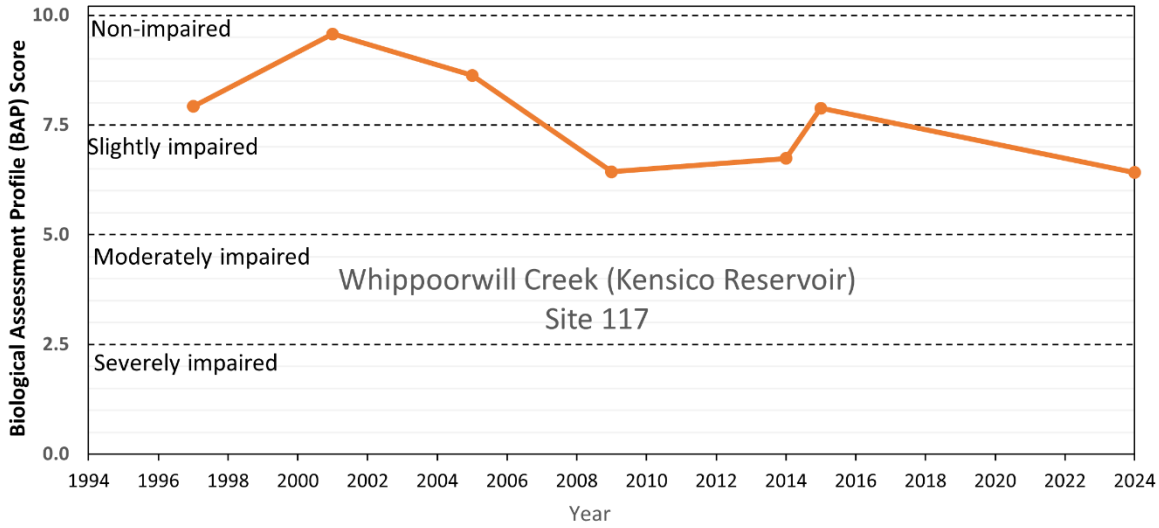


Figure 5.7 Biological Assessment Profile scores for Whippoorwill Creek, 1997-2024.

5.4 Trophic Response of EOH Catskill/Delaware Basins

Chlorophyll versus TP in Kensico and West Branch Reservoirs is plotted in Figure 5.8. Biomass in these two reservoirs is not so clearly dependent on phosphorus, and this may be related to short water residence times. In 2005, two separate turbidity events which required alum treatment of the Catskill Aqueduct inflow to Kensico occurred in spring and fall, and these periods of alum treatment resulted in exceptionally low (<1 mg m-3) chlorophyll means in both reservoirs. In this recent assessment period (2020-2024) both chlorophyll and phosphorus have remained low in Kensico, bordering the oligotrophic range.

The annual maximum values of chlorophyll versus total phosphorus are plotted for each year in Figure 5.9. In 2003, 2007 through 2009, and 2013, there were no major storms and these are years when chlorophyll maxima were relatively high. Both reservoirs had low maxima in 2005 in a year of high turbidity and alum treatment of the Catskill inflow. In recent years, all chlorophyll values reside within the 80% PI of the OECD standard, and Kensico displayed lower algal production than West Branch.

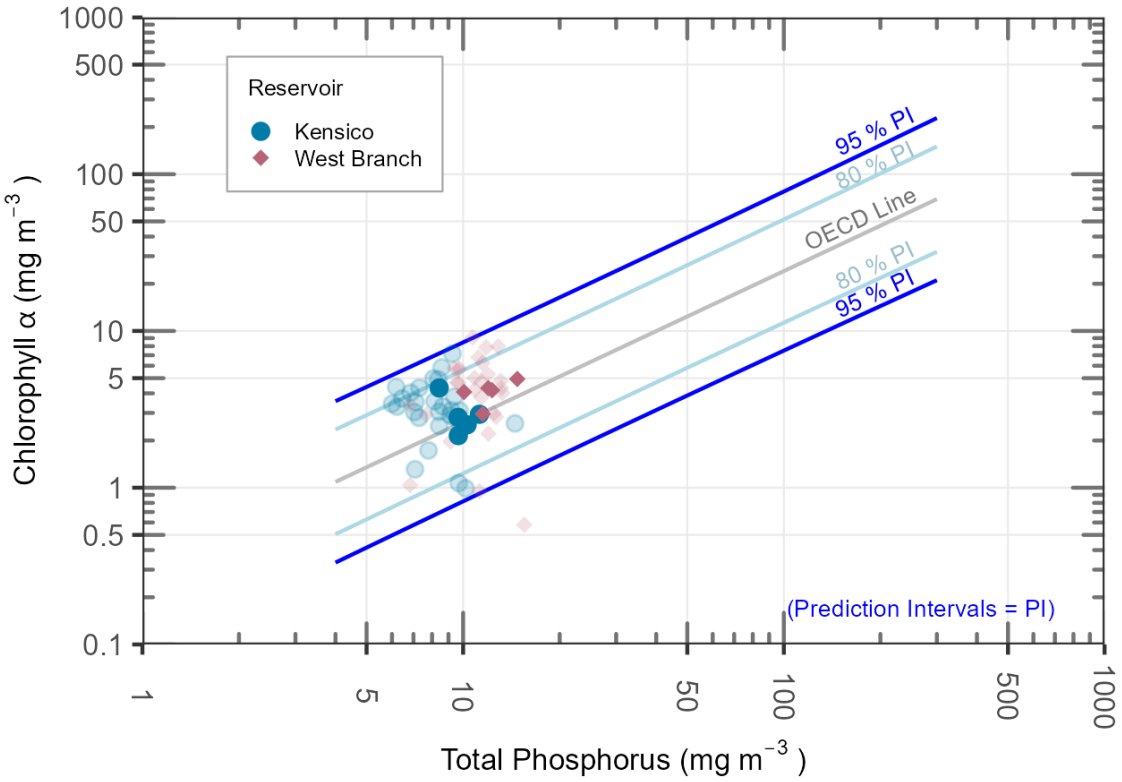


Figure 5.8 Chlorophyll vs total phosphorus in West Branch and Kensico Reservoirs.

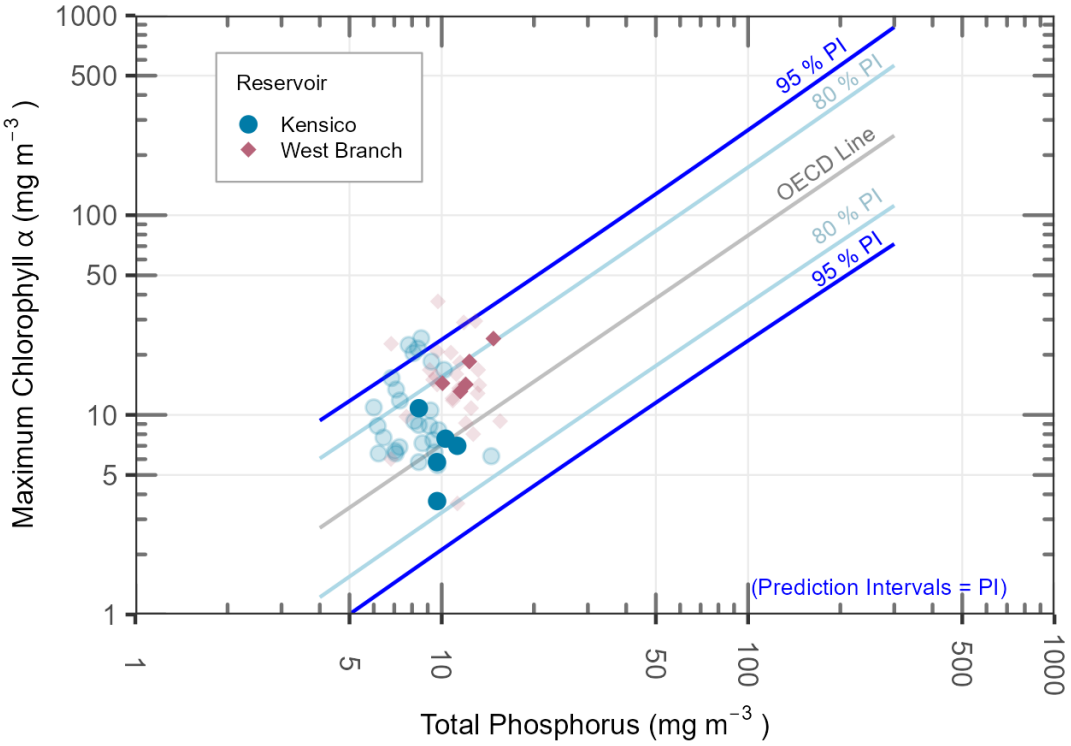


Figure 5.9 Maximum chlorophyll vs TP in West Branch and Kensico Reservoirs.

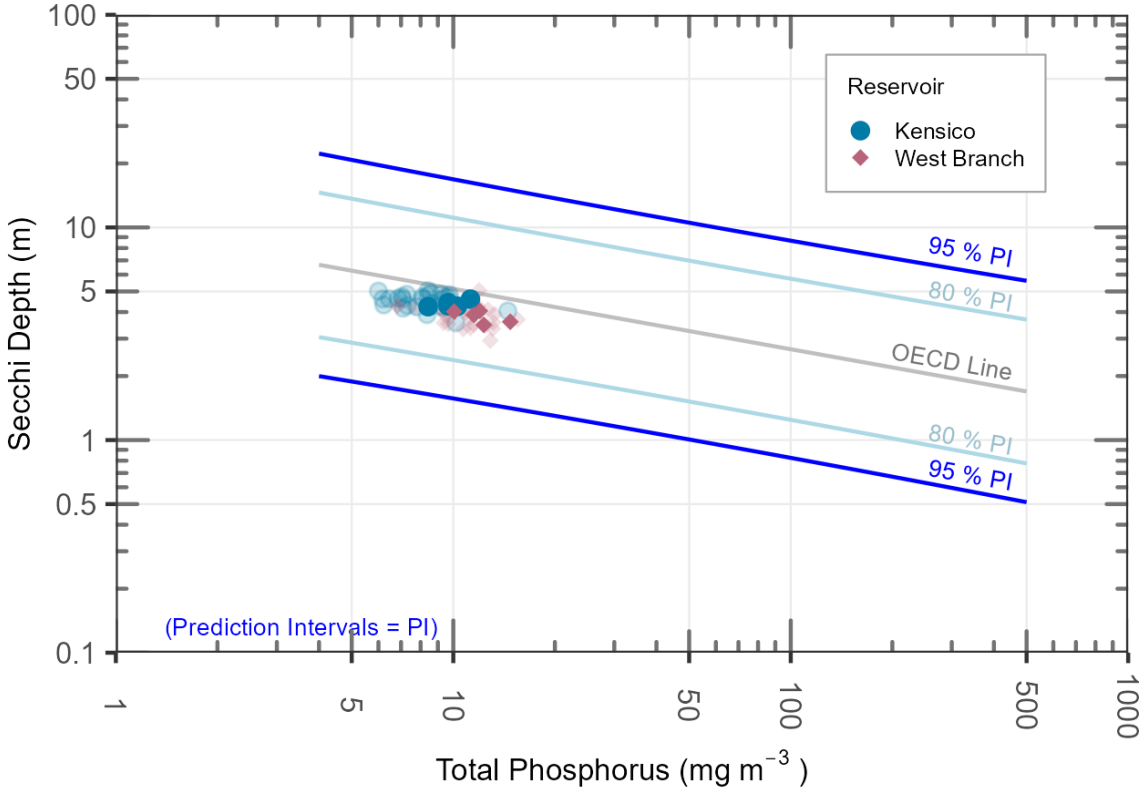


Figure 5.10 Secchi depth vs total phosphorus in West Branch and Kensico Reservoirs.

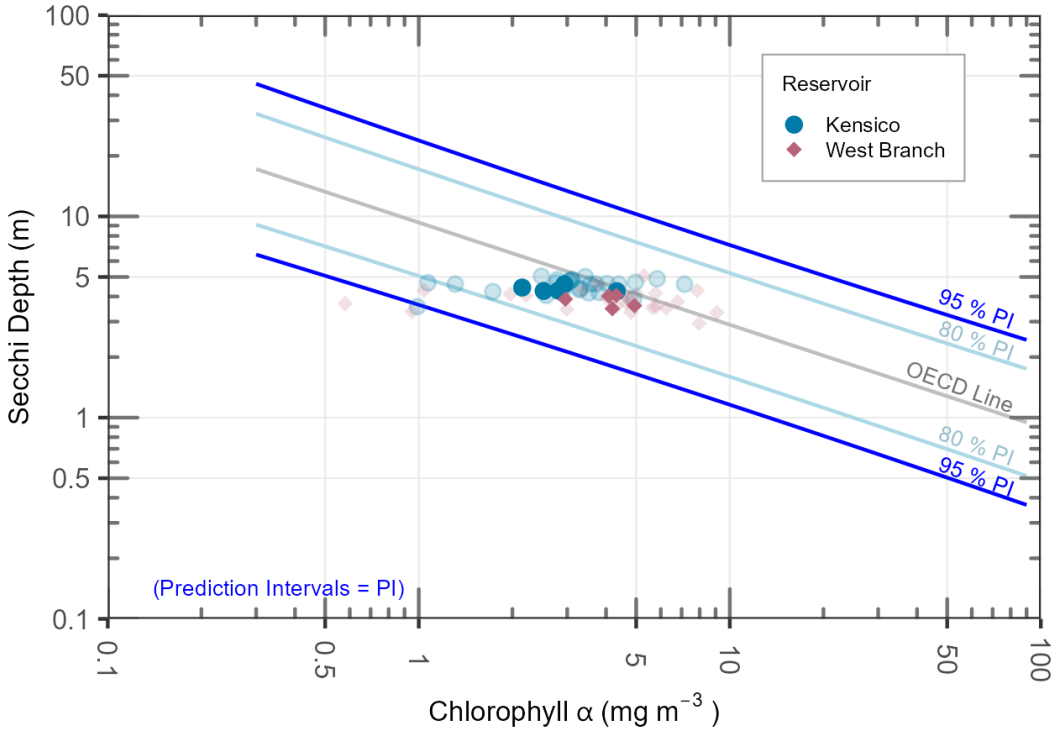


Figure 5.11 Secchi depth vs chlorophyll in West Branch and Kensico Reservoirs.

Secchi depth versus total phosphorus annual mean values are plotted in Figure 5.10. Secchi depth means show little variation and are in line with phosphorus means. This plot reflects the same observation of low Secchi depth values relative to phosphorus as seen in the Catskill and Delaware System reservoirs indicating that substances other than chlorophyll depress transparency.

Secchi depth versus chlorophyll is plotted in Figure 5.11. This plot demonstrates that transparency of the surface water is typically influenced by the chlorophyll levels. Interestingly, both reservoirs had factors other than chlorophyll limiting transparency, particularly in 1993, and again in 2004 and 2005 when Hurricane Ivan and two tropical storms delivered heavy precipitation and flooding. In the current assessment period, Secchi depths at Kensico tended to be deep, indicating excellent transparency.

5.5 Kensico Reservoir Protozoans

DEP has sampled for *Giardia* and *Cryptosporidium* at the two source water inflow sites located upstream of Kensico Reservoir (CATALUM and DEL17), and at the outflow site as the water enters the Delaware Aqueduct (DEL18DT) at least weekly since 2002. The outflow site as the water enters the Catskill Aqueduct (CATLEFF) was also sampled weekly until the CDUV plant came on-line in September 2012, and results for that location have been summarized in previous reports and will not be repeated here (DEP 2021, DEP 2016, DEP 2011). The portion of the Catskill Aqueduct between Kensico Reservoir and the CDUV Plant is currently closed and under construction. USEPA Methods 1623 (2002-March 2015) and 1623.1 (April 2015-present) have been used to collect and process samples. More recently (August 2017) the method adjustment was made to change from acid to heat dissociation. A broad summary of the data acquired during this sampling period is provided here, with a focus on 2020 through 2024.

5.5.1 Giardia

During this 23-year period (2002-2024), 2,375 *Giardia* samples were collected at the Kensico inflows and 1,333 samples at the outflow at DEL18DT. Since the outflow represents the final source water prior to treatment, it is sometimes sampled more often than weekly, especially when water quality results suggest resamples are necessary (e.g., increased turbidity).

The mean concentration of *Giardia* per 50 liters at the outflow of Kensico (DEL18DT) during the recent 2020 through 2024 period was low at 1.49 cysts (n=260). The mean at DEL18DT for the entire sampling period from 2002 through 2024 was slightly higher at 1.66 cysts (n=1,333). The two aqueduct inflows to Kensico annual means ranged from 0.17-6.96 cysts, with a mean of 2.31 cysts (n=1,204) from 2002-2024 at the Delaware inflow (DEL17) and 1.19 (n=1,171) at the Catskill inflow (CATALUM). The Delaware inflow mean *Giardia* concentration for the more recent 2020-2024 period was slightly higher at 2.91 cysts (n=263). While this is a slightly higher mean concentration compared to the overall period, it is partially explained by improvement in the analytical method in 2017 to increase the recovery of *Giardia* cysts. While routine *Giardia* sampling was eliminated at the upstream reservoir outflows in

2022, the outflow of Rondout Reservoir (RDRRCM), the main source of flow to DEL17, averaged 6.1 cysts $50L^{-1}$ (n=32) between 2020 and 2021. The Catskill inflow mean for 2020-2024 at 1.99 cysts (n=238) was slightly above the 2002-2024 mean (noted above as 1.19).

Individual annual mean concentrations of *Giardia* at the inflows and outflows of Kensico Reservoir were examined (Figure 5.12). The annual mean *Giardia* concentrations at the inflows to Kensico Reservoir have generally fluctuated between near zero and 2 cysts $50L^{-1}$ throughout the years. The exceptions being 2003 and 2004 when the Delaware inflow annual means were higher (maximum 4.5 cysts $50L^{-1}$) and more recently from 2018, 2019, 2020, and 2024 when Delaware inflow means were again elevated at 4.8, 7.0, 4.3, and 4.9 cysts respectively, typically during times of heavy rains and snowmelt. For the most part, the Delaware System inflow contributes more *Giardia* to Kensico Reservoir when compared to the Catskill System, even when alum is not being added; however, alum addition could be a contributing factor to the lower *Giardia* concentrations in the Catskill aqueduct when it is added, such as during and in preparation for the 2024 Rondout West Branch Tunnel Shutdown.

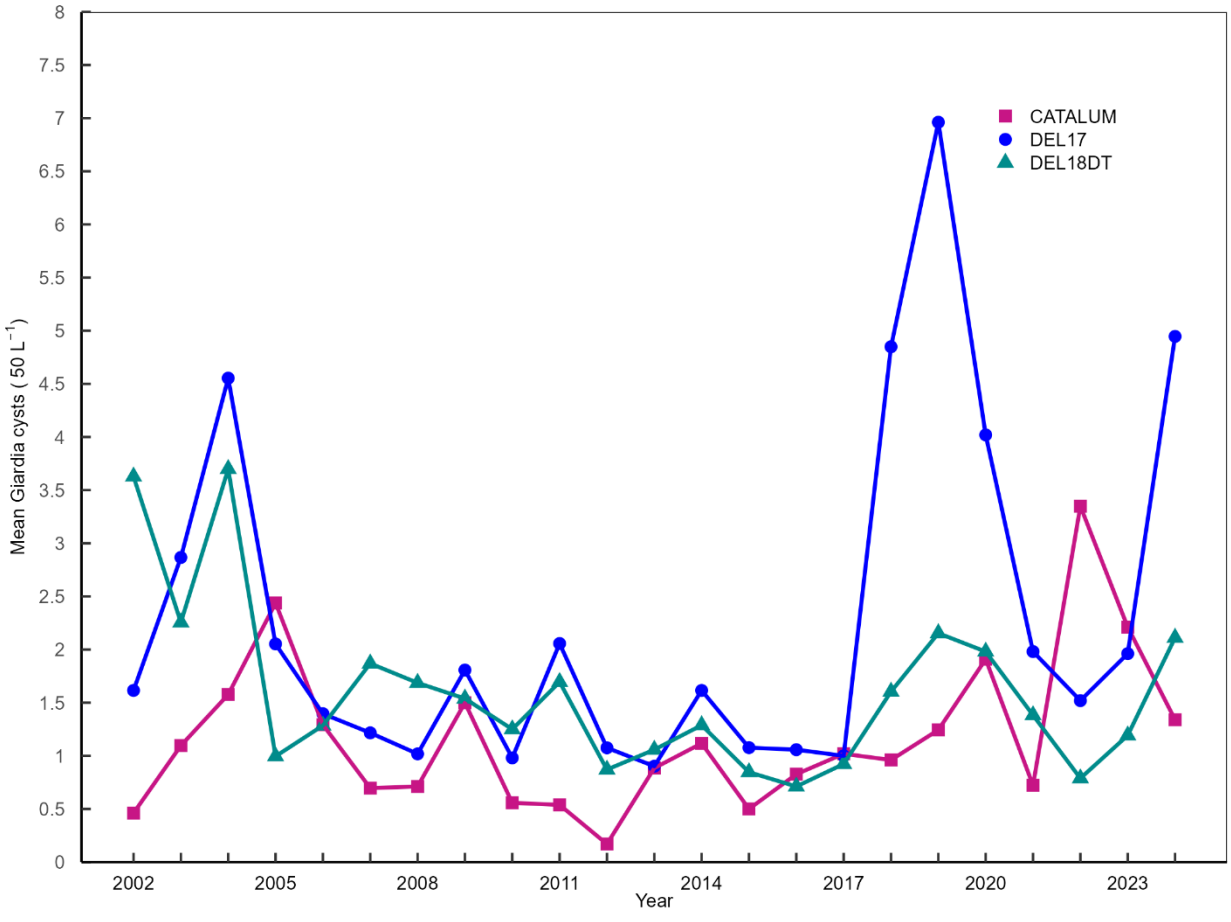


Figure 5.12 Kensico keypoint *Giardia* annual mean concentrations (cysts $50L^{-1}$) for 2002 through 2024.

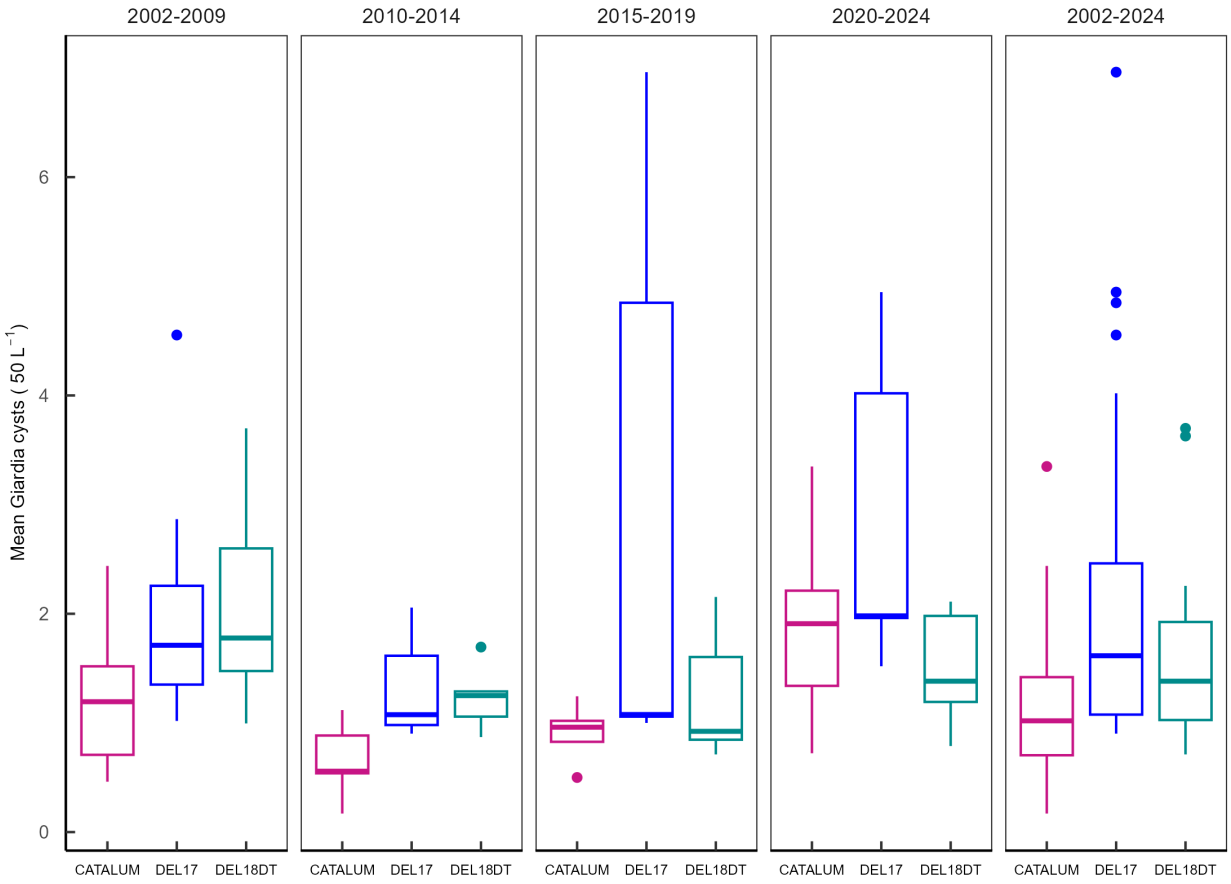


Figure 5.13 Distributions of annual means of *Giardia* concentrations at the Kensico influents and effluents for the three FAD summary and assessment report periods.

The distributions of *Giardia* concentrations are summarized by the previous and the current reporting periods at each site in Figure 5.13. With the exception of elevated *Giardia* from Rondout Reservoir feeding into Kensico during 2015-2019, the site medians have not changed significantly over the 23 year period of record using Method 1623/1623.1.

5.5.2 Cryptosporidium

The data available for *Cryptosporidium* analysis is very similar to *Giardia*, with 2,377 results for the inflows, and 1,333 results for the outflow at DEL18DT. While the tests are done simultaneously, these numbers are slightly different than those for *Giardia* because occasionally results for one organism may not be successful (e.g., stain uptake) but the other organism's result is still valid. In these rare situations, results from only one of the organisms are reported.

The *Cryptosporidium* concentrations at the inflows and outflow of Kensico Reservoir are similar. The outflow of Kensico Reservoir (DEL18DT) had a *Cryptosporidium* mean of 0.16 oocysts 50L^{-1} (n=260) for the recent 2020-2024 period. For the entire sampling period (2002-

2024), the outflow mean was very similar, at 0.15 oocysts (n=1,333). By comparison, the inflow mean concentrations for the entire 2002-2024 period were 0.14 (n=1,205) at the Delaware inflow (DEL17) and 0.09 (n=1,172) at the Catskill inflow (CATALUM). For the shorter, current 2020-2024 period, the Delaware inflow showed a slightly higher mean at 0.25 oocysts (n=263) compared to 0.16 oocysts for the comparable period at the Kensico outflow (DEL18DT). The Catskill inflow *Cryptosporidium* concentration was slightly lower than the long-term period, at 0.12 mean oocysts for the 2020 to 2024 period (n=238).

Individual annual mean *Cryptosporidium* concentrations at the Kensico Reservoir sites were examined from January 2002 through 2024 (Figure 5.14). Most notable is that the maximum annual mean value is only as high as 0.45 oocysts $50L^{-1}$ for the 23 year period. A decrease in annual mean oocysts from the early 2000s to approximately 2009 is apparent (attributed to Watershed Protection Programs such as WWTP upgrades), and they remained low until approximately 2015 when the first method change occurred to improve recovery (April 2015). A second method change occurred in August of 2017; however, that change was more directed at improving *Giardia* recovery. DEL17 annual means have been consistently higher than the inflow at CATALUM since 2017. While still relatively low, this corresponds with a period of increased *Giardia* cysts in the Rondout Reservoir and may indicate 1) the *Giardia* source(s) also contained *Cryptosporidium*, and/or 2) that the unusually high precipitation, snow melt and runoff during this period transported both increased *Giardia* and *Cryptosporidium* from multiple sources into the reservoir through tributaries and overland flow. Lastly, the *Cryptosporidium* annual mean at DEL18DT increased to a high of 0.43 oocysts $50L^{-1}$ in 2024, the highest since 2003, but this value represents 76% non-detects for the year and a single sample maximum of 4 oocysts $50L^{-1}$.

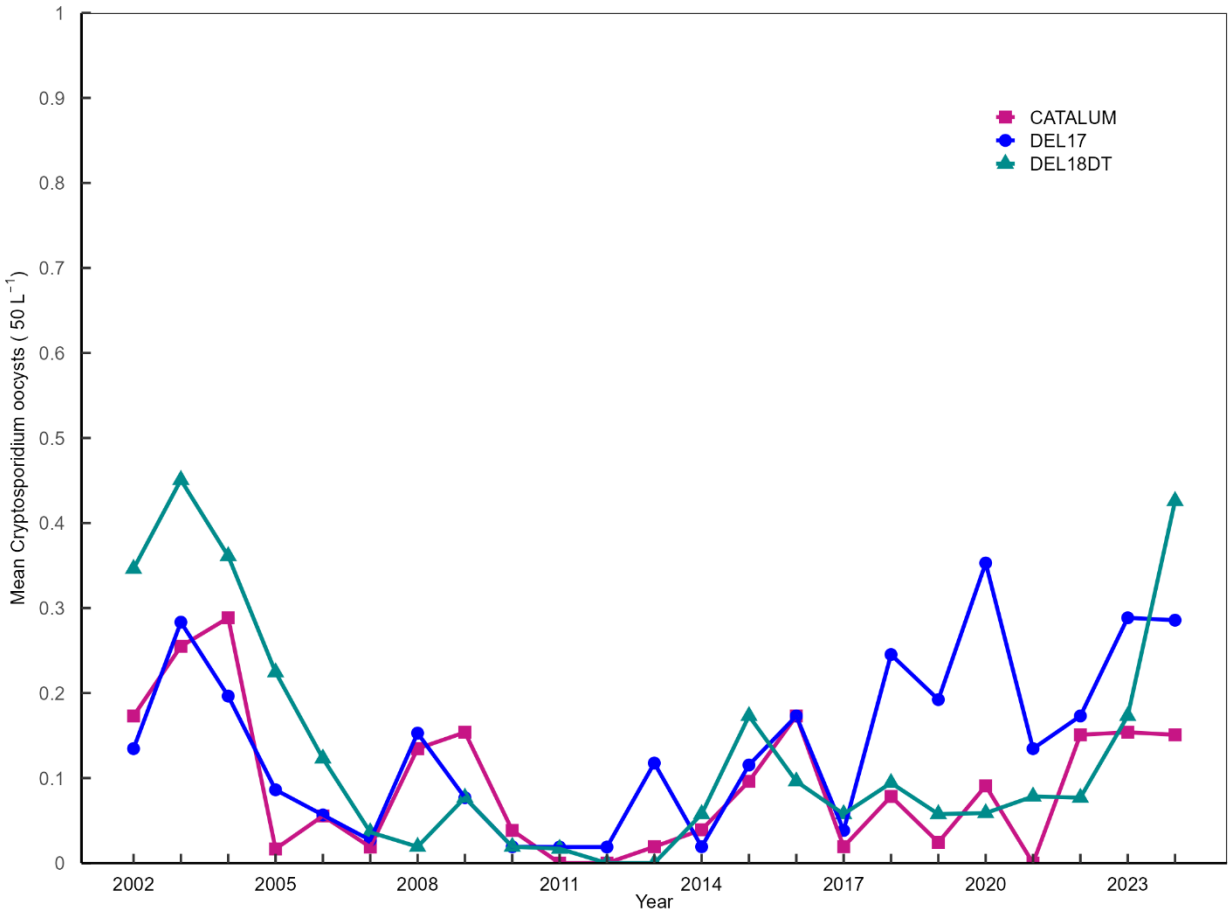


Figure 5.14 Kensico keypoint *Cryptosporidium* annual mean concentrations (oocysts $50L^{-1}$) for 2002 through 2024.

Cryptosporidium distributions for the prior reporting periods are shown in Figure 5.15. Of note, the distribution for the reporting period of 2010-2014 was exceptionally narrow and low, and only includes data prior to method changes. For all assessment periods, median annual averages at the inflows and outflows were below 0.4 oocysts $50L^{-1}$, equivalent to a large proportion of non-detect results. The median annual average at the DEL18DT outflow remained below 0.2 oocysts $50L^{-1}$ for all assessment periods.

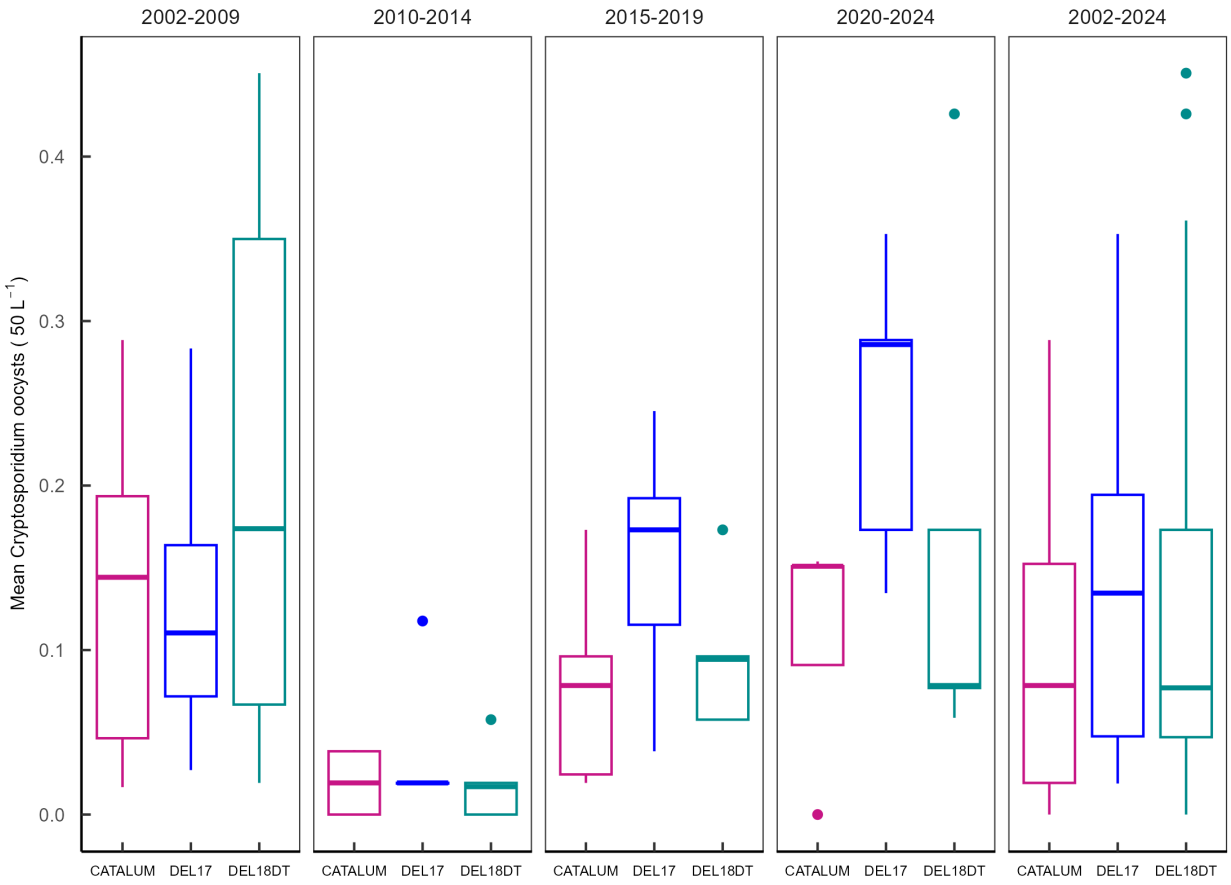


Figure 5.15 Distribution of annual means of *Cryptosporidium* concentrations at the Kensico influents and effluents for the four FAD summary and assessment report periods.

5.5.3 Discussion

DEL18DT *Giardia* patterns very closely follow the patterns at DEL17 for the entire period of 2002-2024, indicating DEL17 is the main driver of *Giardia* in Kensico. The extreme annual average maximums in 2019 and 2024 at DEL17 were less extreme at DEL18DT, indicating the Kensico Reservoir does attenuate *Giardia*. Several operational changes during the most recent five-year period of 2020-2024 affected DEL17, including West Branch mode changes and use of the Croton Falls and Cross River pump stations to divert water from those reservoirs into the Delaware Aqueduct. However, evaluation of the *Giardia* data for times when the pump stations were operating showed that the concentration at the Croton Falls and Cross River outflows were typically lower than at DEL17, and the largest *Giardia* concentrations did not coincide with the times when those noted operational changes were in effect.

Cryptosporidium patterns and averages at DEL17 and CATALUM very closely followed each other for most of the 2002-2024 period of record, but annual averages were elevated at DEL17 beginning in 2018. The recent increase in the 2024 annual mean at the Kensico outflow

(DEL18DT) did not follow patterns seen at DEL17 or DEL18DT, and therefore may be attributable to the Kensico watershed. Regardless of the recent 2024 increase, *Cryptosporidium* annual averages remained low.

Figures 5.16 and 5.17 show matrix spike (MS) recoveries at Kensico inflows and outflow for three different method periods. The first and longest period (2002-2015) used Method 1623 and Merifluor stain for the analysis of protozoa in NYC raw water. The second period was from April 2015 to August 2017 when Method 1623.1 and EasyStain became the routine method. The last period was from August 2017 to the present, when Method 1623.1 with EasyStain continued, but with heat instead of acid dissociation. This last change was specifically intended to improve *Giardia* recovery.

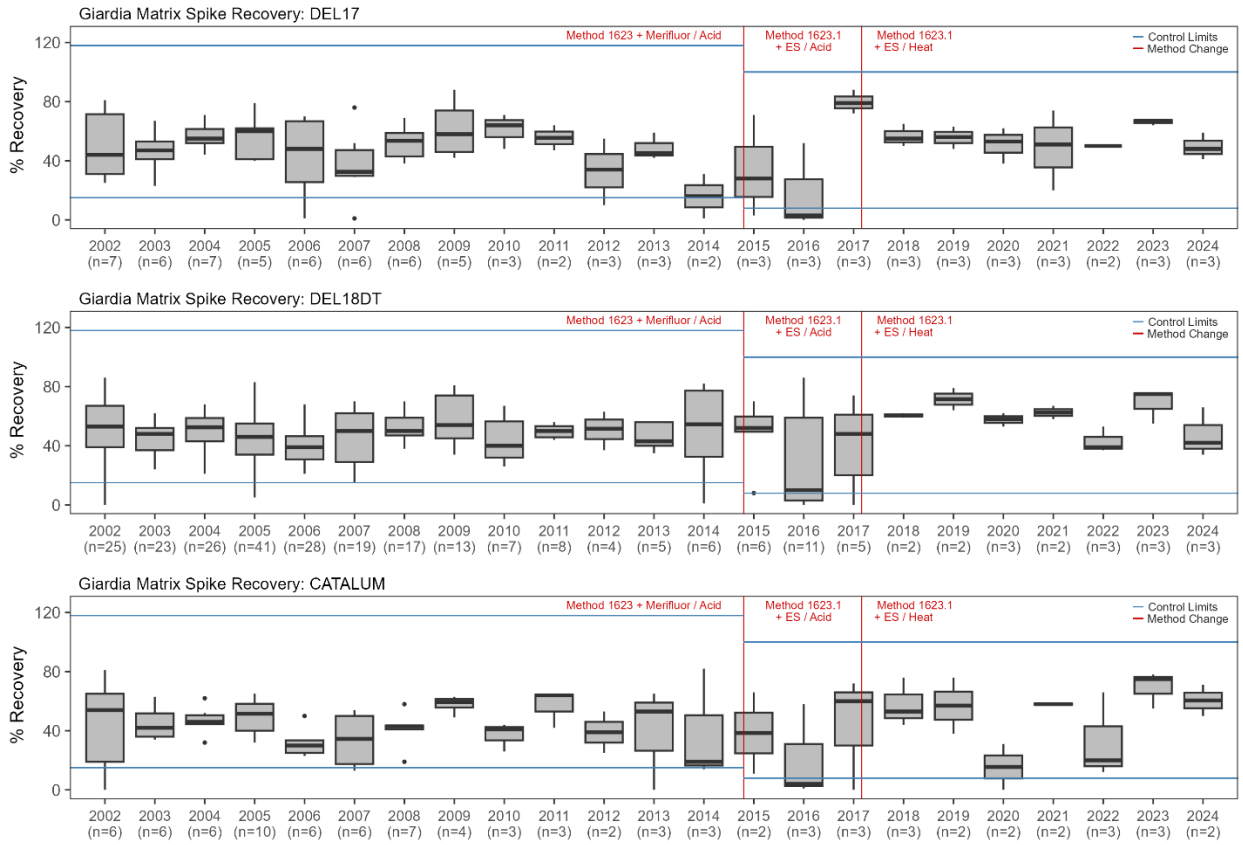


Figure 5.16 Matrix spike *Giardia* recovery percentage at Kensico Reservoir keypoints 2002-2024. Method changes in April 2015 and August 2017 are noted by the red vertical lines.

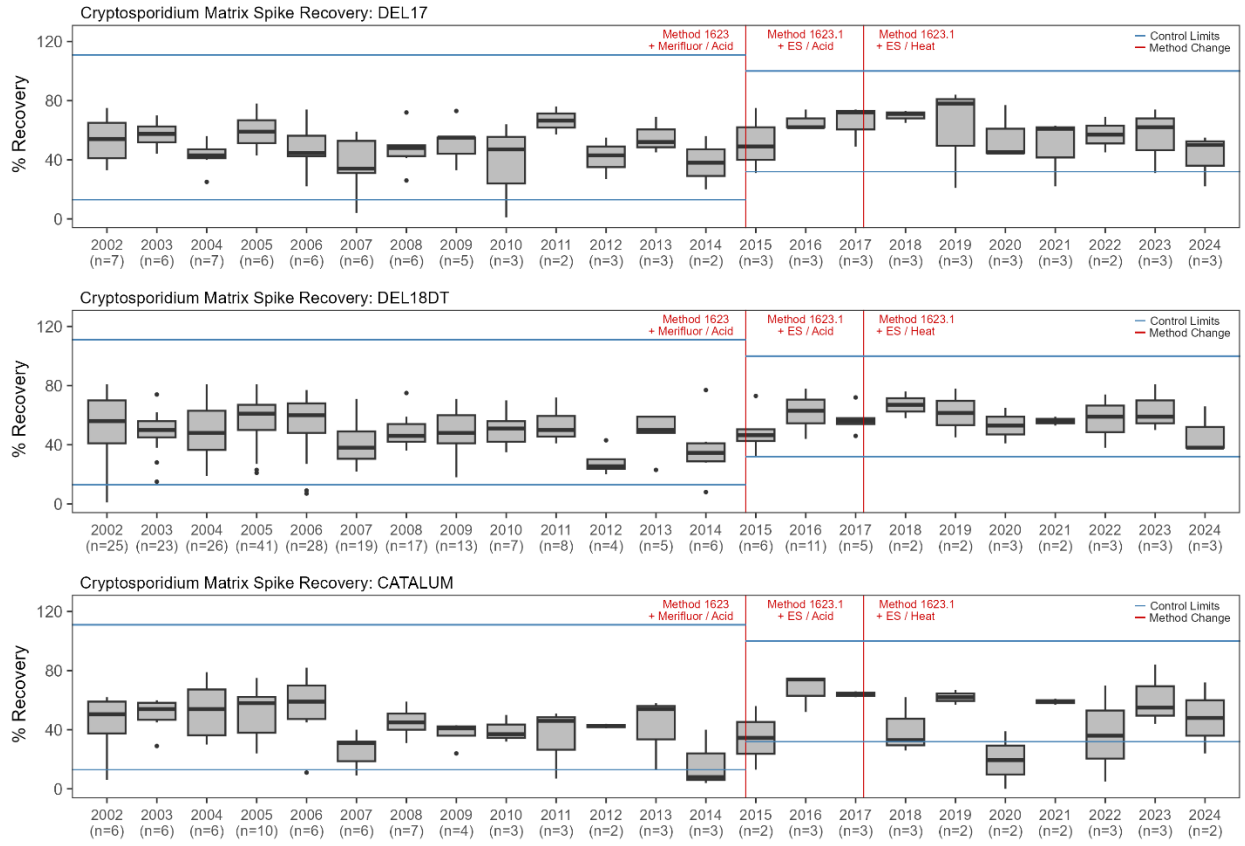


Figure 5.17 Matrix spike *Cryptosporidium* recovery percentage at Kensico Reservoir keypoints 2002-2024. Method changes in April 2015 and August 2017 are noted by the red vertical lines.

The first method change slightly improved MS recovery for *Giardia* in some samples, but continued to result in some very low recoveries. However, since the implementation of second method change (using heat rather than acid dissociation) *Giardia* recovery has improved and, as of this time, has eliminated the extremely low recoveries, with a few exceptions at CATALUM. Results thus far indicate that heat rather than acid dissociation is an improved method variation in the NYC water matrix for *Giardia.*

The impacts were different for *Cryptosporidium*. The first method change in April 2015 appears to have improved recovery of oocysts and lessened the range of the data. With one or two outliers as exceptions, the second method change to heat dissociation does not appear to have had a significant change on the MS recoveries for oocysts. At this time, it appears that heat dissociation has had no major influence on *Cryptosporidium* recovery. Similar to *Giardia* recovery, CATALUM shows the most variability in *Cryptosporidium* recovery.

Routine *Cryptosporidium* and *Giardia* sampling at reservoirs upstream Kensico were determined to no longer be necessary and are therefore not discussed in this report. Upstream

reservoirs are now sampled on an as-needed basis. The Catskill/Delaware UV Disinfection Facility continues to reduce exposure to *Cryptosporidium* and *Giardia* in the distribution system, and DEP will publish a quantitative microbial risk assessment evaluating the risk of *Cryptosporidium* exposure in 2027.

5.6 Water Quality Summary for the East of Hudson Catskill/Delaware System

Water quality in West Branch and Kensico basins continued to be excellent during the 2022-2024 assessment period. Median and peak monthly median values were all well below established water quality benchmarks for fecal coliforms, turbidity, and TP. Long-term downward turbidity trends were identified in the inflows to West Branch Reservoir and could be attributed to stormwater remediation projects. Upward TP trends were apparent at the local Croton inflows, the reservoir and the outflow. All reservoir and outflow trends were likely influenced by operational changes which control the blend of waters that comprise the reservoir. Long-term downward trends were identified for turbidity and fecal coliform for Kensico Reservoir and for its Catskill inflow (CATALUM) and outflow (DEL18DT). Long-term conductivity trends were upward in both the West Branch and Kensico basins and attributed to road deicers. A long-term increase in trophic state index was observed at West Branch while a recent decrease was identified at Kensico.

From 2022-2024, DEP conducted benthic macroinvertebrate biomonitoring on the largest inflow to the West Branch Reservoir (Horse Pound Brook), the Boyd Corners Reservoir (West Branch Croton River), and the Kensico Reservoir (Whippoorwill Creek). The mean BAP score across all sites sampled was 8.76, placing the combined system in the non-impaired category. Whippoorwill Creek was the only sample site assessed as slightly impaired across the reporting period, with a BAP score of 6.42 in 2024. All sites sampled were assessed as headwaters for the Croton region as per NYS DEC protocols, with a modifier of 1.3x added to the BAP scores of samples collected using the statewide traveling kick method and analyzed using the statewide multimetric scoring system. The overall influence of local stream input on both Kensico and West Branch Reservoir water quality is small, because the largest inputs are from the Catskill and Delaware reservoirs via the aqueducts.

Giardia annual mean concentrations have been relatively low at both the inflows and outflows, generally ranging from 0-4.9 cysts 50 L^{-1}. *Cryptosporidium* concentrations continued to be an order of magnitude lower than those for *Giardia*, making it difficult to discern differences between inflows and outflows with any level of statistical confidence. For the recent report period of 2020-2024, the annual mean *Cryptosporidium* oocyst concentrations at the Kensico source water outflow was very low, ranging from 0.06-0.4 oocysts 50 L^{-1}.

In Kensico and West Branch Reservoirs, biomass is not so clearly dependent on phosphorus, and this is likely related to short (often < 1 month) water residence times. Maximum values of chlorophyll seem to develop in years when there is no disturbance from major storms.

These two reservoirs follow the same observation of low Secchi depth values relative to phosphorus as seen in all the Catskill and Delaware System reservoirs.

In the most recent assessment period, both chlorophyll and phosphorus have remained low, with Kensico in the mesotrophic range bordering oligotrophy. The most recent years show chlorophyll values all within the 80% PI of the OECD standard, with Kensico displaying lower algal production than West Branch. Secchi depth means show little variation and are in line with phosphorus means. The same observation of low Secchi depth values relative to phosphorus as seen in the Catskill and Delaware System reservoirs was observed for the EOH Catskill and Delaware reservoirs, indicating that substances other than chlorophyll reduce transparency. In this assessment period, Secchi depths at Kensico tended to be deep indicating excellent transparency. These reservoirs, not surprisingly, reflect the same water quality characteristics seen in the other Delaware System reservoirs.

6. East of Hudson Potential Delaware System Basins

6.1 Introduction

6.1.1 East of Hudson Potential Delaware System Overview

This chapter covers the water quality history of Croton Falls and Cross River reservoirs, located in the Croton system, and shown in Figure 6.1. Croton Falls and Cross River reservoirs are included in this report because they are both equipped with pump stations that facilitate pumping water into the Delaware Aqueduct to supply Kensico Reservoir. The water in these reservoirs is therefore a supplement to Delaware water and, when in operation, undergoes additional monitoring in accordance with the Operational Guidance Plan. The Croton Falls and Cross River pump stations were re-built in 2018 and 2013, to increase capacity to 180 and 60 MGD, respectively. Pumping may be used to support system reliability during drought or operational shutdowns.

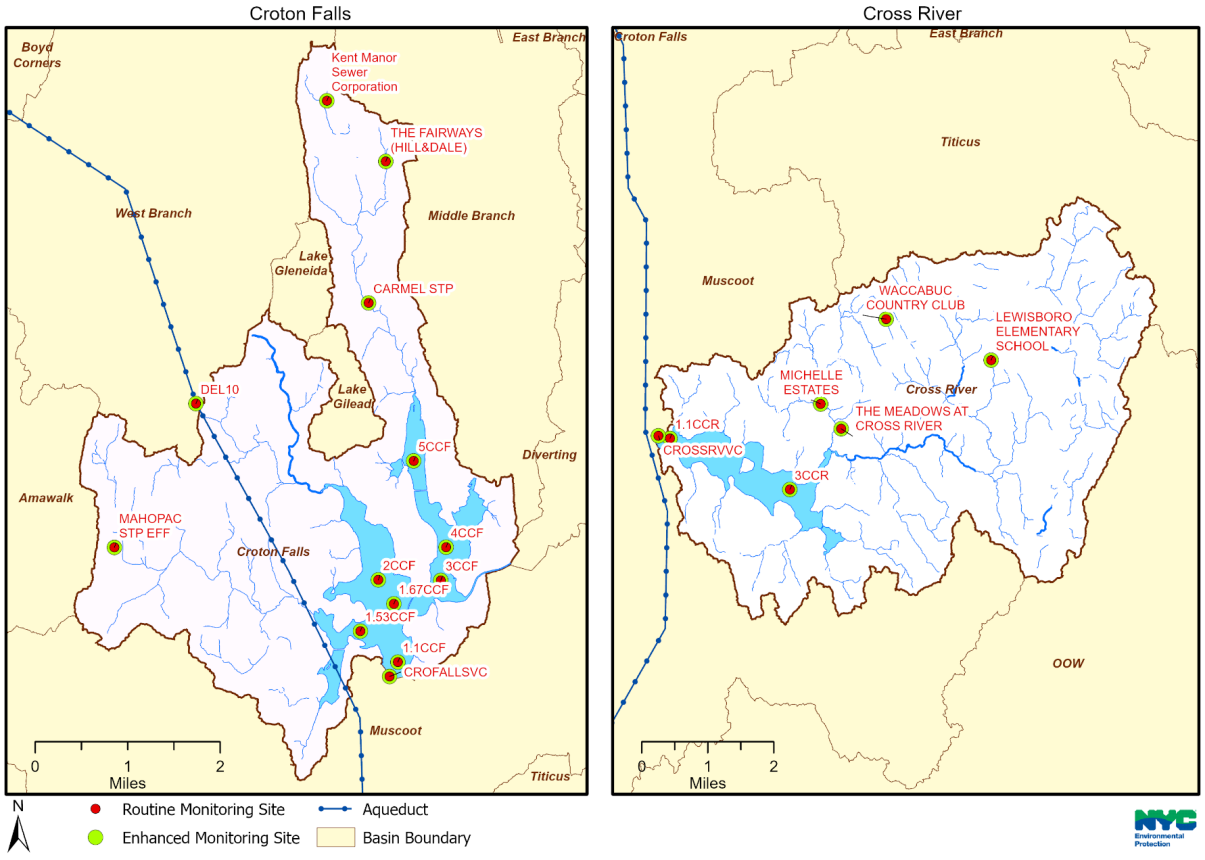


Figure 6.1 Croton Falls and Cross River Reservoir Map.

6.1.2 East of Hudson Potential Delaware System Basins Operations

The Croton Falls pump station was operated in 2019 and 2020 to supplement Kensico as part of the Catskill Aqueduct Repair and Rehabilitation project. Prior to the pump station being operated, the flow pattern at West Branch Reservoir was changed from float mode to reservoir mode as required by NYSDOH. The Croton Falls Pump Station was activated on November 11, 2019, and operated through January 22, 2020, with the exception of two brief shutdowns. Operations of the Croton Falls Pump Station resumed on February 3, 2020, to help maintain elevation at West Branch during the Rondout Effluent Chamber rehabilitation, during which time the diversion of water out of Rondout Reservoir was limited. This segment of pump station operations lasted until February 9, 2020. During the pump station operations, flows ranged from 80 to 190 MGD, with a total of nearly 11.0 BG pumped from Croton Falls into the Delaware Aqueduct.

Both pump stations were offline until 2023, when preparations began for the 2024 shutdown of the RWBT. With written approval from the NYSDOH, the Croton Falls and Cross River pump stations were utilized during two separate dewatering exercises of the tunnel. On March 6 and lasting through March 13, 2023, 75 MGD was diverted from Cross River Pump Station and 186 MGD was diverted from Croton Falls Pump Station to the Delaware Aqueduct and Kensico Reservoir. As per the NYSDOH approval, pump station use was to be discontinued if Kensico Reservoir was placed in either float or bypass operational mode, in order to prevent unfiltered Croton System water from entering the distribution system. Specific conductance data tracing was assessed after the pump station shutdown on March 13, 2023 to determine the time needed for Cross River and Croton Falls water to completely discharge into Kensico Reservoir. DEP found approximately eight and one-half hours were required for complete discharge, and this timeframe was used as a guide during the 2024 RWBT shutdown.

From October 16 through November 5, 2023, Croton Falls and Cross River pump stations were used during another dewatering exercise. Croton Falls diverted up to 180 MGD and Cross River diverted up to 69 MGD to the Delaware Aqueduct and Kensico Reservoir.

Pump stations were used again from October to December 2024, during the RWBT shutdown to maximize usage of the Catskill and Croton systems. Croton Falls Pump Station was used from October 1, 2024 to November 21, 2024, and again from November 26 through December 12, 2024. The Croton Falls Pumping Station had a brief stoppage in service on October 29, 2024 and November 10, 2024, due to power interruptions. There was also a four-day shutdown from November 21through 24, 2024, to maintain the target elevation at Kensico Reservoir. The Cross River Pump Station was used from October 1, 2024 to November 21, 2024, with a brief stoppage in service on October 1 through November 12, 2024, due to power interruptions. All pump station operations were summarized in after-action reports and submitted to NYSDOH.

6.1.3 Water Quality Trending and Assessment

Water quality trending requires a much longer time period than the current five-year reporting period. Trend assessment in this report includes data from 1993 through 2024 and allows an examination of changes over the past 32 years in the context of changes made through protection programs, as well as through natural variation. Status and trends were assessed at Croton Falls and Cross River reservoirs, and their major inflows and outflows. The current water quality status assessment of each basin used aggregated data from the last three years of available data (2022-2024). The trophic response of each reservoir and biological assessment profile score at CROSS2 were also assessed using standard criteria. Appendix C provides more detail on statistical and data collection methods.

6.2 Cross River Basin

The Cross River Reservoir is located in northeastern Westchester County about 25 miles north of the New York City limits. It was formed by damming the Cross River, which flows westward to the Muscoot Reservoir. It was placed into service in 1908. The reservoir consists of one basin, approximately 3.2 miles in length, and holds 10.4 billion gallons at total capacity. Water from the reservoir flows into Cross River and then to Muscoot and New Croton reservoirs. After travelling through the 24-mile New Croton Aqueduct, the water reaches Jerome Park Reservoir and the Croton Water Filtration Plant where it enters New York City's distribution system.

Cross River Reservoir's watershed is 30 square miles in Westchester County, NY with a small part in Fairfield County, CT. Land use in the Cross River watershed consists of 59.1% forested, 28.1% urban, 2.3% brushland, 7.3% water, and 3.2% in agricultural use.

6.2.1 Water Quality Status and Trends in the Cross River Watershed

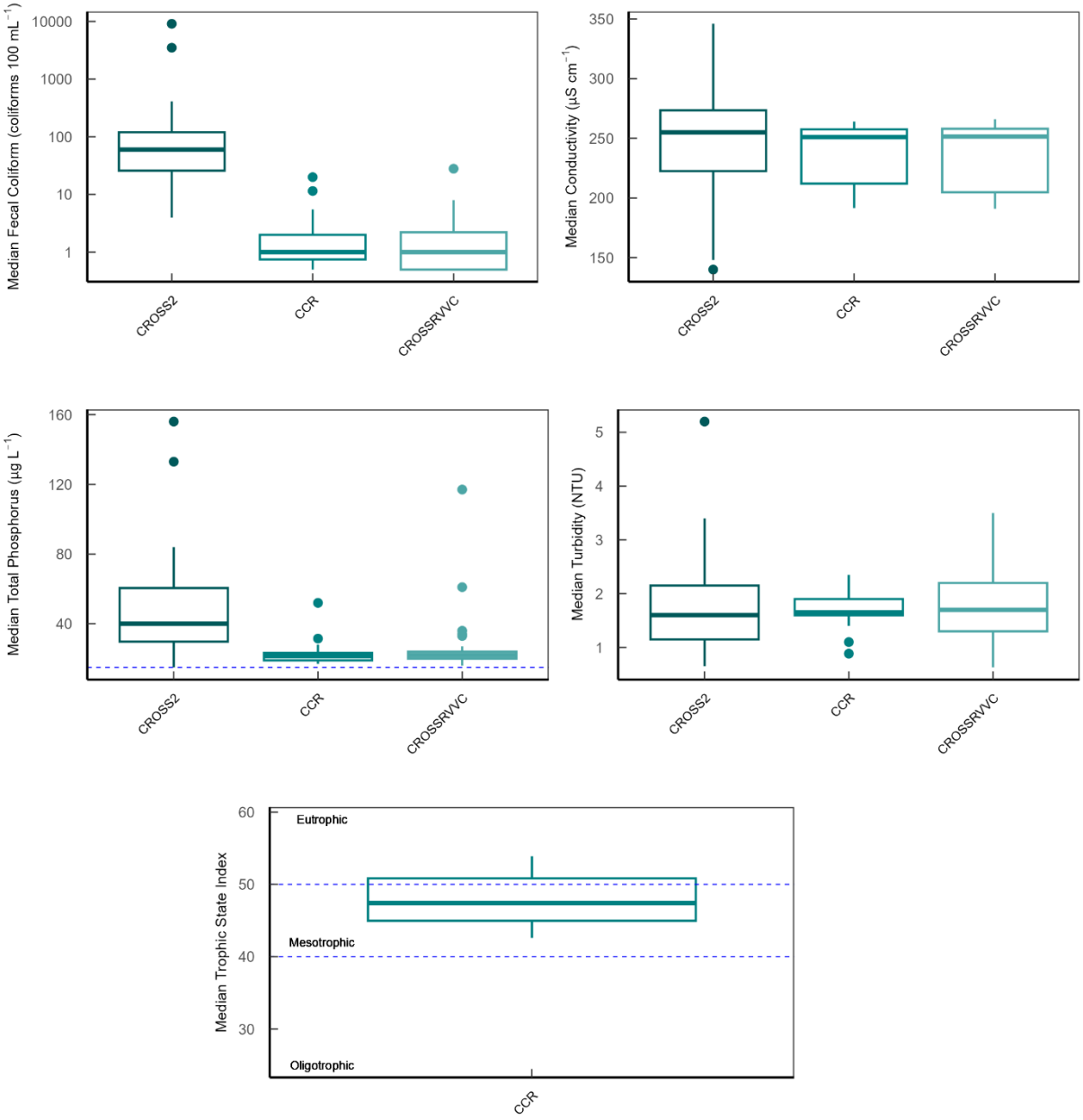
Status (Cross River)

The Cross River basin status evaluation is presented as a series of boxplots in

Figure 6.2, which compare the inflow (CROSS2), reservoir (CCR), and the outflow (CROSSRVVC). For details on methodology and boxplot interpretation, see Appendix C.

For the status evaluation period (2022-2024), median monthly fecal coliform bacteria exceeded the NYSDEC Stream Guidance Value of 200 fecal coliforms 100 mL^{-1} on five occasions in the three-year period, with the highest exceedances in August 2024 and September 2022 (9100 and 3500 fecal coliforms 100 mL^{-1}, respectively at CROSS2). Reservoir (CCR) and outflow (CROSSRVVC) fecal coliforms were low throughout the evaluation period (medians at or below the detection limit of 1 fecal coliform 100 mL^{-1}). Conductivity was highest at the inflow (255 µS cm^{-1}) and slightly lower in the reservoir and outflow (medians of 251 and 252 µS cm^{-1}, respectively). Median monthly TP for the input was 40 µg L^{-1}. Reservoir and outputs were equivalent at 22 µg L^{-1}. Most reservoir values were above the target value of 15 µg L^{-1} for source waters (NYCRR Subchapter D, 18-48 b.1.). Turbidity was generally low at all sites, and

Figure 6.2 Water quality status boxplots using 2022-2024 monthly data for the Cross River



basin main inflow at Cross River (CROSS2), Cross River Reservoir (CCR), and the outflow at the Cross River release (CROSSRVVC).

reservoir (CCR) monthly medians ranged from 1.6 to 1.7 NTU, with one median value above the SWTR limit of 5 NTU (CROSS2 on August 7, 2024 at 5.2 NTU). The TSI values for Cross River Reservoir fell primarily within the mesotrophic range, with a median of 47.

Trends (Cross River)

Water quality trend plots form the Cross River basin are presented in

Figure 6.2 and results of the SKT and TDA analysis are provided in Table 6.1.

A long-term downward turbidity trend was identified for the inflow to Cross River Reservoir, the Cross River Reservoir, and the output from the reservoir. The magnitude of the trend is minimal, except for when adjusting for flow at CROSS2.

The two statistical methods for trend detection provide conflicting evidence of a trend in fecal coliform in the input, reservoir, or output. The trend direction assessment technique spans the entire period of record, and indicates a decreasing trend, especially certain in the output. The LOWESS technique points to more recent upswings at the input, reservoir and output. The output site was moved to a protected location within a shaft building in 2013, coinciding with the sudden drop in coliform counts shown in Figure 6.3.

Long-term upward TP trends were identified for the inflow, reservoir, and outflow. Storm events occurring during the 2010-2014 period caused TP to increase which was sustained by above average flow in 2018 and 2019. High TP values generally occurred during fall months when phosphorus is released from reservoir sediments under conditions of anoxia.

Upward long-term trends in conductivity were identified for all sites in the Cross River basin. Increased usage of road salt deicers and subsequent groundwater contamination are likely the most important factors influencing this trend. Short-term trend detection by LOWESS demonstrates a recent downturn. It appears the reservoir acts to dampen the variability seen in the input, which is likely most directly driven by year-to-year hydraulic changes. Drought conditions caused the large increases observed in 2001-2002 and in 2016 while the downturns in 2003-2006 and 2018-2019 were associated with very wet years. High values in the output in 1997 were due to drawdown from dam repair work.

A long-term upward trend was identified for TSI although intermittent downturns occurred in 2004, 2005, and 2015. The long-term increase generally coincides with the increasing TP observed for the inflow. Earlier in the record, the relatively high value in 2001 appears to be a temporary response to refilling the reservoir in 1998 and drought in 2001-2002.

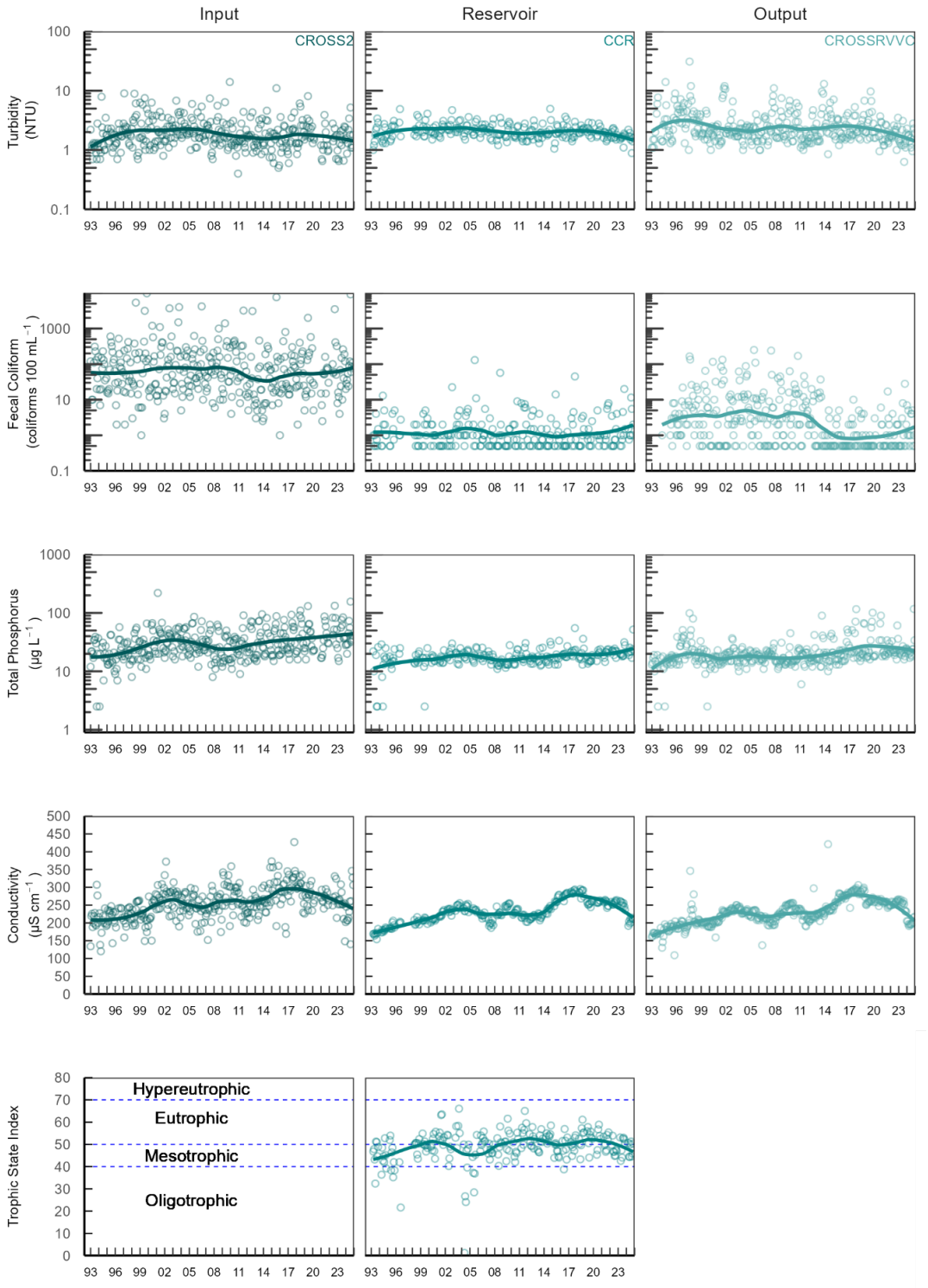


Figure 6.3 Water quality trend plots for the Cross River basin main inflow at Cross River (CROSS2), Cross River Reservoir, and the outflow at the Cross River release (CROSSRVVC).

Table 6.1 Cross River Basin (inflow, reservoir, and outflow) trend results for 1993 – 2024.

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
CROSS2	Input	Turbidity	364	**	-0.008	-0.471	Decreasing trend likely
CROSS2	Input	Turbidity (Flow Adj.)	335	***	-0.02	-1.1083	Decreasing trend virtually certain
CROSS2	Input	Fecal Coliform	359	*	-0.2	-0.3448	Decreasing trend possible
CROSS2	Input	Fecal Coliform (Flow Adj.)	332	NS	-1.011	-1.7729	Decreasing trend possible
CROSS2	Input	Total Phosphorus	358	***	0.5	1.8182	Increasing trend virtually certain
CROSS2	Input	Total Phosphorus (Flow Adj.)	330	***	0.457	1.575	Increasing trend virtually certain
CROSS2	Input	Conductivity	360	***	2.222	0.8732	Increasing trend virtually certain
CROSS2	Input	Conductivity (Flow Adj.)	330	***	1.966	0.7633	Increasing trend virtually certain
Cross River	Reservoir	Turbidity	241	***	-0.012	-0.625	Decreasing trend virtually certain
Cross River	Reservoir	Fecal Coliform	240	NS	0	0	Trend extremely unlikely
Cross River	Reservoir	Total Phosphorus	232	***	0.143	0.816	Increasing trend virtually certain

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
Cross River	Reservoir	Conductivity	238	***	2.432	1.057	Increasing trend virtually certain
Cross River	Reservoir	Trophic State Index	231	***	0.097	0.1944	Increasing trend very likely
CROSSRVVC	Output	Turbidity	374	***	-0.018	-0.882	Decreasing trend virtually certain
CROSSRVVC	Output	Fecal Coliform	346	***	-0.055	-2.7282	Decreasing trend virtually certain
CROSSRVVC	Output	Total Phosphorus	366	***	0.2	1.081	Increasing trend virtually certain
CROSSRVVC	Output	Conductivity	374	***	2.634	1.150	Increasing trend virtually certain

[1]The p-values for each trend test are symbolized as follows:
*NS (Not Significant) = p ≥ 0.20, * = p < 0.20, ** = p < 0.10, *** = p < 0.05.*

6.2.2 Biomonitoring in the Cross River Watershed

The DEP Stream Biomonitoring Program uses protocols developed by the NYSDEC to assess the health of stream macroinvertebrate communities in watershed streams. Stream impairment is assessed via a multi-metric BAP score derived from stream macroinvertebrate assemblages. For full methodology details including headwater adjustment methods as established by NYSDEC in 2018, see Appendix C.

The most recent status of macroinvertebrate communities in the Cross River watershed was evaluated by the analysis of one sample collected in 2024 from site 123 (CROSS2) on Cross River before it drains into the Cross River Reservoir in Lewisboro. The BAP score of 6.59 places the stream in the slightly impaired category, consistent with samples from 2012 (5.68) and 2017 (6.37).

6.3 Croton Falls Basin

Croton Falls Reservoir is located in the Towns of Carmel and Southeast, more than 30 miles north of New York City. The reservoir was formed by damming the West and Middle Branches of the Croton River, which flow south and drain into Muscoot Reservoir, and then New Croton Reservoir. The reservoir consists of three basins, separated by causeways. Water flows between basins through culverts under the roadways. Croton Falls Reservoir holds 14.0 billion gallons at total capacity and was placed into service in 1911.

The Croton Falls drainage basin is 16 square miles and land use consists of 50.2% forested, 36.9% urban, 1.8% brushland or successional land, 0.3% in agricultural and 10.7% water. Sampling sites at Croton Falls Reservoir are shown in Figure 6.4.

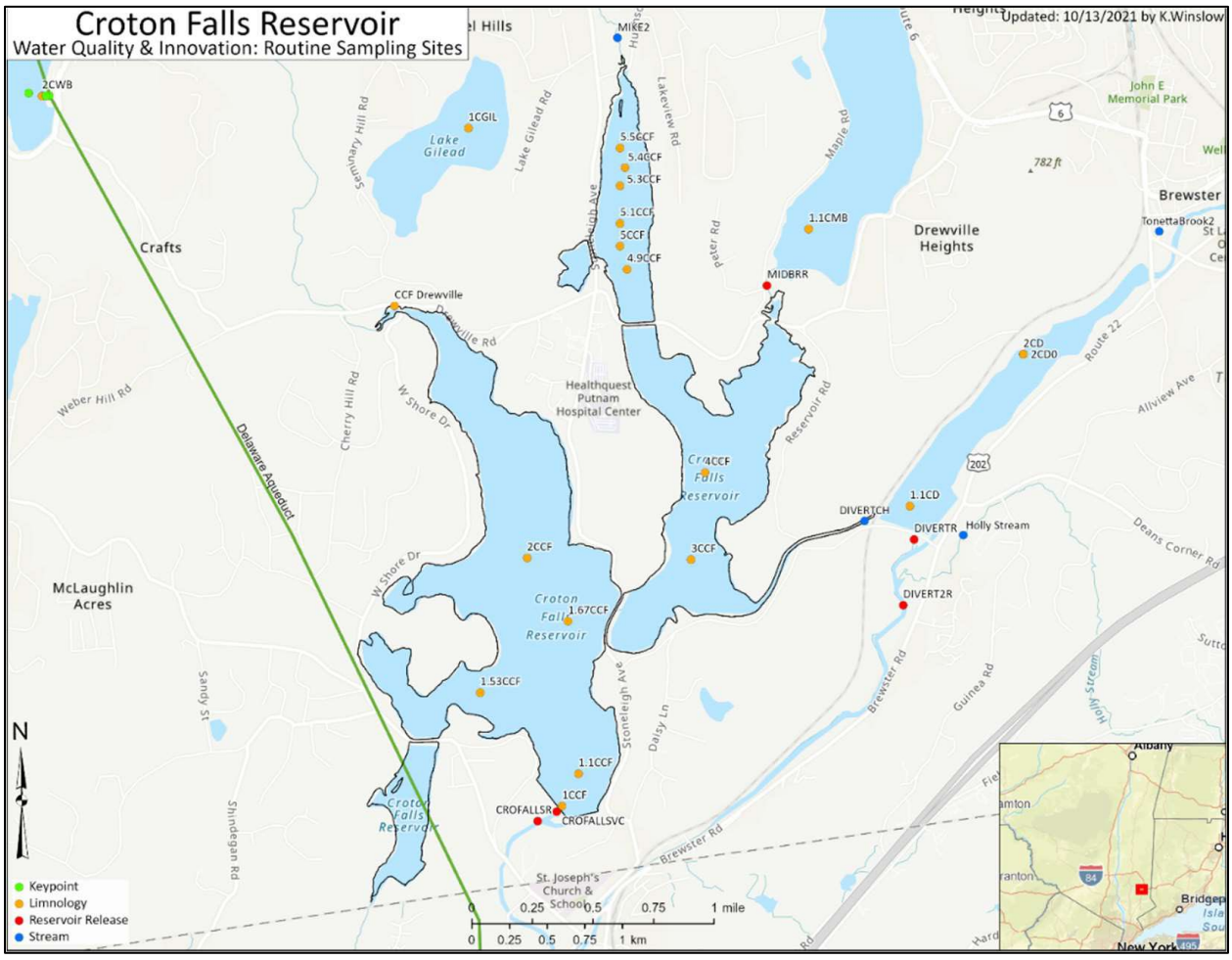


Figure 6.4 Croton Falls Reservoir map and sampling sites.

6.3.1 Water Quality Status and Trends in the Croton Falls Watershed

Status (Croton Falls)

The Croton Falls Reservoir status evaluation is presented as a series of boxplots in Figure 6.5. The main input to Croton Falls Reservoir (CCF) is the West Branch Reservoir Release (WESTBRR). The outflow site is the Croton Falls Valve Chamber (CROFALLSVC).

For the status evaluation period (2022-2024), monthly median fecal coliforms did not exceed the NYSDEC Stream Guidance Value of 200 fecal coliforms 100 mL^{-1} for the WESTBRR inflow site. Fecal coliforms were low in the reservoir (CCF), with no exceedances of the guidance value of 20 fecal coliforms 100 mL^{-1} (NYCRR Subchapter D, 18-48 c.1.). Conductivity was highest in reservoir (CCF) with a monthly median of 397 µS cm^{-1}. Median monthly reservoir TP was 23 µg L^{-1}. Turbidity was low at all sites, with a monthly median of 1.7 NTU in the reservoir (CCF). The TSI values for Croton Falls Reservoir ranged from mesotrophic to eutrophic, with a median of 52.

Trends (Croton Falls)

Water quality trend plots for the Croton Falls basin are presented in Figure 6.6 and results of the SKT and TDA analysis are provided in Table 6.2.

The hydrology of Croton Falls is very complex; the reservoir receives inflows from its local watershed via an unnamed stream, which is not monitored, the West Branch Reservoir release (WESTBRR), Diverting Reservoir via a channel, and from the Middle Branch Reservoir outflow. The West Branch inflow is a mixture of waters from West Branch, Boyd Corners and Rondout reservoirs, the proportions of which are determined by the operational status of the Delaware Aqueduct. WESTBRR is used here as the primary inflow into Croton Falls Reservoir.

A downward turbidity trend was identified for the reservoir, but the magnitude of this trend is minimal. Changes observed at CROFALLSVC outflow may be an artifact of a sampling location change. Commencing in 2013, the sample was collected in the shaft building at the base of the dam. Previously it had been collected outside of the Shaft building in the stream formed by the reservoir release (CROFALLSR). The sporadic high values shown in the plot occurred in late summer and fall and are probably due to the aeration of anoxic water, which will produce turbidity when dissolved iron particles quickly precipitate out of solution.

Downward trends were identified for fecal coliforms in the inflow from West Branch Reservoir (WESTBRR) and in the main basin of Croton Falls Reservoir. The downturn at the outflow after 2013 is likely due to the aforementioned sample location change to the Shaft building.

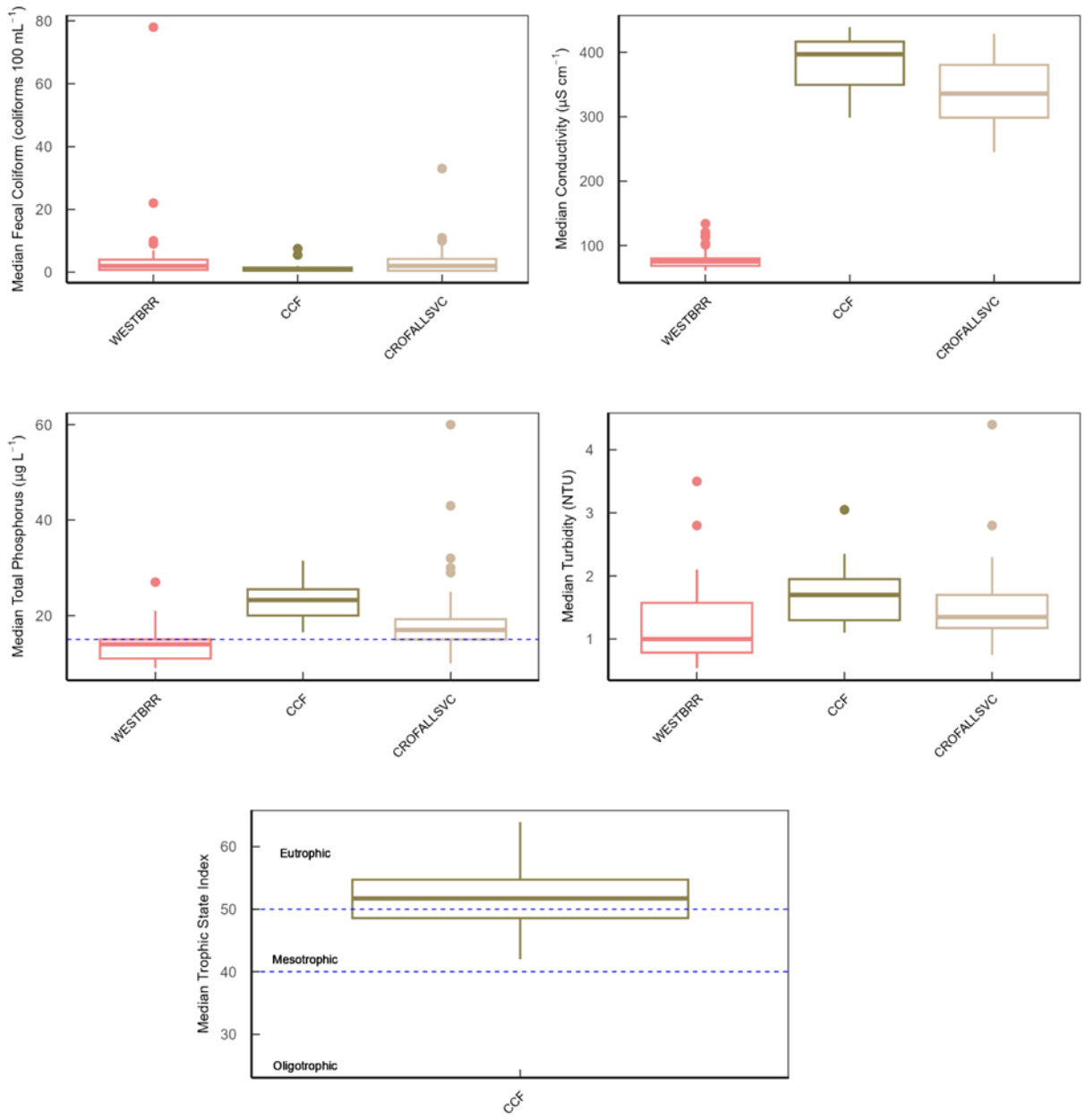


Figure 6.5 Water quality status boxplots using 2022-2024 monthly data for the Croton Falls basin inflow from the West Branch release (WESTBRR), the Croton Falls Reservoir (CCF), and the outflow at the Croton Falls release (CROFALLSVC).

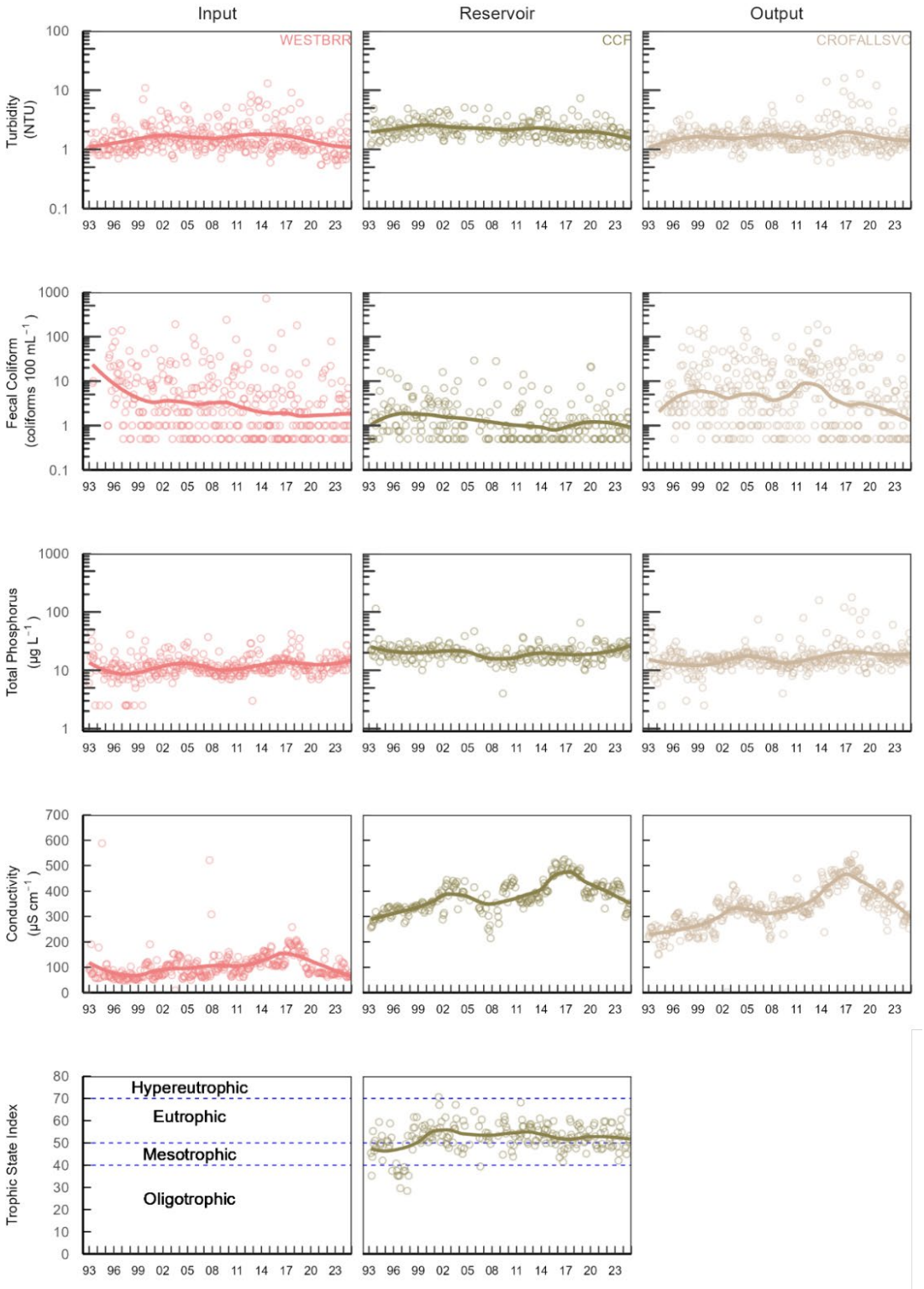


Figure 6.6 Water quality trend plots for the Croton Falls basin inflow from the West Branch release (WESTBRR), Croton Falls Reservoir (CCF), and the outflow at the Croton Falls release (CROFALLSVC).

Table 6.2 Croton Falls Basin (inflows, reservoir, and outflow) trend results for 1993 – 2024.

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
WESTBRR	Input	Turbidity	365	NS	0	0	Decreasing trend possible
WESTBRR	Input	Fecal Coliform	335	***	-0.071	-3.5714	Decreasing trend virtually certain
WESTBRR	Input	Total Phosphorus	351	***	0.1	0.9091	Increasing trend virtually certain
WESTBRR	Input	Conductivity	361	***	1.375	1.5027	Increasing trend virtually certain
Croton Falls	Reservoir	Turbidity	242	***	-0.017	-0.8333	Decreasing trend virtually certain
Croton Falls	Reservoir	Fecal Coliform	242	***	0	0	Decreasing trend virtually certain
Croton Falls	Reservoir	Total Phosphorus	230	NS	0	0	Decreasing trend about as likely as not
Croton Falls	Reservoir	Conductivity	240	***	3.9	1.04	Increasing trend virtually certain
Croton Falls	Reservoir	Trophic State Index	221	*	0.062	0.1173	Increasing trend possible
CROFALLSVC	Output	Turbidity	379	NS	0	0	Trend exceptionally unlikely
CROFALLSVC	Output	Fecal Coliform	348	***	-0.068	-1.7045	Decreasing trend virtually certain

Site	Description	Variable	N	*p*-value[1]	Sen Slope	Percent Change yr^{-1}	Trend Direction Assessment
CROFALLSVC	Output	Total Phosphorus	367	***	0.143	0.9524	Increasing trend virtually certain
CROFALLSVC	Output	Conductivity	371	***	6	1.8127	Increasing trend virtually certain

[1]The p-values for each trend test are symbolized as follows:
*NS (Not Significant) = p ≥ 0.20, * = p < 0.20, ** = p < 0.10, *** = p < 0.05.*

Upward TP trends were identified for the inflow and outflow, but the two trend approaches (LOWESS vs SKT/TDA) deviate on detection of a trend in reservoir. The increase at the WESTBRR inflow was relatively small and likely related to operational changes upstream at the West Branch Reservoir.

As indicated by the LOWESS curve, conductivity in the outflow increased from approximately 220 µS cm^{-1} in 1993 to 450 µS cm^{-1} in 2019. Similar increases were apparent for the reservoir's main basin, and to a lesser extent, the middle basin inflow. Increasing conductivity in the Croton Falls basin is likely due to increases in development activity, principally from road salt (Heisig 2000, Van Dreason 2011). A smaller increase was detected in the West Branch outflow. This increase was probably due to Delaware Aqueduct operational changes that increased the relative contribution of Croton inputs to West Branch Reservoir during the latter half of the data record. The truly interesting observation in the LOWESS from the recent period is a recent partial "recovery". The recent decreasing trend is likely the result of operational changes made in preparation for the Rondout West Branch Tunnel shutdown. This included a pilot "rinse", where DEP operationally sent more low conductivity water from West Branch into Croton Falls. Rinses occurred in July and September 2021.

6.3.2 Biomonitoring in the Croton Falls Watershed

The DEP Stream Biomonitoring Program uses protocols developed by the NYSDEC to assess the health of stream macroinvertebrate communities in watershed streams. Stream impairment is assessed via a multi-metric BAP score derived from stream macroinvertebrate assemblages. For full methodology details including headwater adjustment methods as established by NYSDEC in 2018, see Appendix C.

The most recent status of macroinvertebrate communities in the Croton Falls watershed was evaluated by an analysis of one sample collected in 2022 from site 130 (MIKE2) on Michael Brook in Putnam County, and one sample collected in 2024 from site 150 on an unnamed tributary to the Croton Falls Reservoir. Site 130 was assessed as non-impaired, and site 150 was

assessed at the higher end of slightly impaired. Both scores were adjusted with a 1.3x modifier applied as the streams fit the NYS DEC headwater designation for the region by having a drainage under 16 km^2. Neither site has a sufficient time series dataset for long-term analysis.

6.4 Trophic Response of Croton Falls and Cross River Basins

A series of four plots were used to examine the trophic response of Croton Falls and Cross River Reservoirs. Chlorophyll vs TP in the Croton Falls and Cross River Reservoirs is plotted in Figure 6.7. In 2004 and 2005, tropical storms and heavy precipitation depressed chlorophyll levels in both Croton Falls and Cross River reservoirs. In contrast, 2001 to 2003, 2006, and 2011 were years when standing crops of algae tended to be high. These years included a drought during the 2001 to 2003 time period and the remaining years (2006 and 2011) were influenced by fall tropical storms in the preceding season and again in the fall of the years noted. The current assessment period indicates that Croton Falls and Cross River are similar in nutrient and algal concentrations.

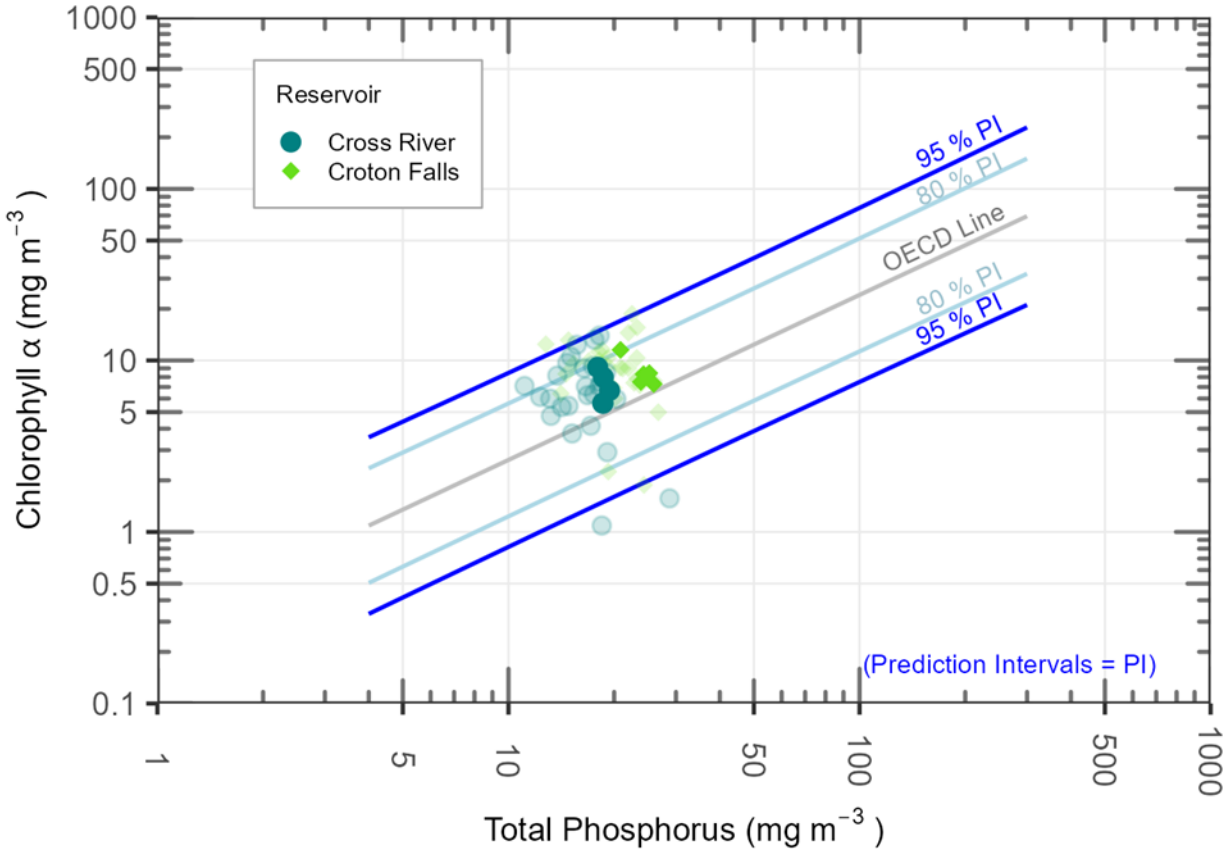


Figure 6.7 Chlorophyll vs TP in Croton Falls and Cross River Reservoirs.

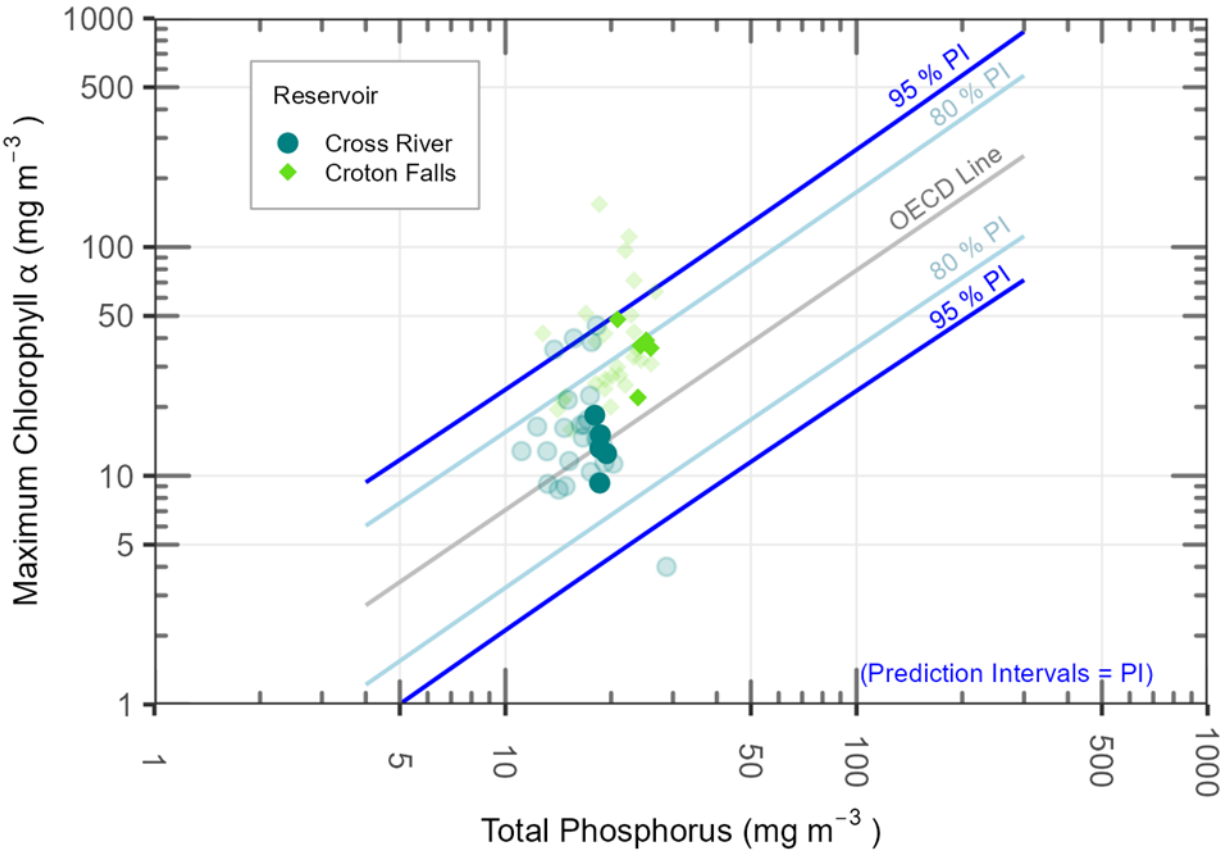


Figure 6.8 Maximum chlorophyll vs TP in Croton Falls and Cross River Reservoirs.

The annual maximum value of chlorophyll vs TP is plotted for each year in Figure 6.8. Again, 2001 through 2003 and 2006 stand out as years with high chlorophyll in both Croton Falls and Cross River. Both the lack of disturbance during drought and heavy precipitation in advance of the growing season are conditions that apparently lead to high standing crops of algae. Croton Falls and Cross River react to precipitation events in approximately the same way. The most recent years show all of five years are within the 95% PI.

Secchi depth vs total phosphorus annual mean values are plotted in Figure 6.9. Similar to other Catskill and Delaware reservoir plots, the Secchi depths are approximately described by the phosphorus levels, but the values all lie below the standard. Non-phosphorus bearing particles may therefore contribute to limiting transparency. Cyanobacterial blooms commonly observed at site five in Croton Falls contribute to low transparency. For Cross River, the highest phosphorus level and most shallow Secchi depth occurred in 1996 when Tropical Storm Bertha affected the area.

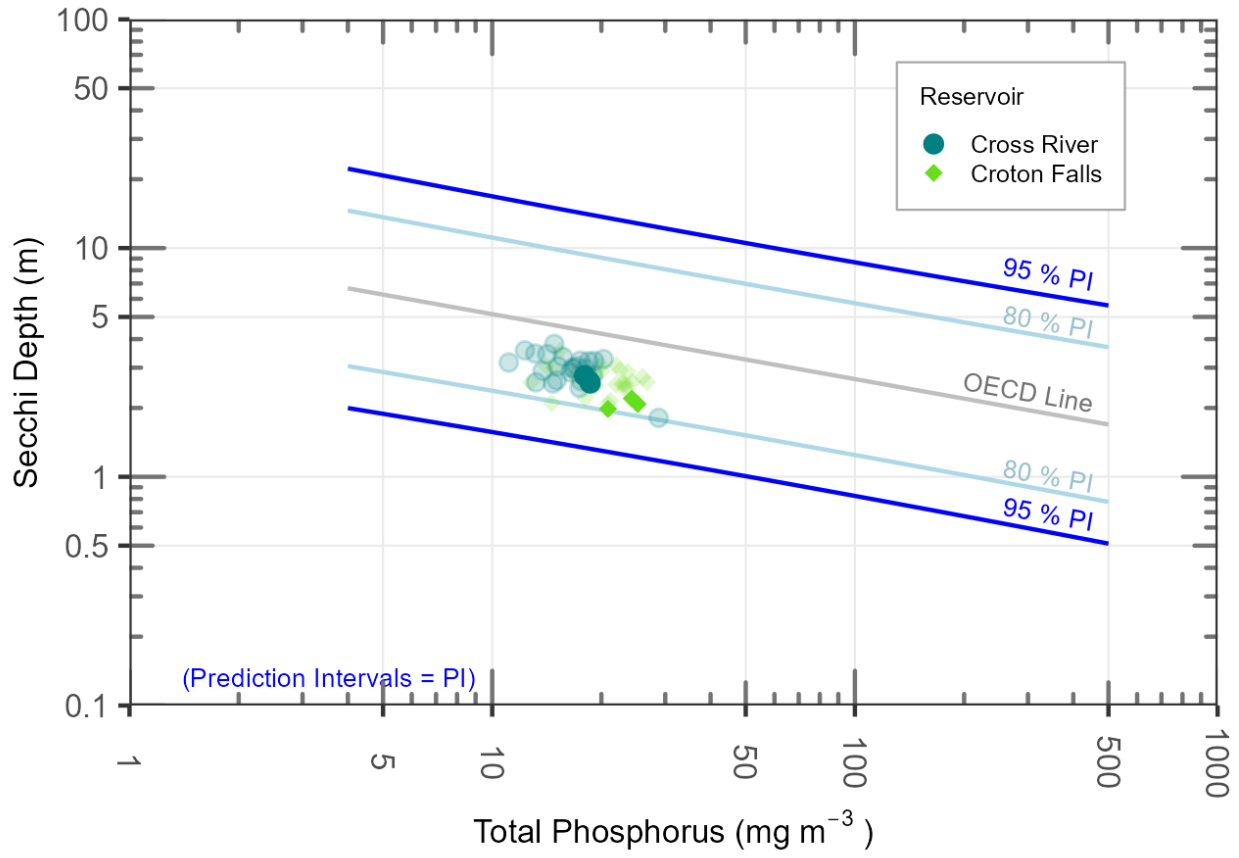


Figure 6.9 Secchi depth vs TP in Croton Falls and Cross River Reservoirs.

Secchi depth vs chlorophyll is plotted in Figure 6.10. This plot demonstrates that transparency of these reservoirs is typically governed by algal growth. Nearly all points approximately conform to the OECD relationship and fall within the 80 % confidence intervals. The greatest variation for Cross River occurred in 2004 when there was exceptionally low chlorophyll coincident with atypical Secchi depth. Tropical Storm Frances and Hurricane Ivan occurred in September of that year and seem to have affected the mean transparency. Years with Secchi depths less than expected seem to be 1993, 1994, and 2005 indicating transparency was influenced by non-algal particles. In 2001 to 2003, drought conditions resulted in Secchi depths tending to be slightly deeper than expected at the chlorophyll levels observed, so settling may have contributed to minimal levels of non-algal particles in these years. The most recent years lie surprisingly close to the OECD line demonstrating the close relationship of transparency to the level of algae present.

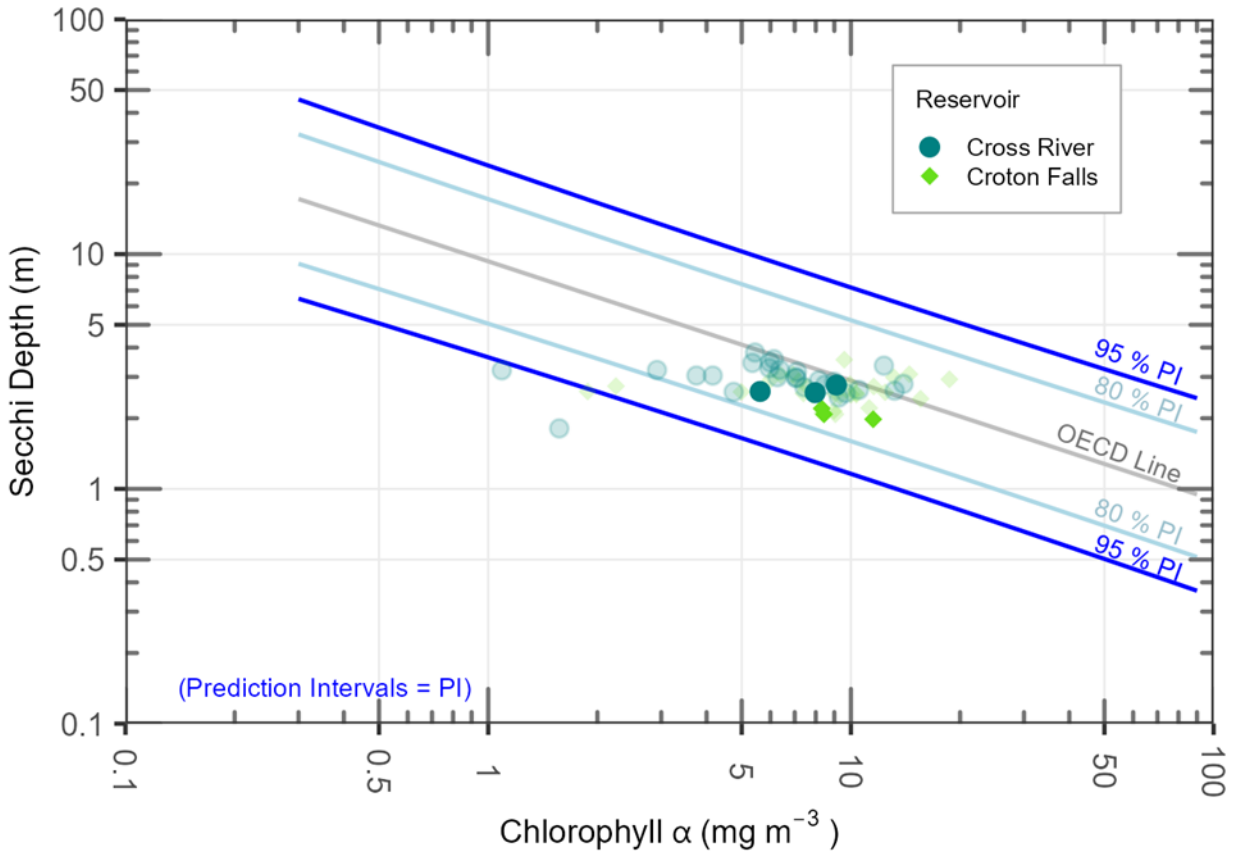


Figure 6.10 Secchi depth vs chlorophyll in Cross River and Croton Falls Reservoirs.

6.5 Water Quality Summary for Potential Delaware System Basins

Water quality status for the assessment period (2022-2024) for Croton Falls and Cross River basins was generally good with few extreme events during the period (noting that Tropical Storm Ida occurred in September 2021, just prior to the status evaluation period). Fecal coliform levels were low in both reservoirs, although recent years show in increase in Cross River. With fecal coliform and turbidity values being mostly affected by spring runoff and late summer storms, the pump stations are least likely to be available for resiliency at those time periods. Turbidity in both basins was generally low. TP monthly medians for the reservoirs were above the target value of 15 µg L^{-1} for source waters. The median Trophic State Index was primarily in the eutrophic range for Croton Falls Reservoir and mesotrophic in Cross River Reservoir.

From 2022-2024, DEP conducted benthic macroinvertebrate biomonitoring on the largest inflow to the Cross River Reservoir (Cross River) and two inflows to the Croton Falls Reservoir (Michael Brook and an unnamed Croton Falls Tributary). The mean score for the combined EOH Potential Delaware region was 7.39, on the high end of slightly impaired. While the two Croton Falls sites were assessed as non-impaired, Cross River was assessed as slightly impaired with a

score of 6.59. This is consistent with the mean BAP score for the site over the period of record since 1998 (6.70).

The current assessment period indicates that the basins of Cross River and Croton Falls are similar in water quality regarding nutrient and algal concentrations. Operational intentional release of West Branch water to Croton Falls may be beneficial for the very recent reduction in specific conductance but this should be separated from overall hydraulic patterns as a genuine cause. This period likely also shows better conductivity because West Branch Reservoir has been placed in reservoir operational mode more frequently than prior periods, where the float operational mode was frequently used. As a result, West Branch takes more of the characteristics of Rondout Reservoir than Boyd Corners Reservoir, which cascades to improve water quality in Croton Falls Reservoir

The Croton Falls and Cross River reservoirs are important options for water quality and quantity augmentation. Water quality in these reservoirs is trending, as might be expected, for a highly populated region. Watershed protection programs are described in other sections and have allowed for the continued use of these basins for operational purposes.

7. Modeling Evaluation

7.1 Overview

DEP's multi-tiered water quality modeling program develops, tests and applies models that use historic and future climate data to simulate individual watersheds, reservoirs and the entire water supply system. Models are used to evaluate the impact of climate change on the water supply, to assess the impact of watershed protection programs on drinking water quality, and to guide day-to-day reservoir operations as well as to plan for the long-term reliability of the system.

During the current FAD assessment period, DEP developed SWAT models for the six WOH watersheds capable of simulating streamflow and nutrient loads (nitrogen and phosphorus). Here, we report on the impacts of recent changes in the WOH watersheds, including estimated trends in manure nutrient production, soil phosphorus content, and water quality. Several scenarios using SWAT model were conducted to evaluate the relative impacts of existing best management practices on water quality at the sub-basin scale. The two sub-basins chosen for these analyses were the Town Brook and West Branch Delaware Headwaters within the Cannonsville watershed.

DEP has continued extensive monitoring, modeling, and special studies to investigate sources, quality, and composition of organic matter in the water supply. Monitoring of UV254 has been expanded to all six primary inflows sites in the WOH watersheds. Additionally, diversions from Cannonsville, Neversink, and Rondout reservoirs are now continuously monitored for UV254. General additive models were developed to predict daily DOC concentrations in the six primary inflowing streams into WOH reservoirs. DEP also validated empirical models for predicting daily five haloacetic acid formation potential (HAA5fp) and total trihalomethane formation potential (TTHMfp) in West Branch Delaware and Neversink rivers. Ecosystem (TASC-Forest) and watershed (SWAT-Carbon) models were developed to simulate fluxes of carbon through ecohydrological system.

To understand the fate and transport of organic matter in reservoirs, two-dimensional models of UV254 for Cannonsville, Neversink, Ashokan, and West Branch Reservoirs were completed. A special study investigated the transport of organic matter during storm events in the Neversink watershed. In this study, the role of lignin as DBP precursor was also quantified. During the current FAD assessment period, DEP also performed several OST-water quality model simulations. These simulations helped managers effectively manage the water supply system during elevated turbidity events in the watershed.

Compared to the Esopus Creek watershed, contribution of Shandaken Tunnel to the total turbidity loading into Ashokan Reservoir remained low (~ 5%). Climate scenarios for impact assessment models were developed using CMIP6 climate projections. Additionally, a

methodology was developed to correct for Global Climate Model (GCM) underestimation of multiyear precipitation variability.

7.2 Source Water Protection Programs Evaluation

During the current FAD assessment period, DEP's modeling group evaluated recent changes in the watershed, including trends in estimated manure nutrient production, soil phosphorus content, and water quality at the sub-basin scale. Model scenarios were used to evaluate the relative impacts of existing watershed management practices on water quality at this scale. This approach aligns with recommendations from the National Academy of Sciences expert panel, which emphasized the importance of objectively identifying locations for best management practice (BMP) implementation by prioritizing landscape areas expected to generate the greatest runoff and pollutant loading (NASEM 2020).

Specific data and modeling analyses completed were: (i) long-term trend in total dissolved phosphorus (TDP) in Cannonsville Reservoir inflow at Beerston, NY, (ii) manure nutrient production in the WOH watersheds, (iii) TDP and total nitrogen (TN) trends in two subbasins of Cannonsville (Town Brook and WBDR Headwaters) and five other subbasins within the WOH watershed, (iv) trends in soil phosphorus content in three types of crop fields (hay, pasture and rotated crops) in Cannonsville watershed, and (v) modeling BMP impacts on water quality in two subbasins of Cannonsville watershed (Town Brook and WBDR Headwaters). A detailed description of these is presented next.

7.2.1 Long-term trend in TDP in Cannonsville Reservoir inflow

Previous assessments of dissolved phosphorus (the fraction of total phosphorus that is readily available for phytoplankton growth and subsequent eutrophication) loading into the Cannonsville Reservoir, based on measured data, indicated a substantial decline in recent years compared to the early 1990s. Modeling analyses attributed this reduction to a combination of decreased point and non-point source contributions resulting from watershed management actions, as well as land-use changes not directly tied to management (DEP 2011; Hoang et al. 2019; DEP 2021). These studies further concluded that although the risk of eutrophication in the Cannonsville Reservoir has diminished, maintaining current dissolved phosphorus loading rates is essential to preserve long-term drinking water quality. Since 2011, the average annual loading of TDP at the reservoir's main tributary has been estimated at approximately 10,000 kilograms per year (Wang et al. 2025a). Current contributions from point sources, based on data from active wastewater treatment plants within the watershed, account for less than 1% of total TDP loading. Flow-weighted mean daily concentrations of TDP, measured through monthly grab samples and storm-event monitoring at the main tributary near Beerston, NY, have shown minimal change in water quality since 2011 (trend slope = 0.001 $\mu g\ L^{-1}$ per year; Figure 7.1).

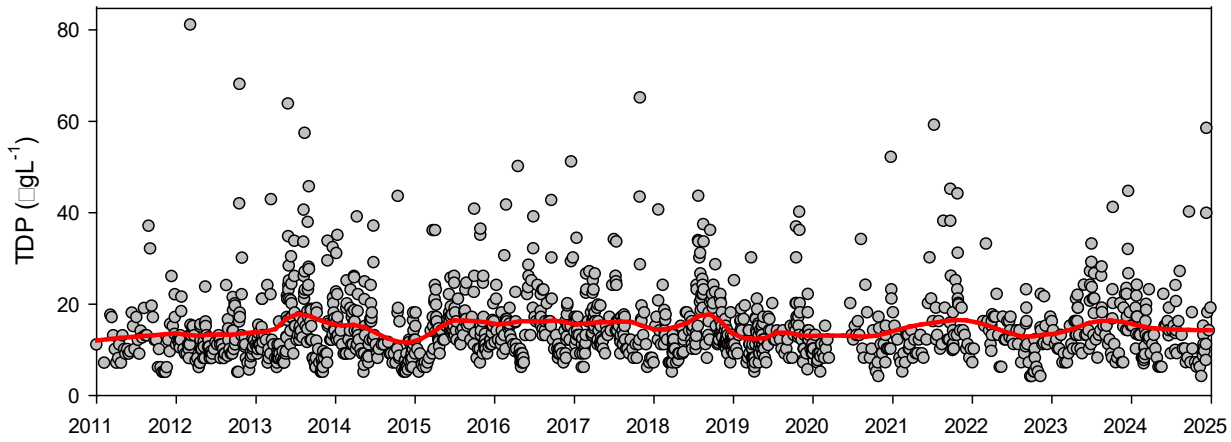


Figure 7.1 TDP concentration at Beerston, NY water quality monitoring site for the period 2011-2024.
(N=1,399. Red line is the lowess smoothed curve.)

7.2.2 Manure nutrient production in the WOH watersheds

A major shift in livestock populations within the West of Hudson watershed from 2019 to 2024 includes a 27% decrease in dairy cattle and a 16% increase in beef cattle. The livestock counts were used to estimate annual manure phosphorus production in the Cannonsville watershed between 2009 and 2024 (Table 7.1, Figure 7.2), with nutrient content derived from the literature (ASAE 2003; Ruddy et al. 2006; Kellogg and Moffitt 2011). Animal-type–specific animal-unit factors convert the number of animals into standardized animal units by accounting for differences in weight, age, and feed consumption. While estimated total manure phosphorus generation in the Cannonsville basin has stabilized in recent years (Figure 7.2), several sub-basins within the WOH watershed were projected to exhibit increasing trends (Figure 7.3). These include Elk Creek, Town Brook, and West Branch Delaware River Headwaters in the Cannonsville watershed; Bear Kill and Manor Kill in the Schoharie watershed; Tremper Kill in Pepacton watershed; Kramer Brook in Neversink watershed; and Chestnut Creek in Rondout watershed. A subset of these sub-basins was selected for water quality trend analysis and for SWAT modeling of best management practices.

7.2.3 TDP and TN trends in two subbasins of Cannonsville (Town Brook and WBDR Headwaters) and selected subbasins within the WOH watershed

Water quality data, including nitrate (NO_3-N), TN, TDP, and TP, collected monthly from DEP water quality gauges (DEP 2024), were used for trend analysis. Data were available from gauges corresponding to sub-basins with increasing manure production, except for Elk Creek. Trend analysis was conducted after excluding outliers, which were identified using the Hampel filter method (Pearson 1999). This method classifies values outside the interval defined by the median ± three median absolute deviations as outliers. Outlier detection was implemented with

the *pracma* R package, using a window length of six observations on either side of each data point. To assess long-term trends in water quality between 2009 and 2025, the Regional Kendall nonparametric trend test (Helsel and Frans 2006) was applied. This test uses monthly data at individual sites, with seasons (months) serving as blocking variables, and determines trends based on Kendall rank correlation. The *rkt* R package was used to perform this analysis.

Table 7.1 Livestock counts between 2019 and 2024 in the West of Hudson (WOH) watershed based on WAC program data.

	2019		2024	
Animal Type	No. of Animals	Animal Units	No. of Animals	Animal Units
Dairy	8,963	9,280	6,512	6,596
Beef	6,372	5,814	7,407	6,845
Horses	756	697	636	638
Sheep	1,362	168	1,703	210
Pigs	963	157	591	103
Goats	481	62	197	21
Chicken	7,454	39	5,229	28
Turkey	365	7	195	3
Ducks	47	0	172	1
Total		16,224		14,443

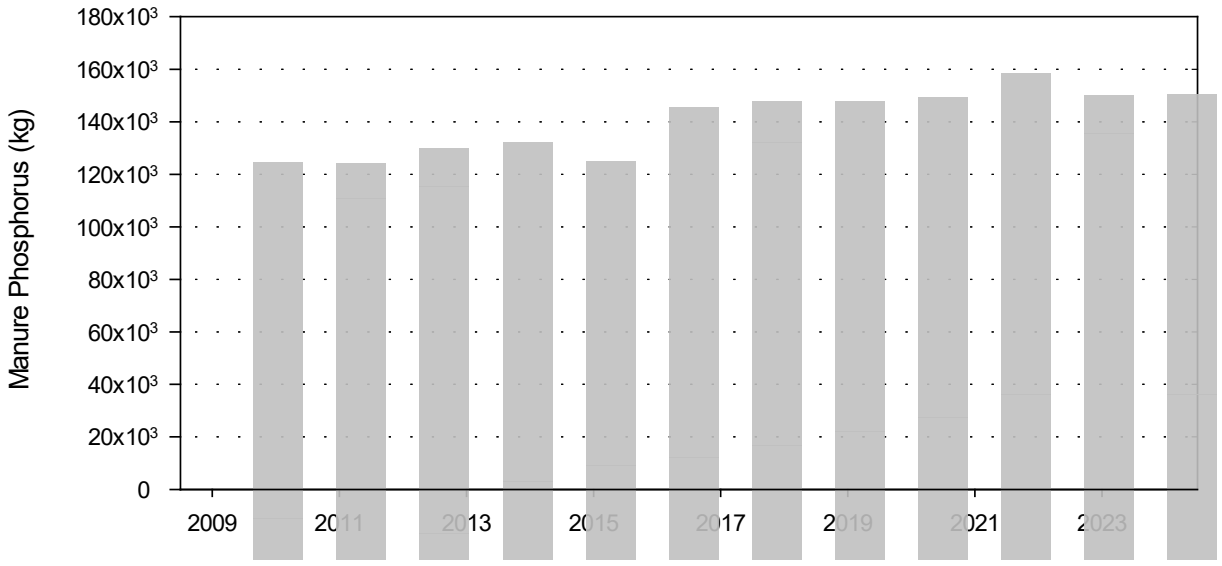


Figure 7.2 Estimated manure phosphorus generated in the Cannonsville watershed from beef, dairy and other animal types combined.

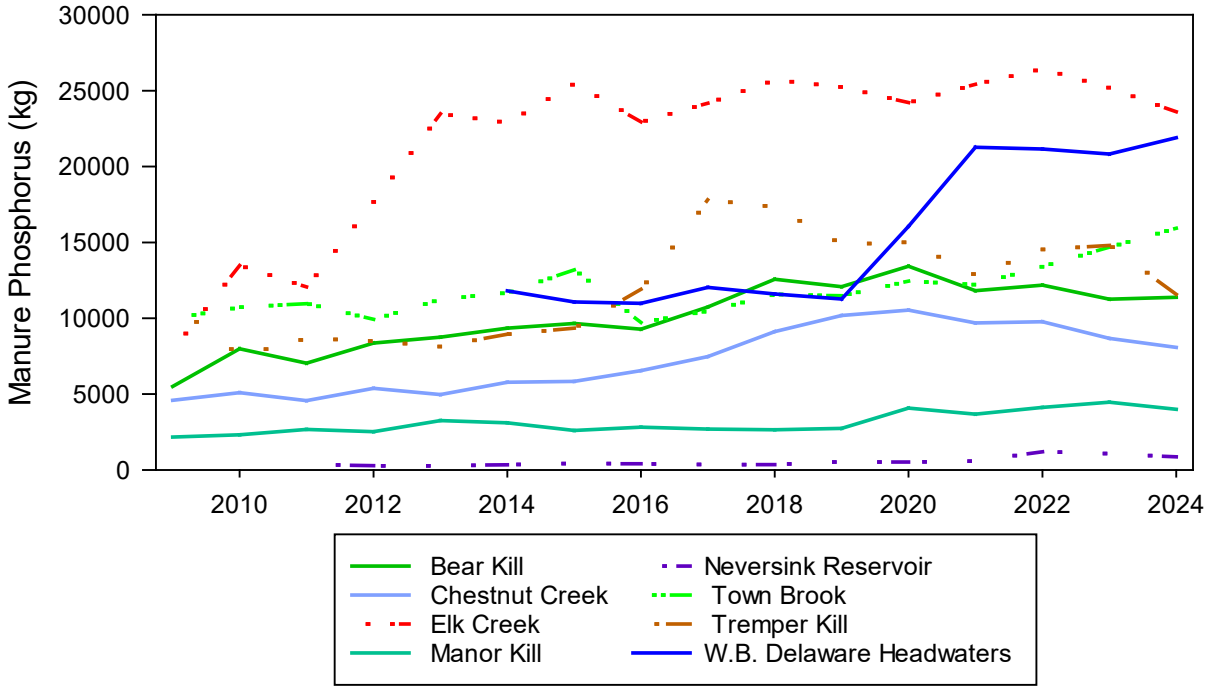


Figure 7.3 Sub-basins in the West of Hudson (WOH) watershed where livestock counts indicate a rising trend in estimated manure phosphorus production.

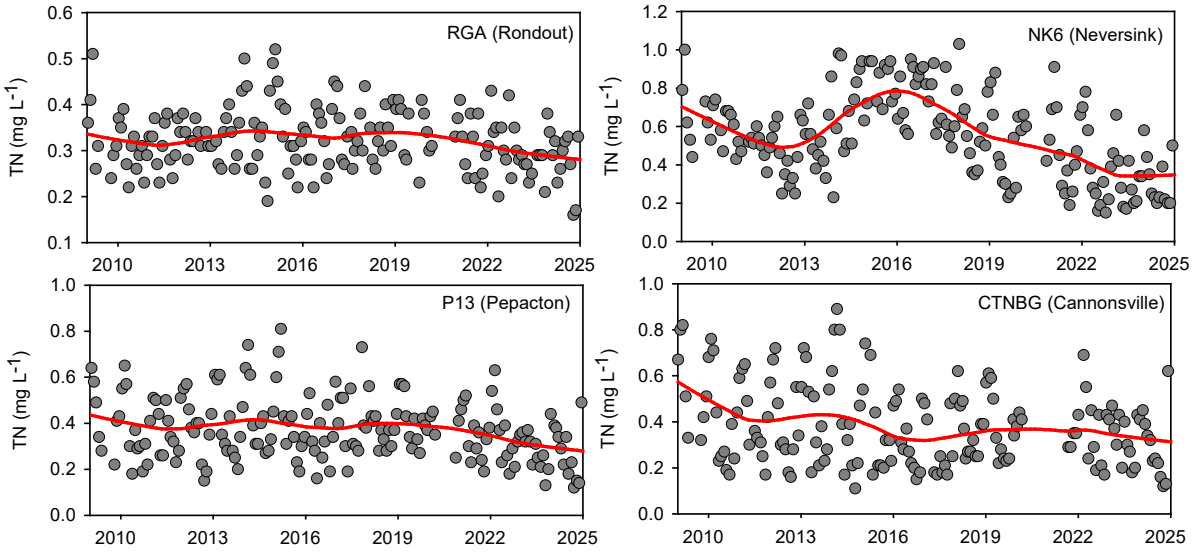


Figure 7.4 Sites with a statistically significant (p-value < 0.05) decreasing trend in TN.

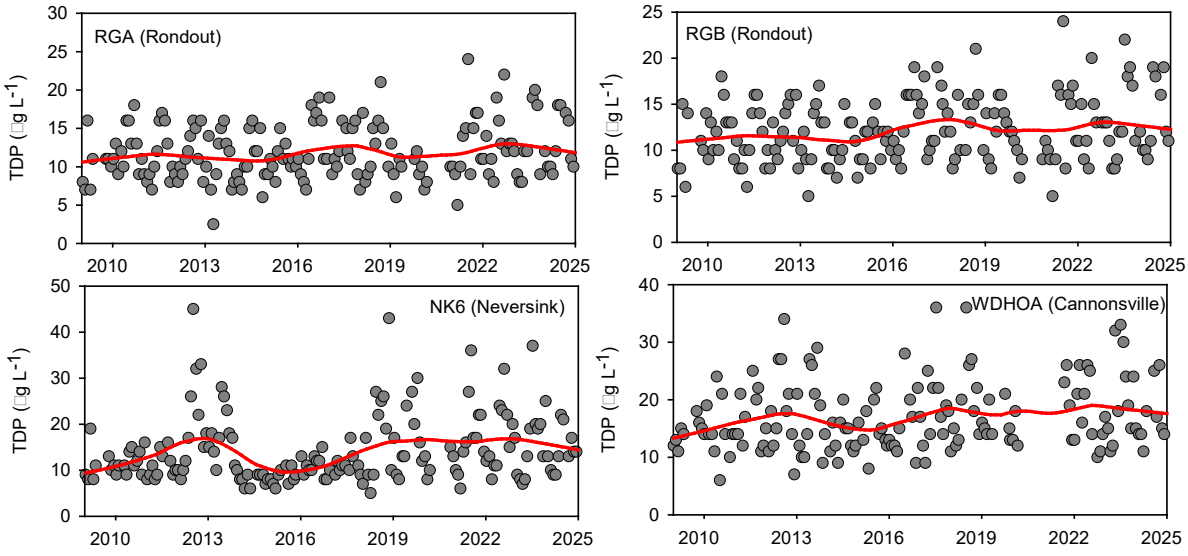


Figure 7.5 Sites with a statistically significant (p-value < 0.05) increasing trend in TDP. (N=1,399. Red line is the lowess smoothed curve.)

Table 7.2 Results of Regional Kendall trend test on water quality parameters.

Site	NO_3-N		TN		TDP		TP	
	Slope (mg yr^{-1})	p-value	Slope (mg yr^{-1})	p-value	Slope (µg yr^{-1})	p-value	Slope (µg yr^{-1})	p-value
CTNBG	**-0.007**	**<0.0001**	**-0.008**	**<0.0001**	0	0.435	**0.19**	**0.025**
WDHOA	0.007	0.053	0.004	0.135	**0.142**	**0.02**	0	0.909
P-13	**-0.006**	**<0.0001**	**-0.006**	**<0.0001**	0	0.29	0	0.645
S6I	0	0.942	-0.002	0.473	0	0.819	0	0.616
S7I	0	0.029	-0.0009	0.066	0	0.342	0	0.927
NK6	**-0.015**	**<0.0001**	**-0.018**	**<0.0001**	**0.2**	**0.004**	0.076	0.39
RGA	**-0.0016**	**0.045**	**-0.0016**	**0.037**	**0.091**	**0.004**	**0.105**	**0.0007**
RGB	-0.0012	0.294	-0.0014	0.23	**0.091**	**0.008**	**0.111**	**0.004**

**Stream monitoring sites at sub-basins in major reservoir watersheds are CTNBG (Town Brook in Cannonsville), WDHOA (Headwaters of Cannonsville), P-13 (Tremper Kill in Pepacton), S6I (Bear Kill in Schoharie), S7I (Manor Kill in Schoharie), NK6 (Kramer Brook in Neversink), and RGA/RGB (Chestnut Creek above and below Grahamsville wastewater treatment plant). Statistically significant trends are highlighted using bold text.*

Water quality trend analysis reveals a general decline in NO_3-N and TN concentrations at most sites, with statistically significant reductions observed in major agricultural sub-basins such as Town Brook in the Cannonsville watershed and Tremper Kill in the Pepacton watershed Table 7.2; Figure 7.4). This decreasing trend in NO_3-N and TN is likely associated with the overall reduction in dairy manure production across the watershed, though additional factors such as

winter cover cropping and riparian buffer planting may also have contributed to the decline in nitrogen forms. In contrast, trends for TDP and TP varied across sites: four of the eight sites showed no trend, while the remaining four exhibited increasing trends (Table 7.2). Notably, streams in agricultural sub-basins with increasing trend include WDHOA (Headwaters of Cannonsville) for TDP (Figure 7.5) and CTNBG (Town Brook) for TP.

7.2.4 Trends in soil phosphorus content in Cannonsville watershed

A dataset based on analysis of 8,586 soil samples for Morgan-extractable P, an indicator of plant-available phosphorus in soil, collected between 2010 and 2022 from 2,677 fields across farms in the Cannonsville watershed, was obtained from the WAC. The general range of Morgan soil test phosphorus levels by field crop category and year is presented in Figure 7.6. As shown, median soil test phosphorus values and interquartile ranges for most years were within or below the recommended optimal range for field crops. However, several fields in the rotated crops category tested above optimal phosphorus levels (9-19 lbs $acre^{-1}$; Ketterings and Workman (2022)), suggesting that crop yield response to additional phosphorus application in these fields would be minimal. Many fields tested above the lower limit for very high value (40 lbs $acre^{-1}$). Elevated phosphorus concentrations in many fields within the Cannonsville watershed, as well as across the United States, are largely the result of past management practices and are commonly referred to as "legacy" phosphorus (Sharpley et al. 2013).

The WAC uses nutrient management and precision feed plans as a coordinated strategy to reduce legacy phosphorus. NMP use the NY State Phosphorus Runoff Index (P-index) developed by Cornell University, ensuring that manure and fertilizer applications reflect each field's phosphorus loss risk. Precision feed plans reduce the amount of phosphorus entering the farm system by tightening rations, so animals excrete less. With the P-Index identifying high-risk fields and guiding nutrient applications, and precision feeding lowering overall inputs from farms, WAC is decreasing new phosphorus accumulation while steadily trying to draw down legacy phosphorus across the watershed.

Fields in the Cannonsville watershed are sampled every three years according to the farm's NMP, and on average, three years of data were available per field during the 2010–2022 sampling period. For trend analysis, only fields with at least two years of soil test phosphorus data were included. Following the approach outlined in NASEM (2020), the Regional Kendall test was applied using field as the blocking variable, ensuring that comparisons were restricted to values within the same field. Regional Kendall test statistics were then aggregated across all fields and further categorized by three major crop types: hay, pasture, and crop rotation. Two modifications were made to the *rkt* R package to accommodate the dataset. First, the minimum number of sample points per block required for trend calculation was reduced from the default of four to two. Second, the mean trend slope was used instead of the median slope across all pairwise comparisons of soil test phosphorus values. This adjustment was necessary to avoid reporting zero or no trend, which often occurred when the median slope was influenced by

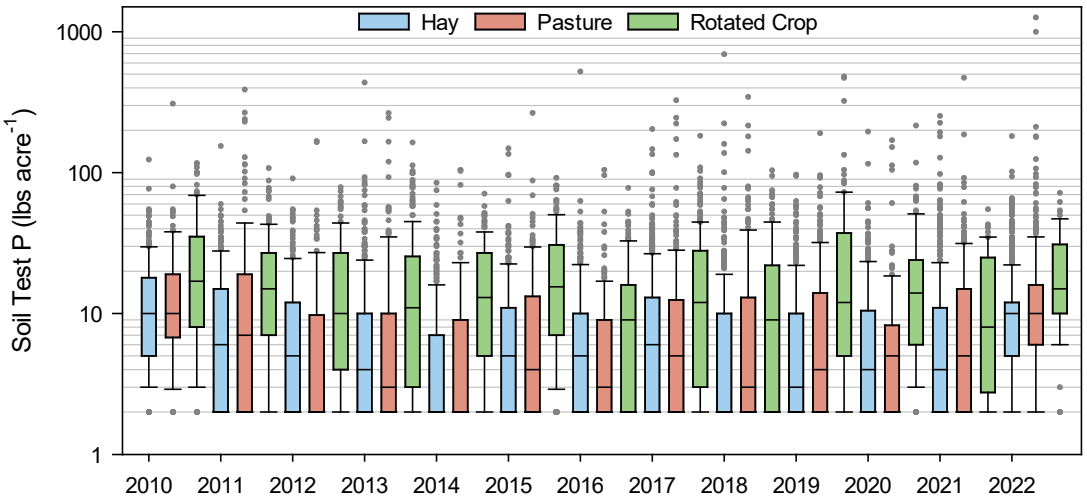


Figure 7.6 Range in soil test phosphorus levels for major crop categories observed in the Cannonsville watershed.

numerous data pairs showing no change in soil test phosphorus values, as noted in NASEM (2020).

Trend test results indicate a statistically significant downward trajectory in soil test phosphorus across all fields between 2010 and 2020 (p-value < 0.001), with an annual slope of –1.38%. Similar declines were observed when fields were categorized by major crop types (Table 7.3). However, the inclusion of soil test data from 2021 and 2022 produced notable differences in the outcomes. For the "all fields" and hay categories, the downward slope diminished and became non-significant. In pasture fields, the trend reversed to an increase of +0.50% per year, which was statistically significant (p-value < 0.005). In contrast, rotated crop fields showed little change in trend slope during the same period.

Table 7.3 Results of trend test on soil test phosphorus data from the Cannonsville watershed.

Field Category	Trend for sampling period 2010-2020			Trend for sampling period 2010-2022		
	No. of fields	Slope (%/yr)	p-value	No. of fields	Slope (%/yr)	p-value
All	2201	-1.38	<0.001	2677	-0.09	NS
Hay	1066	-1.52	<0.001	1465	-0.23	NS
Pasture	542	-1.74	<0.05	670	0.50	<0.005
Rotated crop	470	-1.42	<0.05	493	-1.22	<0.05

**NS – not significant at p = 0.05*

These findings suggest a marked increase in soil phosphorus in hay and pasture fields in recent years, particularly in 2022, as illustrated in Figure 7.6. While it remains uncertain whether

this increase reflects inter-annual variability, the onset of a longer-term trend, or specific watershed practices, the watershed-wide increase in beef cattle populations may have contributed to elevated soil phosphorus in grazed hay and pasture fields. Another possible explanation is that grazing areas typically begin with relatively low soil phosphorus, making changes more readily detectable.

The continued decline in soil phosphorus within rotated crop fields is promising, as these fields are often located in wetter regions prone to runoff and therefore more likely to facilitate the drawdown of legacy phosphorus (NASEM 2020). Using the estimated drawdown rate (slope in Table 7.3) in soil P, a first-order exponential decay equation (Fiorellino et al. 2017; Gatiboni et al. 2025) was used to estimate drawdown time for soil P in each field category to reach the agronomic optimum level as follows:

$$\boldsymbol{y = Ae^{(\lambda t)}} \tag{7.1}$$

where y is the soil P level (lbs acre^{-1}), A is the initial soil P level (lbs acre^{-1}), λ is the drawdown rate (%), t is the number of years.

At the current rate of decline, approximately 23 years (from 2022) would be required for the interquartile range of soil phosphorus levels in rotated croplands (2020–2022 baseline) to reach the agronomic optimum of 19 lbs acre^{-1} (Figure 7.7). For the hay and pasture field category the drawdown rate determined using the 2010-2020 sampling period indicated that it would take approximately 18 and 24 years respectively to reach the agronomic optimum of 9 lbs acre^{-1} from the same baseline period. In all three cases the 75th percentile value for the baseline period was used as the initial soil P level (Figure 7.7).

7.2.5 Modeling BMP impacts on water quality in two subbasins of Cannonsville watershed (Town Brook and WBDR Headwaters)

Scenarios evaluating the impact of BMPs on water quality were simulated for the Town Brook and West Branch Delaware Headwaters sub-basins within the Cannonsville watershed. Both sub-basins exhibit increasing trends in manure production and share similar land-use characteristics and drainage areas. However, they differ substantially in the amount of manure generated in recent years (Figure 7.3), particularly in dairy manure production (Table 7.4).

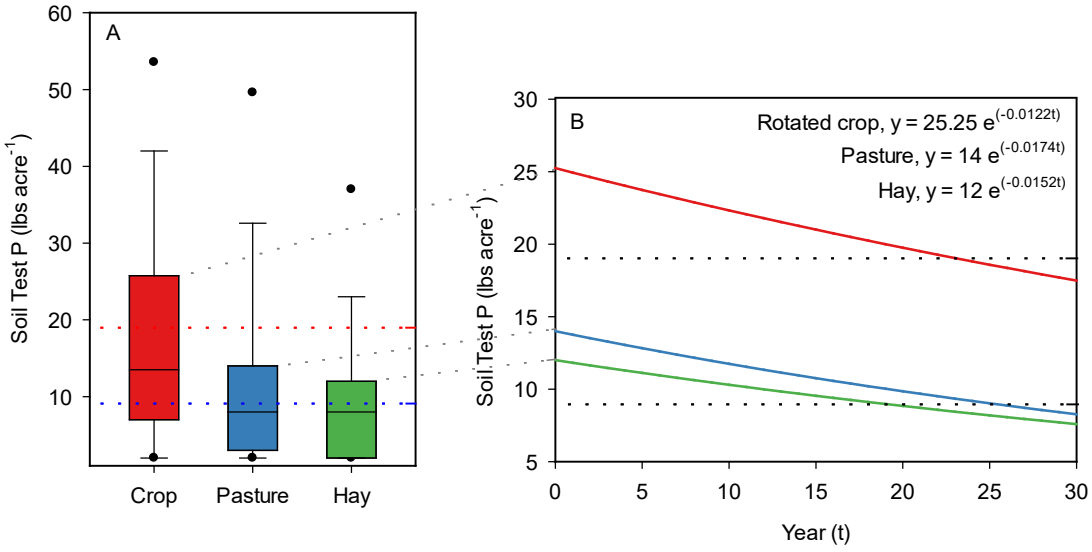


Figure 7.7 Range in soil test P in samples collected between 2020 and 2022. (A). Dashed lines are the upper limit of recommended optimum range for field crops (red; 19 lbs acre^{-1}), and for hay fields and pasture (blue; 9 lbs acre^{-1}). Whiskers are the 90th percentile value and dots are the 95th percentile value for each category. Estimated drawdown time (years) for the interquartile range in soil test P to reach the agronomic optimum (B).

Table 7.4 Watershed area, land use, and estimated manure production.

	Watershed Characteristics			Estimated Manure Production (2022-2024)	
Watershed	Drainage area (ha)	Cropland (ha)	Pasture (ha)	Beef (kg/day)	Dairy (kg/day)
Town Brook	3699	313	626	15,000	11,000
West Branch Headwaters	4023	320	730	11,000	43,000

A baseline scenario was established using the SWAT-HS model, calibrated to TDP loading at the Beerston water quality monitoring site as reported in DEP (2021). This baseline served as the reference against which BMP scenarios were compared. Model performance based on the coefficient of determination (R^2) and percent bias (PBIAS) demonstrated its ability to accurately simulate observed TDP loading in the sub-basins, confirming its suitability for BMP scenario analysis (Figure 7.8). A list of current management practices simulated using SWAT and a brief description is presented in Table 7.5.

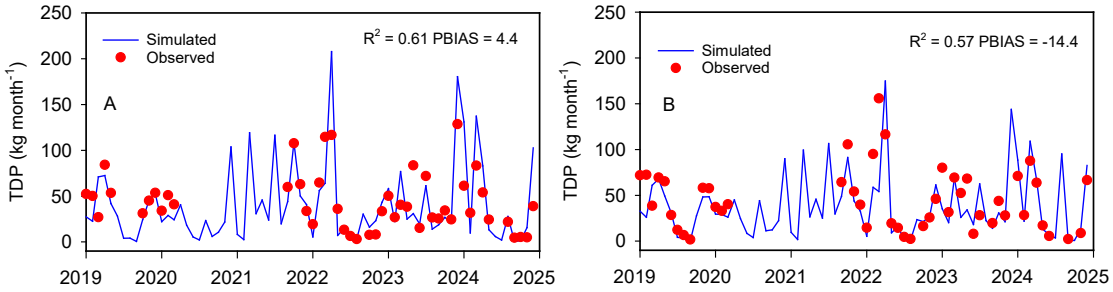


Figure 7.8 Comparison of simulated and observed TDP loading at West Branch Headwaters (A) and Town Brook (B) sub-basins in the baseline scenario.

Table 7.5 SWAT scenarios for BMP impact analysis.

#	Scenario	Description
1	Baseline	Run based on model calibrated to the Cannonsville watershed outlet at Beerston; assumes no manure spreading and cattle grazing in wet areas of pastures; fertilizers and manure broadcast on the soil surface.
2	Wet area spreading	Baseline scenario with no restriction on manure spreading and cattle grazing in wet areas of pastures.
3	Manure injection	Baseline scenario with 90% of the dairy manure applied below the top 10mm of the soil in pastures.
4	Winter cover cropping	Baseline scenario with winter rye as a cover crop in cropland areas.
5	Riparian buffer planting	Baseline scenario with vegetated filter strips in croplands near riparian areas.

The baseline scenario (Scenario #1 in Table 7.5) incorporates a nutrient management plan implemented on agricultural lands to control nonpoint source pollution. This plan accounts for manure application to croplands, as well as manure management practices in dairy farms and pastures. Calculations consider the proportion of time cattle (by age group) spend inside and outside barnyards, along with manure deposition during grazing and manure collected in barnyards. The effect of exclusion fencing near streams is represented in the model by preventing manure application in areas prone to saturation, as defined using a topographic wetness index (DEP 2021).

Barnyard manure collection reflects the impact of manure storage facilities, with a portion applied to croplands and the remainder spread on pastures not susceptible to saturation. In croplands, the simulated rotation schedule consists of four years of corn followed by six years of hay, managed according to recommended practices. Starter inorganic fertilizer (18% N and 18% P) is applied on the day of corn planting at a rate of 100 kg ha^{-1}. Dairy manure is applied

twice per growing season, once in April/May and again in October/November at approximately 2,670 kg ha^{-1} per application, equivalent to 374 kg ha^{-1} dry weight. The baseline scenario assumes that both fertilizers and manure are broadcast on the soil surface.

Scenario #2 mirrors the baseline but removes restrictions on grazing and manure spreading in pastures, regardless of saturation potential or runoff risk. Although the total manure input through grazing and spreading remains the same as in Scenario #1, the expanded area of application includes high-runoff zones, resulting in lower application rates per unit area.

Manure injection technology, aimed at improving manure management, water quality, soil productivity, and farm viability, is being piloted for use in the NYC Watershed by the DCSWCD in collaboration with CCEDC and the WAC. The team is also collaborating with Cornell University and Virginia Tech to evaluate project impacts. This multi-year project will help farms in the West of Hudson NYC Watershed adopt advanced manure management technologies to improve water quality and farm productivity. A public private partnership created a custom manure handling and spreading service adding needed capacity and introducing disc coulter manure injection, GPS based precision rate control, application mapping, and improved manure transport. The project is funded by a $3 million USDA Conservation Innovation Grant for On Farm Trials awarded to the DCSWCD.

This method enables precise application of manure below the soil surface, ensuring more uniform distribution across farms and reducing nutrient losses through runoff. Following Merriman et al. (2019), the effect of subsurface manure injection (Scenario #3) was simulated by limiting the fraction of manure applied to the top 10 mm of soil to 0.10.

In recent years, winter cover cropping has become a widely adopted conservation practice in NYC watersheds. This practice benefits soil by suppressing weeds, reducing erosion, and enhancing overall soil quality and nutrient status, with the added potential to improve water quality. Winter rye, the most grown cover crop in the region, is favored for its high adaptability. The impact of winter cover cropping on water quality (Scenario #4) was evaluated in SWAT simulations by incorporating winter rye as a cover crop, with planting scheduled during the first week of October.

Riparian buffer planting in NYC watersheds began in 1998 under the CREP, a partnership between DEP, NYS, and the USDA. The primary goal of CREP is to improve water quality by reducing sediment, nutrient (phosphorus and nitrogen), and pathogen inputs from streams into the reservoirs that supply NYC's drinking water, while also enhancing wildlife habitats in the Catskill and Delaware watersheds. Currently, more than 1,240 acres of farmland (cropland and pasture) in the Cannonsville watershed are enrolled in CREP. Since 2008, an additional ~119 acres of non-agricultural riparian forested areas in the Cannonsville basin have been planted through the Catskill Streams Buffer Initiative.

To evaluate the impact of riparian buffer planting on water quality, SWAT scenarios were developed using the vegetative filter strip (VFS) method described by White and Arnold

(2009). SWAT inputs for VFS include the fraction of total runoff entering the most concentrated 10% of the filter strip area and the ratio of field area to filter strip area. These parameters were set to 0.5 and 50, respectively, following VFS guidelines (Waidler et al. 2011). In this scenario (Scenario #5), vegetated filter strips were assumed to be present in croplands adjacent to riparian areas, identified using a topographic wetness index.

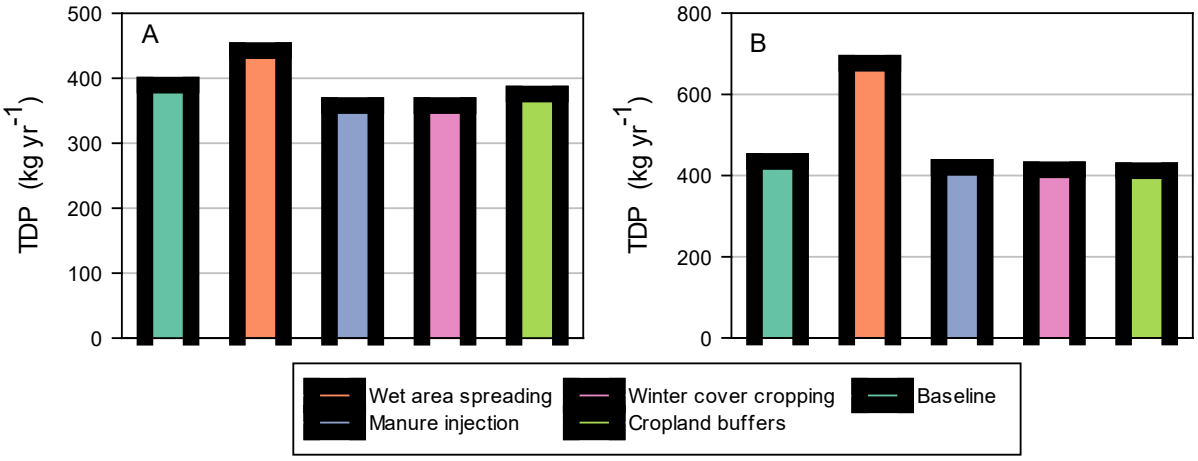


Figure 7.9 Comparison of baseline TDP loading for the period 2009 to 2024 with BMP scenarios for the (A) Town Brook sub-basin and (B) West Branch Headwaters sub-basin.

Table 7.6 Comparison of average annual change in TDP loading under BMP scenarios. Period of simulation is 2009 to 2024 for each of the four scenarios that were compared to baseline.

Scenario name	Town Brook	W.B. Headwaters
	Change from baseline scenario	
Wet area spreading	+13.6%	+55.5
Manure injection	-8.2%	-3.4%
Winter cover cropping	-8.1%	-4.8%
Riparian buffer planting	-3.6%	-5.3%

The scenario of cattle grazing and manure spreading without restrictions on saturated areas produced the largest difference in TDP loading relative to the baseline in both watersheds (Figure 7.9 and Table 7.6). The increase in TDP loading was substantially greater in the West Branch Headwater sub-basin (Figure 7.9) compared to the Town Brook sub-basin (Figure 7.9), likely reflecting the higher volume of dairy manure generated in recent years within this sub-basin. Although this scenario represents an extreme case and the water quality impacts are less likely to occur in practice, it underscores the challenges in manure management associated with

the growing livestock population in certain sub-basins within the watershed. It also highlights the critical importance of implementing both agronomic (NMP and PFM plans) and structural BMPs through the Watershed Agricultural Program. Best management practices that help manage nutrients, such as exclusion fencing to prevent cattle access to near-stream saturated areas and the use of manure storage facilities which provide greater control over the rate, timing, and location of manure application, enhance nutrient recycling and reduce runoff risks.

Model simulations suggest that the combined implementation of manure injection, winter cover cropping, and riparian buffer planting could reduce overall TDP loading by ~14–20% in the two study sub-basins (Figure 7.9 and Table 7.6). These are significant reductions considering that agricultural areas (croplands and pasture) occupy only about a fourth of the total drainage area of these predominantly forested sub-basins. However, the actual effectiveness of these BMPs on water quality depends on factors such as the extent of adoption and the specific locations where BMPs are applied. In the scenarios, manure injection was assumed to occur in all pastures receiving dairy manure, cover cropping was adopted across all cropland areas, and riparian buffers were assumed to be present only in croplands adjacent to riparian zones. Additional buffers in pastures and non-agricultural forested areas may also contribute to water quality improvements. While uncertainties remain in model projections, these scenarios provide valuable estimates of the relative impacts of BMPs, accounting for land use and landscape position within the watershed.

7.2.6 Summary

Since 2011, concentrations and loadings of TDP in the Cannonsville Reservoir have shown no discernible trends. Point source contributions remain minimal, accounting for less than 1% of total TDP loading. Between 2019 and 2024, the West of Hudson watershed experienced notable shifts in livestock populations: dairy cattle numbers declined by approximately 27%, while beef cattle numbers increased by about 16%, resulting in an overall reduction of animal units by ~11%.

Although total annual manure production across the watershed has remained stable over the past decade, certain sub-basins exhibited increasing trends. Stream water quality data from these sub-basins reveal a general decline in nitrate nitrogen and total nitrogen concentrations. This trend is likely linked to reduced dairy manure production, which typically contains higher nitrogen content than beef manure. BMPs, such as winter cover cropping and riparian buffer planting, may also have contributed to nitrogen reductions, though field-scale studies are needed to confirm their impact. Instream phosphorus concentrations in these sub-basins have either remained stable or shown slight increases, particularly in areas with significant agricultural activity. However, these increases are relatively small compared to the observed decreases in nitrogen.

Watershed modeling analysis focused on two sub-basins within the Cannonsville watershed that exhibit increasing trends in manure production. Although both sub-basins have

comparable areas under agricultural land use, recent years have shown differences in the estimated volume of manure generated. Model scenarios highlight the importance of current management practices and the need for implementation and maintenance of BMPs for future manure management and underscore the need to prioritize BMPs in sub-basins with the greatest influence on water quality.

Simulations of current BMPs including winter cover cropping, riparian buffers in croplands, and manure injection demonstrate their relative effectiveness at the sub-basin scale. A combination of these practices shows promise for significantly reducing dissolved phosphorus loading. Achieving further reductions in instream phosphorus and continued improvements in water quality may also require addressing "legacy" soil phosphorus. Many crop fields in the Cannonsville watershed currently exceed the optimum soil phosphorus range for crop production. Although soil test phosphorus levels are steadily declining, at the current rate it may take another two decades for farm fields (croplands and pastures) to reach optimal levels. Conventional nutrient management strategies such as adjusting the rate, timing, and placement of fertilizer and manure applications along with practices that promote soil phosphorus drawdown, including crop rotation and cover cropping, are expected to benefit water quality in the long term.

7.3 Natural Organic Matter and Disinfection Byproducts

NOM, generated by the decomposition of plant litter in forested watersheds, is delivered to receiving waterbodies through both surface runoff and subsurface flow pathways. When water containing NOM is disinfected with chlorine during drinking water treatment, the organic matter reacts with chlorine to form DBPs, some of which are known to pose risks to human health. Because NOM serves as the precursor material for DBP formation, understanding the sources in the watershed as well as fate of these compounds in receiving waterbodies is critical for protecting water quality and public health. DEP is addressing this challenge by conducting a monitoring and modeling program of organics and DBP-related compounds in various parts of the water supply system including watersheds, streams, reservoirs, and the distribution network. A summary of these activities is presented in Table 7.7, followed by a detailed review of the data and modeling results.

Table 7.7 Monitoring, modeling and special studies of organic carbon and DBP-related parameters in the watershed.

Monitoring

Subsystem	Sites	Parameters	Frequency*	Notes
stream	six primary inflow sites (WOH)	UV254	W-M + 3 storms	ongoing
		DBPfp	2M + 3 storms	only CBS and NCG sites; ongoing
		DOC	W-M + 3 storms	only CBS and NCG sites; ongoing
reservoir	Cannonsville, Neversink	UV254, DBPfp, DOC	M	ongoing
keypoints (diversion)	Cannonsville, Neversink, Rondout	UV254	W, CM	ongoing
		DBPfp	2M	ongoing
	Pepacton, Schoharie, Ashokan	UV254	W	ongoing
	Cannonsville	spectral abs.	CM	2017, 2019, 2023-2024
	Neversink	spectral abs.	CM	2017, 2019-2023
	Pepacton	spectral abs.	CM	2023
	Rondout	spectral abs.	CM	2023-2024

Modeling

Subsystem	Model/Site	Development Stage	Simulation Variables	Reference
watershed	TASC-Forest/ Biscuit Brook	preliminary testing	plant growth	(Dangol et al. 2025)
watershed	SWAT-Carbon/Neversink	Complete	DOC soil carbon	(Mukundan et al. 2023)
	TASC-Forest-Carbon	under development		
watershed stream	General Additive Model (GAM); six primary inflow sites (WOH)	complete	DOC	(Wang et al. 2025b)
	empirical; Cannonsville, Neversink	complete	DBPfp	(Wang et al. 2024)
reservoir	W2; Cannonsville, Neversink, Ashokan, West Branch	complete	UV254	Watershed Water Quality Annual Reports

Special Studies

Subsystem	Site	Parameters	Reference
watershed	Neversink	nine sampling events covering 11 sites in 2022; DOC, DON, UV254	(Shakhawat et al. 2025)
stream	Neversink River	six storm events monitoring of organics by University of Massachusetts during 2019-2024	(Shakhawat et al. 2024)
watershed	WOH; 30 sites (synoptic survey)	spectral abs., DOC, DBPfp, EEMs	Ongoing by USGS (2025-2029);

** W: weekly, M: monthly, CM: continuous monitoring, 2M: 2× monthly*
EEMs: fluorescence excitation emission matrix

7.3.1 Monitoring – A spatiotemporal assessment of DBPfp, precursors, and proxy measures

DBPfp, UV254, DOC, and broad-spectrum absorbance (absorption measurements across the UV – visible spectrum (220 – 720 nm), taken with S::CAN UV-Vis Spectro::lyser V2 sensors) were selected as analytes of interest for this assessment. The significance of these analytes, with respect to DBP modeling, has been demonstrated in previous work (Wang et al. 2024) and is further supported by this analysis. Laboratory DBPfp analysis includes HAA5fp and TTHMfp and is a measure of the maximum potential for DBP formation. UV254 measures ultraviolet absorbance at a wavelength of 254 nm and serves as a proxy for DBP precursors. The effectiveness of UV254 as a predictor of DBPfp is related to interaction of this wavelength with aromatic bonds in certain types of organic matter (the humic fraction of organic matter, for example). Specific UV absorbance (SUVA) is a metric of UV254 normalized for DOC, where

$$\boldsymbol{SUVA}\left(\frac{\boldsymbol{L}}{\boldsymbol{mg}\cdot\boldsymbol{m}}\right)=\frac{\boldsymbol{UV_{254}}\,(\boldsymbol{cm^{-1}})}{\boldsymbol{DOC}\,(\frac{\boldsymbol{mg}}{\boldsymbol{L}})}\times\mathbf{100}\,(\frac{\boldsymbol{cm}}{\boldsymbol{m}}) \tag{7.2}$$

As part of the long-term program to evaluate DBP-related analytes within source water supply watersheds, monitoring for UV254 and DOC began in 2011 at some locations and has since expanded to include all sites in Figure 7.10. Across all locations, UV254 and DOC results total more than 14,000 and 23,000 records, respectively. DBPfp monitoring data are available from 2017 – present, including approximately 1,250 results each for HAA5fp and TTHMfp across 17 sites. The use of in-situ S::CAN UV-Vis Spectro::lyser V2 sensors for collection of absorption spectral data began in 2017 and concluded in 2025 at four keypoint locations in the West of Hudson (WOH) Delaware system: WDTOCM, NRR2CM, PRR2CM and RDRRCM.

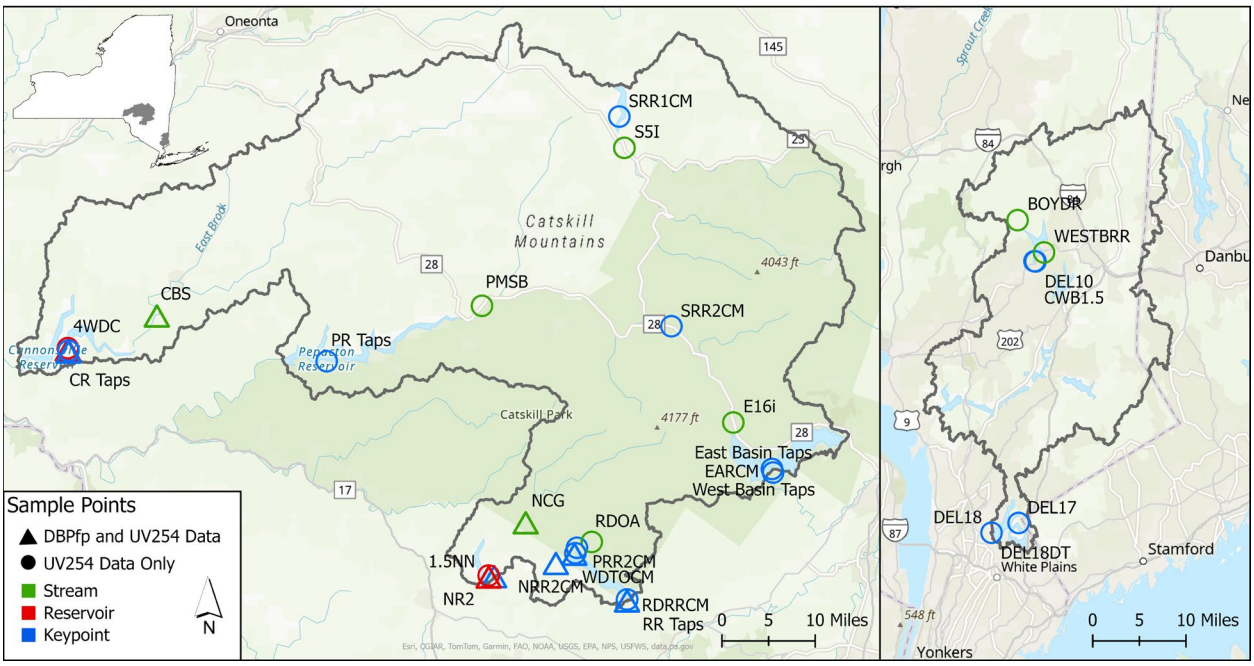


Figure 7.10 Sampling locations throughout the watersheds for monitoring DBPfp and related analytes.

Consistent with previous findings, UV254 was highly predictive of both HAA5fp and TTHMfp in the Cannonsville and Neversink watersheds (Figure 7.11). Associated data include samples from stream, reservoir, and keypoint sites from 2017 to 2025. The correlation between UV254 and DBPfp is stronger in the Neversink watershed than in the Cannonsville watershed, which may be related to differences between the two watersheds. Neversink is predominantly forested where transport processes dominate precursor export, while Cannonsville is largely forested with a higher percentage of agricultural land where production (source) processes of precursors are more important (Wang et al. 2024). In both watersheds, stream site results were more wide-ranging than reservoir and keypoint site results, representing the highest and lowest values of both DBPfp and UV254.

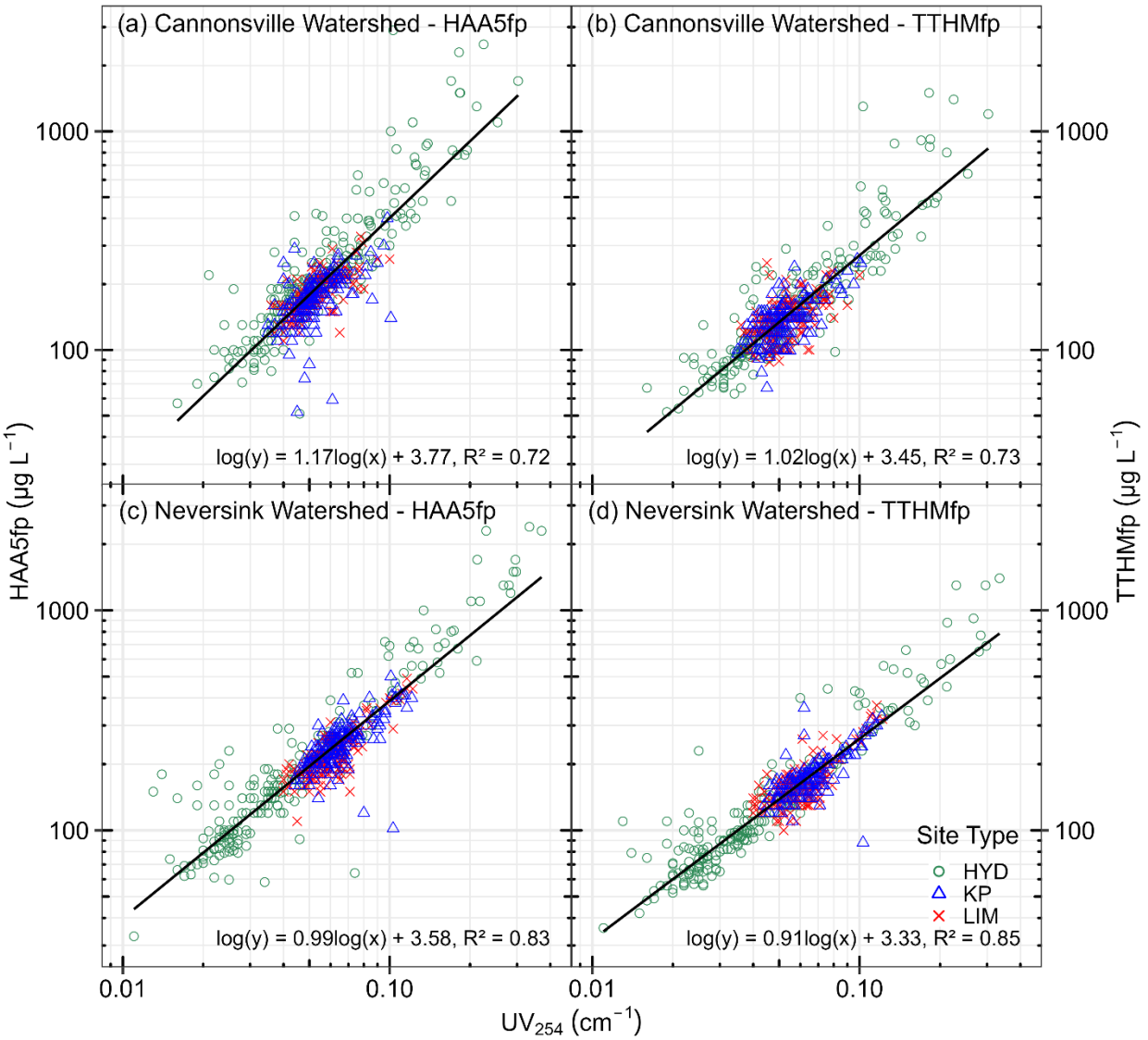


Figure 7.11 DBPfp (HAA5fp and TTHMfp) versus UV254 for Cannonsville Watershed sites [(a) and (b)] and Neversink Watershed sites [(c) and (d)], 2017 – 2025. (HYD, KP, and LIM indicate streams, keypoints (diversion and elevation taps), and in-reservoir monitoring sites.)

Regarding the SUVA metric, current findings are comparable to those of previous work (Wang et al. 2024), with average values ranging from 2.3 – 3.2 L mg^{-1} m^{-1} between 2017 and 2025 across all sites, suggesting similar aromaticity throughout the system. DBPfp was found to be only weakly correlated with SUVA for the Neversink watershed (Figure 7.12), with a wide range of HAA5fp and TTHMfp for a given SUVA value. Findings were similar for the Cannonsville watershed.

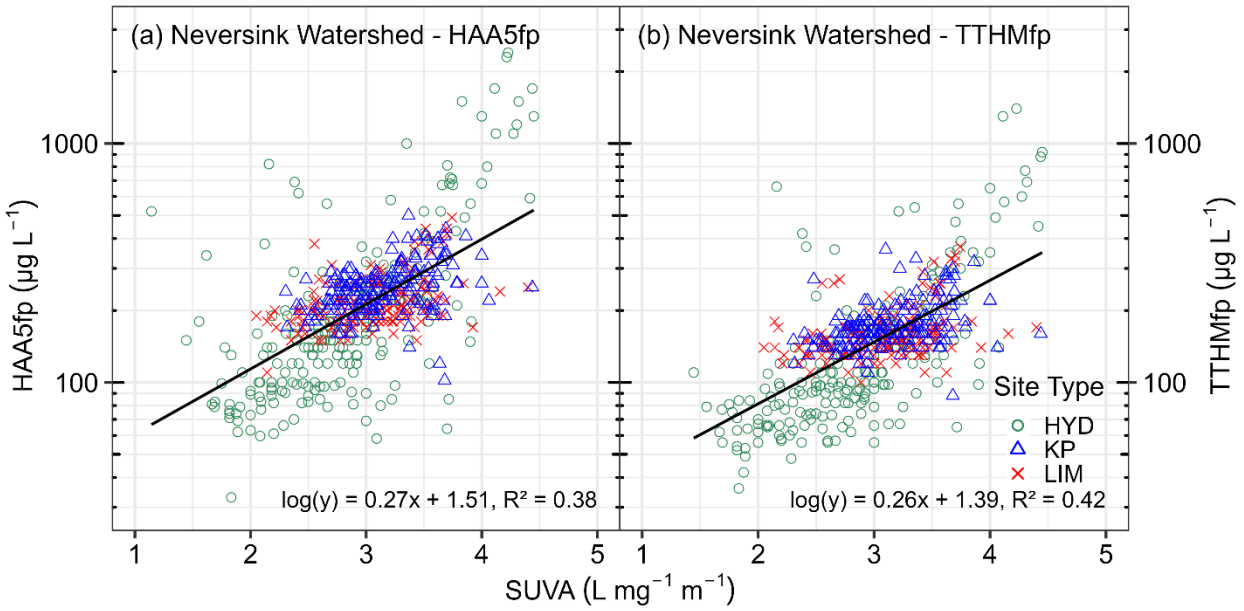


Figure 7.12 DBPfp versus SUVA for Neversink Watershed sites, 2017 – 2025. HYD, KP, and LIM indicate streams, keypoints (diversion and elevation taps), and in-reservoir monitoring sites.

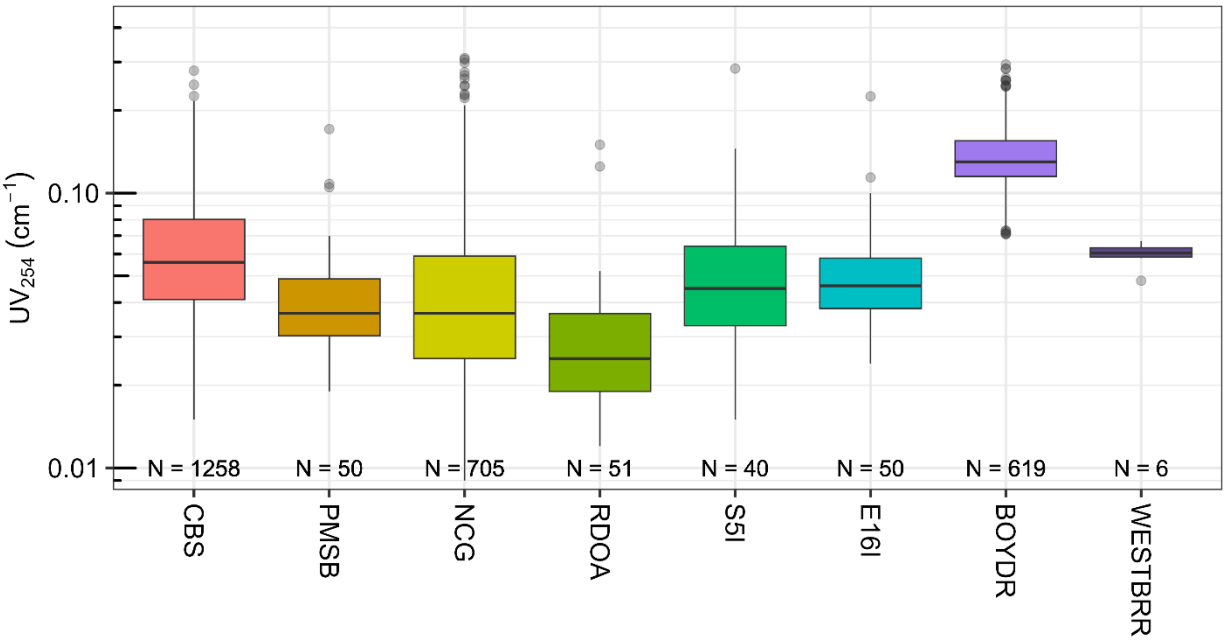


Figure 7.13 Daily average UV254 at inlets to six WOH reservoirs, and downstream of Boyd Corners and West Branch reservoirs, 2013 – 2025.

Figure 7.13 and Figure 7.14 summarize UV254 observed at stream sites (2013 – 2025), and keypoints (2011 – 2025), respectively. For streams, typical UV254 values range from 0.02 – 0.14 abs cm^{-1} across all sites, with the highest values recorded at Boyd Corners Reservoir Release (BOYDR), and West Branch Delaware River at Beerston (CBS). At the site RDOA, Rondout Creek near Lowe's Corners, values are generally the lowest among the direct stream inputs. There is seasonal variation with increasing UV254 values during spring and fall runoff; the highest annual recorded values are typically associated with the strongest storm events. Among keypoint sites, UV254 typically ranges from 0.03 to 0.08 abs cm^{-1} across all sites, with the highest values at Schoharie keypoint sites.

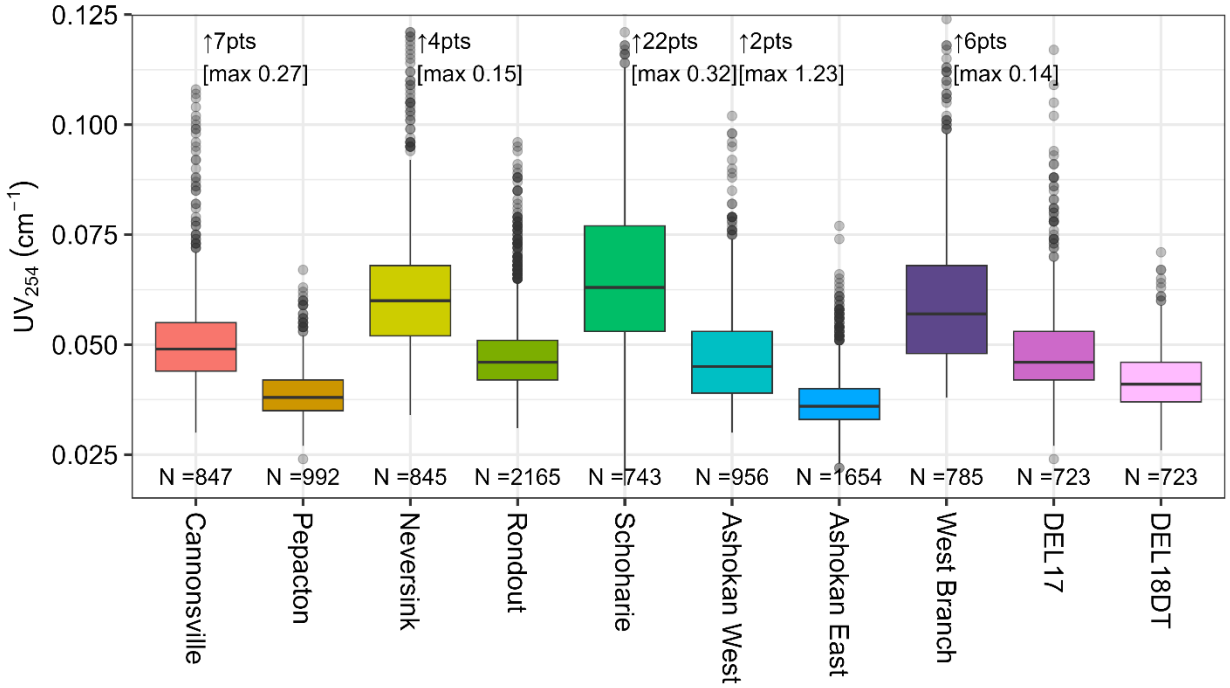


Figure 7.14 UV254 at keypoints (diversion and elevation taps), 2011 – 2025 (DEL18DT data for 2012 – 2025).

A clear seasonal pattern exists for UV254 in Kensico Reservoir as measured in the diversion at DEL18DT (Figure 7.15). Higher values (both mean and median) are typically recorded from December to March, and lower values from April to September. This seasonal fluctuation is distinct from upstream reservoirs, suggesting it is influenced by water travel time and operational practices of the upstream Catskill/Delaware reservoirs. The most extreme values (> 0.06 cm^{-1}) have occurred during October through December (Figure 7.15).

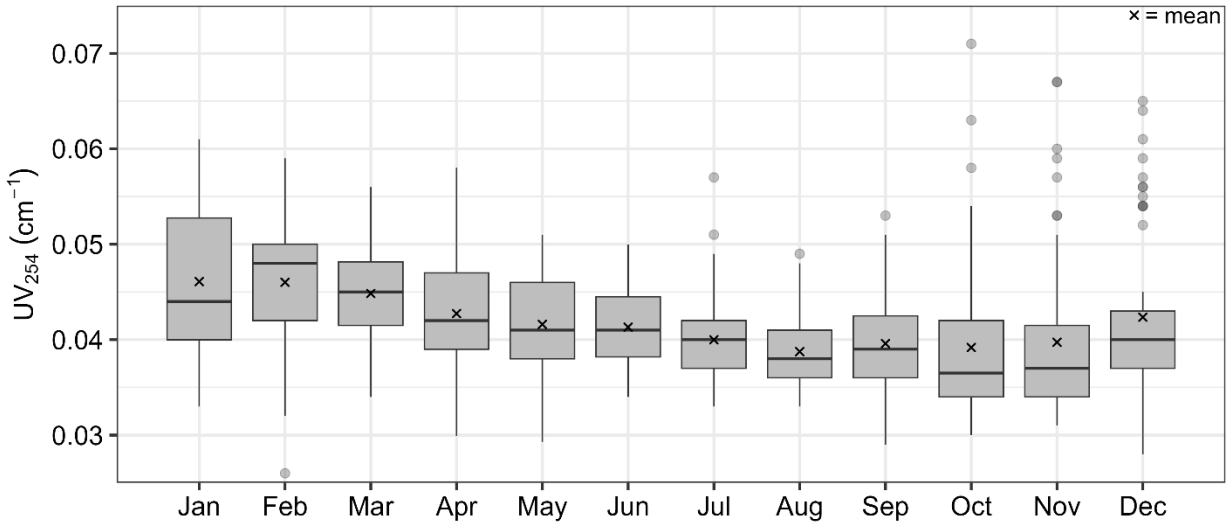


Figure 7.15 Seasonal variation in UV254 in diversion from Kensico Reservoir (site DEL18DT, 2012-2025).

A yearly boxplot of UV254 for the same site DEL18DT before water enters the distribution system is presented in Figure 7.16. The median UV254 prior to 2018 was < 0.04 cm^{-1}, whereas during 2018 – 2025, it was ≥ 0.04 cm^{-1}, and within an interannual range of 0.04 – 0.048 cm^{-1}. The increasing long-term trend ($p < 0.05$) is attributed to similar increasing trend in upstream reservoirs.

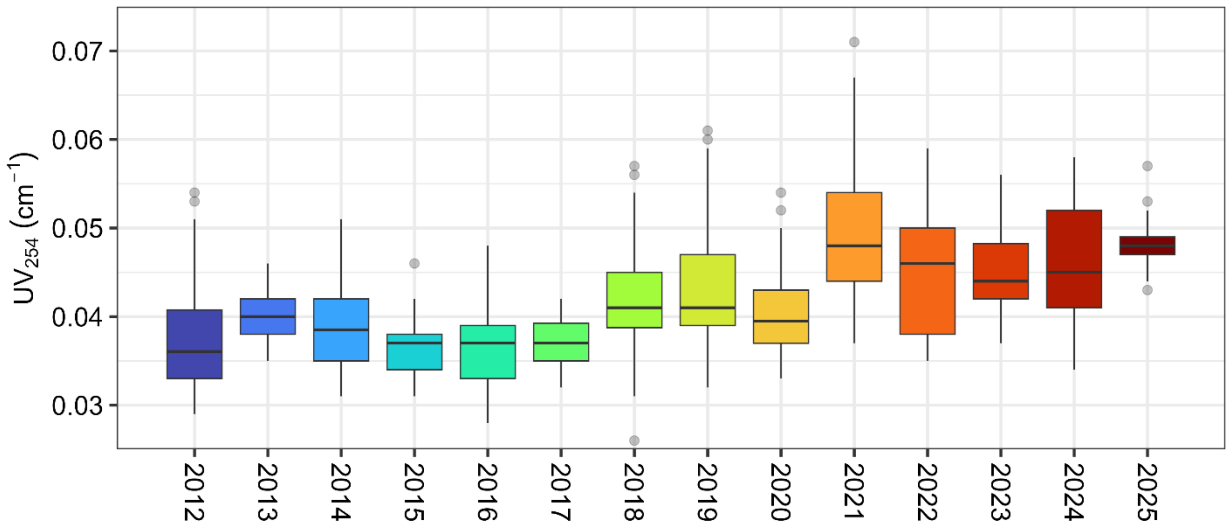


Figure 7.16 Interannual variation in UV254 in diversion from Kensico Reservoir (site DEL18DT).

7.3.2 Monitoring – In-situ Absorption Spectra to Assess Dissolved Organic Matter Quality

During 2017-2024, DEP deployed S::CAN UV-Vis Spectro::lyser V2 sensors (35 mm pathlength) at four keypoint locations within the Delaware district (NRR2CM, WDTOCM, PRR2CM, and RDRRCM). The S::CAN sensors record absorption from 220 to 720 nm at an interval of 2.5 nm wavelength at 5 min frequency. From these absorption data, four categories of spectral properties (features) that are known to characterize organic matter were explored: (1) absorbance at single wavelength (A_λ), (2) absorbance ratio ($E_{\lambda1}$:$E_{\lambda2}$; ratio of absorbance at two wavelengths), (3) spectral slope ($S_{\lambda1\text{-}\lambda2}$; linear slope of log-transformed absorbance curve between two wavelengths), and (4) spectral slope ratio ($Sr_{S\lambda1\text{-}\lambda2/S\lambda3\text{-}\lambda4}$; ratio of two spectral slopes). These spectral properties indicate characteristics of organic matter regarding its molecular weight, aromaticity, and reactivity. Among several features corresponding to many wavelengths evaluated, the ones that showed the highest correlation with DBPfp, are shown in Table 7.8. The correlation was determined at yearly as well as monthly time scales. Generally, A_{255} was found to be the best predictor of DBPfp, except for HAA5fp for the site WDTOCM, for which $S_{365\text{-}390}$ was better than A_{225}. Further, the other spectral features as predictors of DBPfp varied from month to month suggesting seasonal variability in the composition and quality of organic matter exported from the watershed.

Two spectral features of note are E2:E3 and $S_{275\text{-}290}$, which have been related to molecular weight and aromaticity of organic matter in the literature (Korak and McKay 2024). E2:E3 is defined as the ratio of absorbance at 250 to 365 nm. In this analysis, E2:E3 was found to be inversely related to TTHMfp (June and December; site WDTOCM). E2:E3 decreases because of stronger light absorption by high molecular weight compounds (Helms et al. 2008). A significant relationship of E2:E3 with TTHMfp suggests major contribution of high molecular weight compounds to the bulk organic matter. The other feature, spectral slope $S_{275\text{-}290}$, was found to be inversely correlated in February but positively correlated in July (HAA5fp; Table 7.8), making it difficult to interpret the result and infer the quality and composition of organic matter. Absolute $S_{275\text{-}290}$ has been shown to covary with E2:E3 and is inversely related to relative abundance of condensed aromatic and polyphenolic carbon (Korak and McKay 2024). The correlation observed in July is consistent with this and would suggest that greater relative contribution of aromatic carbon would lead to greater HAA5fp. A major source of uncertainty in seasonal relationships is insufficient dataset size ($n \approx 5$ to 8). There were other spectral features that were found to be significant predictors (e.g., $S_{365\text{-}390}$, and $Sr_{S275\text{-}350/S415\text{-}600}$; Table 7.8), but these have not been investigated in the literature.

Table 7.8 Annual and monthly correlations (r) between spectral indices (features) and DBP formation potential.
Only the features with the best correlations are shown (r = 1 represents perfect positive correlation, -1 represents perfect negative correlation, and 0 represents no correlation). r is not calculated if number of samples < 5. Spectral slope, S is calculated from $A_\lambda = A_{\lambda_1} e^{S(\lambda_2 - \lambda_1)}$, where S < 0. Same features are shown by a common color.

	Cannonsville Reservoir Diversion (site WDTOCM)				Neversink Reservoir Diversion (site NRR2CM)			
	TTHMfp		HAA5fp		TTHMfp		HAA5fp	
	Feature	r	Feature	r	Feature	r	Feature	r
Year	A_{255}	0.49***	$S_{365\text{-}390}$	-0.48**	A_{255}	0.84***	A_{255}	0.85***
Jan								
Feb	A_{255}	0.65+	$S_{275\text{-}295}$	-0.72*				
Mar	$S_{415\text{-}600}$	-0.97**	Sr_$S_{275\text{-}350}$/ $S_{415\text{-}600}$	-0.98**				
Apr								
May								
Jun	E2:E3	-0.94**	$S_{220\text{-}240}$	0.84*				
Jul	$S_{675\text{-}720}$	0.79+	$S_{275\text{-}295}$	0.89*				
Aug								
Sep	$S_{350\text{-}400}$	-0.85*	Sr_$S_{365\text{-}390}$/ $S_{390\text{-}425}$	0.87*				
Oct								
Nov								
Dec	E2:E3	-0.69x	A_{255}	0.69x	A_{255}	-0.54x	$S_{365\text{-}390}$	-0.96*

***p-value < 0.001, **p-value = < 0.01, *p-value = < 0.05, +p-value < 0.1, xp-value > 0.1

7.3.3 Modeling – Stream Dissolved Organic Carbon (DOC)

DOC is a proxy for organic matter in water and indicates the potential for forming DBPs in the distribution system. During the FAD assessment period, DEP developed General Additive Models (GAMs) to predict daily DOC concentrations in six major streams in the WOH watersheds (Cannonsville - CBS, Pepacton - PMSB, Neversink - NCG, Rondout - RDOA, Schoharie - S5I, and Ashokan - E16I). GAMs are generalized linear models, in which the dependent variable is modeled by unspecified smoothing functions that are nonparametric and can be nonlinear (Eq. 8.1). The smooth functions can be estimated by scatterplot smoother, such as running mean, running least square line, or a spline:

$$\ln(y) = \beta_0 + f_1(X_1) + f_2(X_2) + \cdots + f_k(X_k) + \varepsilon \quad (7.3)$$

where, y is DOC, β_0 is a constant, f_1 ... f_k are the smoothing functions of the predictors X_1 ... X_k, and ε is the error term. The smoothing functions in this study were estimated by cubic regression splines, which provided the most robust predictions.

The predictor variables in the study were discharge (Q), soil temperature (Ts), total phosphorus (TP), and turbidity (Tb), as well as variables that describe seasonality and antecedent conditions. For details on the model development see Wang et al. (2025b). Using GAMs applied to all available data, continuous, daily DOC concentrations were obtained for 1990 – 2022. Model performance across the study streams was moderate, with NSE values ranging between 0.53 to 0.83. The transport patterns of annual DOC concentrations and fluxes differed across the streams (Figure 7.17). Annual DOC concentrations are mostly the highest at CBS while consistently the lowest at RDOA. However, the fluxes at CBS are among the lowest, comparable to those at RDOA. DOC fluxes at NCG are among the highest, followed closely by those at S5I.

Long-term trend analysis on annual DOC concentrations and fluxes showed absence of significant monotonic trend at all streams in the recent 20 years (2003-2022). The order of streams with decreasing average annual DOC fluxes during 2003-2022 is as follows: NCG > S5I > E16I > CBS > RDOA > PMSB (Table 7.9). At each stream site, DOC export during extreme events contribute disproportionately to the total annual export. At S5I, E16I and NCG, extreme events contributed nearly 50% of the annual DOC export (Table 7.9). After excluding DOC concentrations associated with the top 5 daily Q, the average annual DOC fluxes are more

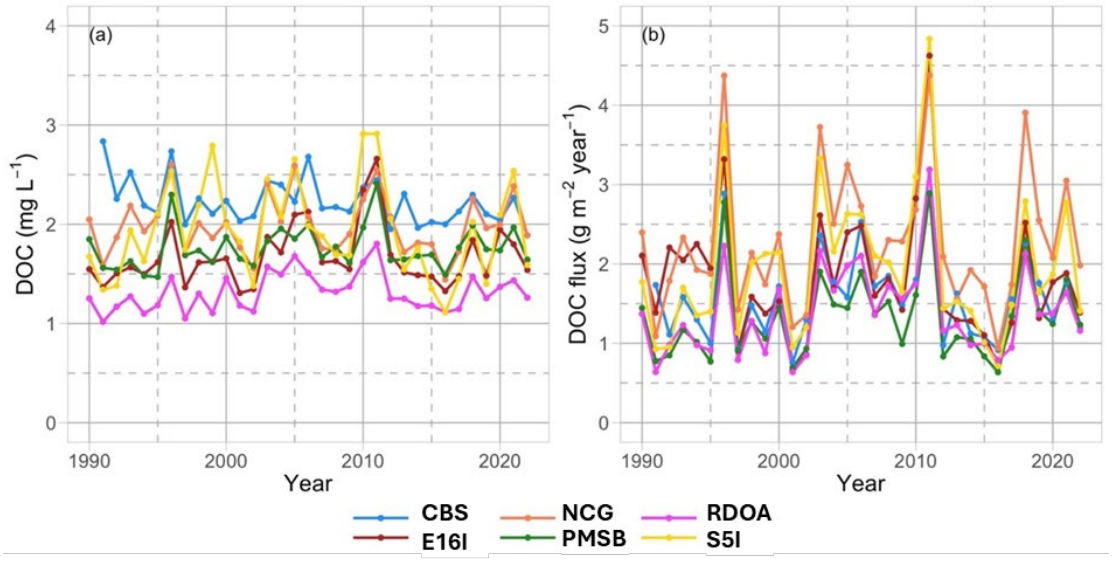


Figure 7.17 a) Annual flow-weighted average DOC concentrations and b) annual fluxes at the six study streams.

Table 7.9 Average annual DOC fluxes (g m^{-2} yr^{-1}) and percentage of annual DOC fluxes contributed by the top 5 daily Q (m3 s^{-1}) during 2003 and 2022 at each stream.

	CBS	E16I	NCG	PMSB	RDOA	S5I
Drainage area (km^2)	849.9	491.5	170.5	417.3	98.0	606.7
flux (g m^{-2} $year^{-1}$)	1.7	1.9	2.5	1.4	1.6	2.1
% of flux during top 5 daily Q*	36	46	46	36	40	49
Flux excluding DOC at the top 5 Q	1.1	1.0	1.5	1.0	1.0	1.2

** The annual DOC export accounted by certain range of Q is calculated by* $F^i = (365\,\overline{Q}^i f^i \overline{C}^i)/100$*, where* F^i *is the annual export associated with the ith Q range;* $\overline{Q}^i$ *is the average daily drainage area normalized Q (cm* day^{-1}*) for the ith Q range;* f^i *is the fraction of days in which Q is in the ith Q range; and* $\overline{C}^i$ *is the average DOC concentration (mg* L^{-1}*) when Q is in the ith Q range (Raymond and Saiers 2010).*

similar among the streams at lower values (Table 7.9). However, NCG still has noticeable higher values than the other streams, while the differences between fluxes at S5I and the other streams (CBS, E16I, PMSB and RDOA) are very small.

The continuous daily DOC values produced by this approach will aid in calibrating mechanistic models to characterize various watershed processes related to DOC production, transport, and fate.

7.3.4 Modeling – Stream UV254 and DBP Formation Potential

During the current FAD assessment period, DEP proposed and validated a two-component, simple statistical approach to predict HAA5fp and TTHMfp in inflows to Cannonsville and Neversink reservoirs using environmental variables (streamflow, total phosphorus, and soil temperature) and UV254 (see Wang et al. 2024 for details). The first component of the model predicts UV254 from streamflow, soil temperature, and total phosphorus; the second component then predicts HAA5fp and TTHMfp from UV254. The resulting models are presented in

Table 7.10, and performance for the CBS site is presented in Figure 7.18.

These models, in combination with routine monitoring of UV254, will allow DEP to generate improved 'loading' information of UV254 for reservoir models. In addition, these models will also estimate UV254 and DBPfp for long-term historic conditions and help understand the role of seasonality, extremes, and provide opportunity for validating reservoir models for a wide range of hydrologic conditions.

Table 7.10 Empirical models for predicting UV254 (cm^{-1}), HAA5fp ($\mu g\ L^{-1}$), and TTHMfp ($\mu g\ L^{-1}$) in West Branch Delaware (site CBS) and Neversink (site NCG) rivers.

West Branch Delaware River at Cannonsville	Neversink River at the Neversink
$\ln(UV_{254}) = -4.999 + 0.291\ln(Q) + 0.269\ln(TP) + 0.043\,T_{s,50}$	$\ln(UV_{254}) = -4.704 + 0.554\ln(Q) + 0.201\ln(TP) + 0.021\,T_{s,50}$
$\log_{10} HAA5fp = 3.77 + 1.17\ \log_{10} UV_{254}$	$\log_{10} HAA5fp = 3.58 + 0.99\ \log_{10} UV_{254}$
$\log_{10} TTHMfp = 3.45 + 1.02\ \log_{10} UV_{254}$	$\log_{10} TTHMfp = 3.33 + 0.91\ \log_{10} UV_{254}$

Q = streamflow ($m^3\ s^{-1}$), TP = total phosphorus ($\mu g\ L^{-1}$), $T_{s,50}$ = soil temperature at 50 cm depth (°C). Equations for HAA5fp and TTHMfp have been updated since the publication of Wang et al. (2024).

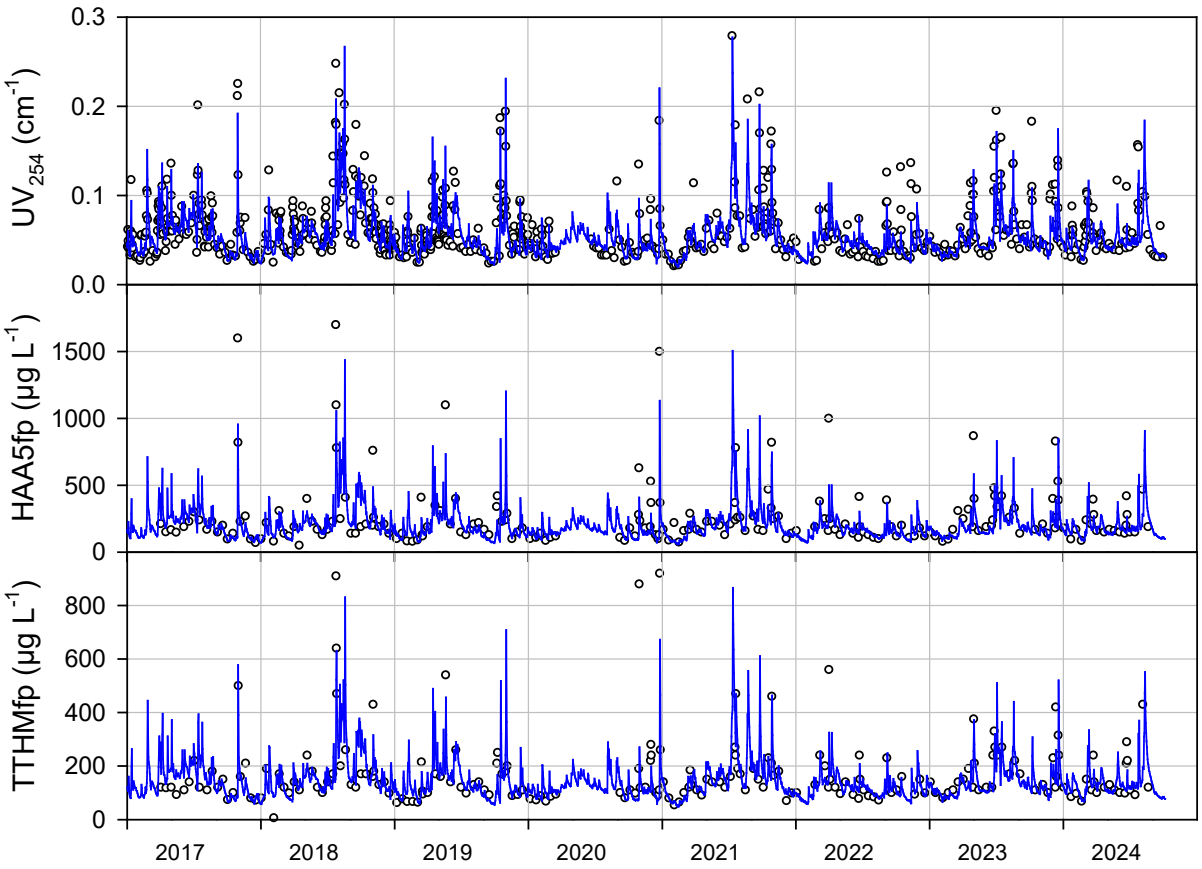


Figure 7.18 Performance of stream models in predicting UV254 and DBPfp for the West Branch Delaware River site (CBS) at Cannonsville Reservoir, 2017-2024.

7.3.5 Modeling – Forest Ecosystem Models

NYC watersheds are primarily forested and play a crucial role in organic matter-water cycling as well as maintaining high quality water supply. Process-based models that simulate plant growth and subsequent organic matter dynamics in soil and aquatic environment are necessary for assessing the impact of forest management practices and natural disturbances on water quality. During the current assessment period DEP developed and applied the SWAT-Carbon model for the Neversink watershed capable of simulating stream DOC. Remotely sensed data were used to parameterize and simulate forest growth and evapotranspiration. The DOC predictions across sites showed model sensitivity to soil properties, particularly soil depth and available water capacity (Mukundan et al. 2023). These simulations also indicated that instream DOC parameters were less sensitive in the Neversink watershed. Watershed models such as SWAT and its variants including SWAT-HS and SWAT-Carbon, which are part of the DEP's hydrologic modeling framework, often do not include state-of-the-art representation of forest ecosystem processes, therefore limiting their use in assessing environmental impacts of forest disturbance (e.g., land use change, forest management, and extreme weather events) on water quality. Recent work at the DEP integrated the Daily CENTURY (DAYCENT) based forest growth algorithm into SWAT-Carbon model and renamed the integrated model as Terrestrial Aquatic Sciences Convergence-Forest (TASC-Forest) model. This integration aims to improve the representation of key forest processes, such as biomass and nutrient allocation, litterfall, death, and the transformation of various tree components into litter and soil carbon pools.

TASC-Forest's ability to simulate monthly carbon fluxes, i.e., net ecosystem exchange (NEE) and ecosystem respiration (R_{eco}), and evapotranspiration (ET) was evaluated across multiple forest biomes: evergreen, mixed, and deciduous, using flux tower observations from seven AmeriFlux sites across the conterminous U.S. TASC-Forest substantially improved the simulation of NEE and ET across seven AmeriFlux sites compared to SWAT-Carbon, but R_{eco} was consistently underestimated during the summer months, likely due to the rapid decline in soil moisture during this period. When compared to other ecosystem models, TASC-Forest's performance for simulating NEE was on par with the top-performing models. Detailed description and findings of this study can be found in Dangol et al. (2025).

A framework was established to implement the TASC-Forest model at the watershed scale, and to evaluate its performance in simulating aboveground carbon, ET, streamflow, and DOC flux in the Biscuit Brook subwatershed within the Neversink watershed. Using a Bayesian change point detection method, a shift in the pattern of annual DOC export (transport of DOC from land to streams) was identified since 2003 (Figure 7.19). DOC export showed an increasing trend prior to 2003, followed by a negligible non-statistically significant decreasing trend after 2003 (p-value > 0.05) (Figure 7.19). The temporal pattern of annual DOC export followed the precipitation pattern, which indicates that precipitation is the primary driver of DOC export in the Biscuit Brook watershed. Although there was an abrupt shift in annual precipitation to a wetter period post 2003 (Figure 7.19), DOC export did not follow the precipitation trends before

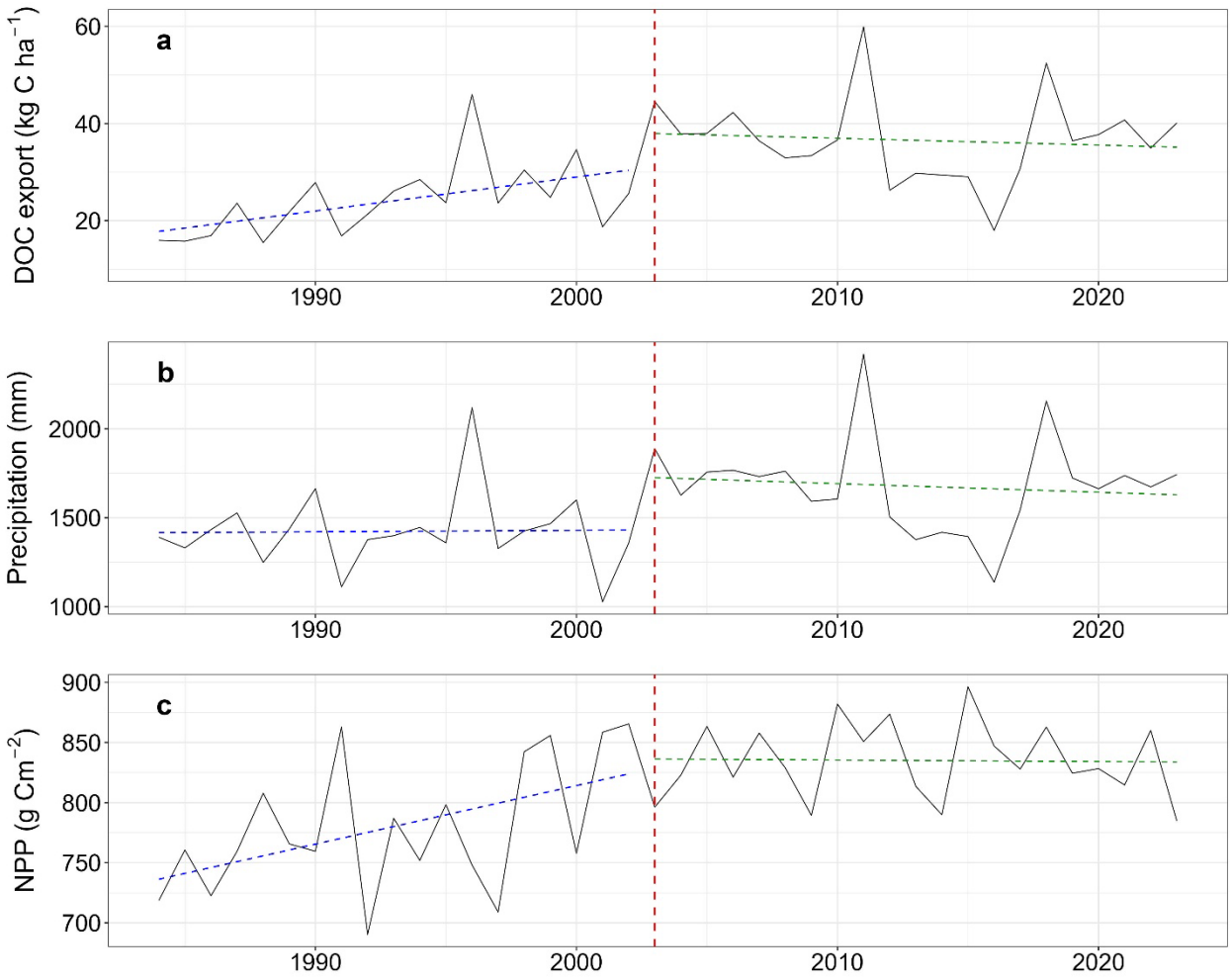


Figure 7.19 Change point and linear trend comparison of annual dissolved organic carbon (DOC) export, net primary productivity (NPP), and precipitation for the Biscuit Brook watershed.

The dashed vertical red line indicates the identified change point in annual DOC export. The dashed blue and green lines represent linear trend before and after the change point, respectively.

or after 2003. Instead, DOC export trends resembled those of net primary productivity (NPP) before and after 2003. This suggests a potential interaction between forest productivity and underlying complex hydrological and biogeochemical processes that influence temporal changes in DOC export in the Biscuit Brook watershed.

This study provided a foundation for future applications of TASC-Forest in larger NYC forested watersheds, advancing our understanding of the interrelationships among climate, vegetation, hydrology, carbon and nutrient cycling, and water quality. The applicability of TASC-Forest is not limited to water quality studies but can be expanded for forest management

scenarios (see Lee et al. (2025)), carbon sequestration, and carbon accounting studies at the watershed scale. Work is also underway to incorporate simulation of soil organic carbon transformation based on its biochemical composition.

7.3.6 Modeling – In-reservoir UV254

DEP made significant progress during the current FAD assessment period in developing and testing DBP formation potential models using a proxy state variable UV254 for four of the source water reservoirs – Cannonsville, Neversink, West Branch, and Ashokan reservoirs. DEP selected mechanistic, dynamic two-dimensional (vertical and longitudinal structure) hydrothermal/transport model CE-QUAL-W2 (W2; Coles and Wells 2013), which has been previously shown to perform well in simulating the seasonal density stratification and plunging inflows and spatial distribution of turbidity in NYC reservoirs (Gelda and Effler 2007; Gelda et al. 1998; 2009). In addition, W2 is already a component of OST's water quality simulation module. UV254 was modeled in W2 as a generic constituent with kinetics represented by a "lumped" first-order process that is adjusted for temperature (Arrhenius equation) and low UV254 levels (inverse Monod equation):

$$\frac{dc}{dt} = -k\theta^{(T-20)} \frac{c}{c + k_s} c \tag{7.4}$$

where, c = UV_{254} concentration (abs cm^{-1}), t = time (sec), k = first-order net loss rate (sec^{-1}), θ = temperature correction multiplier (dimensionless), T = water temperature (°C), and k_s = half-saturation constant (cm^{-1}).

Both adjustments are commonly made for biochemical processes in aquatic environment. Photolysis, adsorption, and biodegradation as explicit mechanisms of transformation of dissolved organic matter can be added in the model, if supported by data in future work. The first-order net loss rate coefficient, k was determined to be 0.0 d^{-1} for Neversink, 0.002 d^{-1} for West Branch and Ashokan, and 0.0025 d^{-1} for Cannonsville Reservoir. These values of k are indicative of nearly refractory, i.e., resistant to biodegradation, nature of organic matter exported from the watershed and into the water supply. Temperature correction coefficient, θ, was set to 1.024 [a typical value for biological processes used in water quality models (Chapra 2008)], and k_s was set to a low (relative to typical in-reservoir levels) value of 0.001 abs cm^{-1} for the four reservoirs.

Model testing (calibration-validation) was performed for 2011-2022, the longest period of available UV254 data in the diverted water. Input data required by the model included bathymetry, hourly meteorology (air temperature, dew point, wind, and solar radiation), inflows, outflows, water surface elevation, inflow temperatures and inflow UV254. Model testing data consisted of in-reservoir and outflow temperatures and UV254. Details on development of data for model testing are presented in Watershed Water Quality Annual Reports (DEP 2023; 2024; 2025).

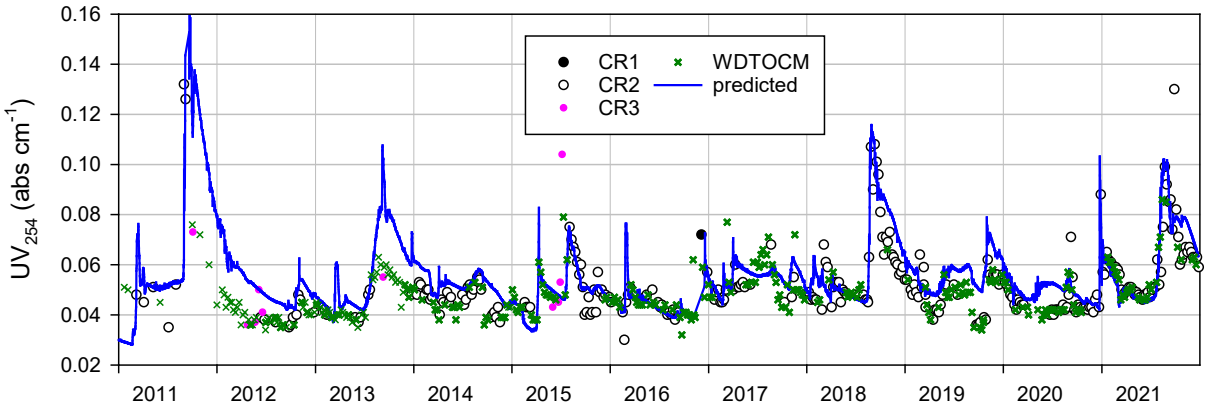
Model Performance: Performance of the model for withdrawal UV254 is shown in Figure 7.20. The model generally predicted well the seasonal dynamics and the peak response to loading events, and subsequent attenuation of UV254 levels. The model performance for the withdrawal from Cannonsville Reservoir is particularly good for 2016–2021 (RMSE = 0.008 cm^{-1}), for which DEP was able to define the loading of UV254 from WBDR more accurately, mostly from the observed data. For the earlier period, uncertainty in the specification of loading remains high that resulted in overprediction (e.g., during 2011–2012 following Hurricane Irene in August 2011).

The model underpredicted Neversink Reservoir withdrawal UV254 during the wet period of late-July–September 2018 (Figure 7.20). One likely source of uncertainty is the representativeness of observations from the site NR2 – the observations are expected to correspond to hypolimnetic levels (the keypoint site NR2 corresponds to the hypolimnion during stratified conditions); however, observed UV254 magnitude suggests that some epilimnetic water is also drawn (corroborated by temperature observations), which may be possible only if stop-shutters at higher elevations (NR3 and NR4) are only partially blocking the entry way. Model simulations show that the envelope of withdrawal does not extend above thermocline into the epilimnion during the stratified period. Nevertheless, the overall level of performance of the model for 2011-2021 is satisfactory (RMSE = 0.01 cm^{-1}) and the model would be acceptable for making operational and planning decisions. The model also performed well in predicting Ashokan Reservoir withdrawal UV254 (site EARCM; RMSE = 0.006 abs cm^{-1}; Figure 7.20), except during 2011-2012 due to uncertainty in estimates of loading of UV254 following Hurricane Irene in August 2011.

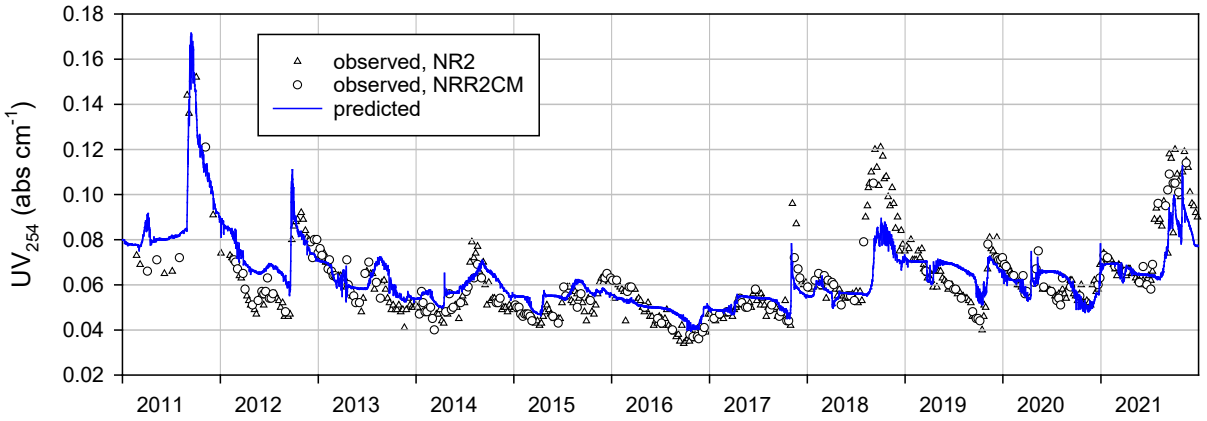
Performance of the model in predicting UV254 at DEL10/DEL17 was excellent (Figure 7.20). RMSEs for DEL17 was 0.005 cm^{-1}. The model predicted the seasonal variations well for the reservoir as well as bypass/float modes of operation (Figure 7.20). Overall, the model performance in simulating UV254 is satisfactory, consistent with earlier modeling efforts of the NYC reservoirs, and supportive of integration of the model in OST. These results suggest that the autochthonous production of UV254-absorbing organic matter (DBP precursors) is not significant in these reservoirs. This represents a reversal from an earlier study of Cannonsville Reservoir (Stepczuk et al. 1998), which found that algal growth during a more productive phase of 1990s contributed significantly to these precursors. Since then, median TP concentration in the inflowing WBDR has declined from 31 µg L^{-1} to 17 µg L^{-1} (Mukundan et al. 2020) and the trophic state of the reservoir has improved from eutrophic to mesotrophic (DEP 2025).

Future efforts may be directed first towards enhancing the monitoring program, including adding analytes and increasing the frequency, and then towards improving the model.

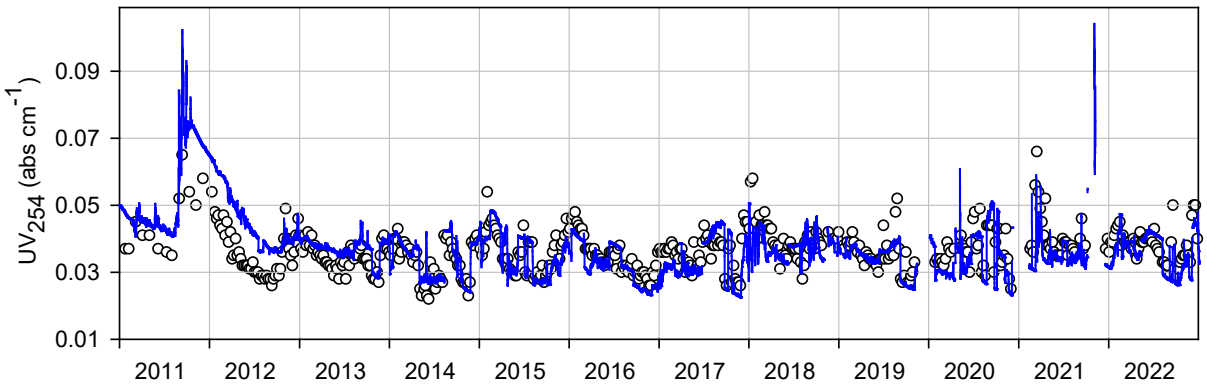
(a) Cannonsville Reservoir



(b) Neversink Reservoir



(c) Ashokan Reservoir



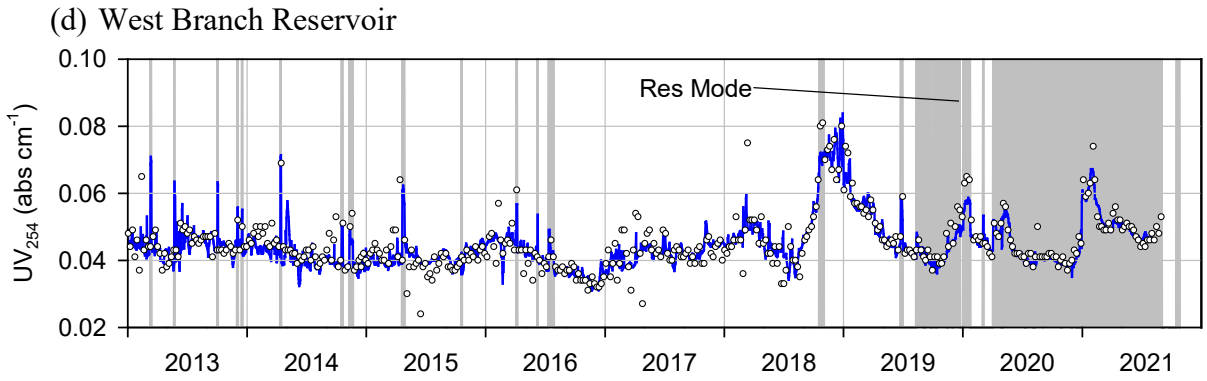


Figure 7.20 Performance of UV254 models, presented as comparison of observed and predicted withdrawal levels of UV254 (a) Cannonsville Reservoir, (b) Neversink Reservoir, (c) Ashokan Reservoir, and (d) West Branch Reservoir (shaded areas represent time when water from Rondout Reservoir was discharged into West Branch Reservoir).

From the successful applications of W2 for UV_{254} presented above, we conclude that: (i) UV254 can be modeled in the reservoir environment with a simple first-order kinetic model, (ii) autochthonous sources of dissolved constituents causing UV254 absorbance in these reservoirs are negligible, and (iii) allochthonous sources of UV254 are largely refractory.

7.3.7 Modeling – Evaluation of Boyd Corners Reservoir Bypass – UV254

Patterns of increases in UV254 in the outflow from Boyd Corners Reservoir during runoff events followed by increases in West Branch Reservoir UV254 have been observed throughout the monitoring period since 2013. It was hypothesized that bypassing a portion of the Boyd Corners outflow during runoff events could reduce its impact on the West Branch Reservoir. To test this, DEP considered "what-if" scenarios of reducing the outflow by 30 MGD and evaluated the impacts with a stand-alone W2-based UV254 model (i.e., not operating within OST) for West Branch Reservoir. A combination of Boyd Corners outflow and Delaware Aqueduct mode of operation were considered (see DEP 2025 for additional details).

The study concluded that reducing Boyd Corners Reservoir flow entering West Branch Reservoir improves (i.e., reduces) UV254 absorbance modestly, by ~ 0.01 cm^{-1}, especially when Boyd Corners was spilling, West Branch was in float/bypass mode, and West Branch UV254 > 0.075 cm^{-1}; otherwise, improvement was less than 0.01 cm^{-1} (inter-quartile range of improvement 0.0004 – 0.0054 cm^{-1}). Furthermore, reservoir mode was found to be effective in reducing the impact of elevated UV254 of Boyd Corners Reservoir.

7.3.8 Special Studies – Neversink River Monitoring

To better understand loading of organics during storm events, DEP sampled six storms in the Neversink watershed (site NCG) between 2019 and 2024. The study concluded that (i) storm events show large increases in concentration and loading of all organic parameters except bromine incorporation, (ii) hysteresis effects are evident when comparing organics

concentrations in the rising and falling limb of the hydrograph, and such effects are likely dependent upon the antecedent conditions, (iii) The base flow NOM is low in DBP precursor content (especially TTHA precursors) indicating less fresh hydrophobic organic matter, and (iv) the topographic index [TI = ln(α/tan β); α = basin area and β = surface slope; (Wolock et al. 1997)] may be a useful predictor of baseflow NOM concentrations. The study also reported dichloroacetic acid (DCAA) and trichloroacetic acid (TCAA) separately, and both showed a strong correlation with UV254 (Figure 7.21); however, a nonlinear relationship defined TCAA better.

Lignin components in organic matter were characterized using CuO oxidation method for eleven monomers in the functional groups of aldehydes, acids, and ketones. The lignin yield (concentration and loading) for the storm event generally followed the stream flow pattern and a strong positive relationship between the lignin yield and the DBP formation potential was observed. Furthermore, the eleven monomers explained about 35% of the DBP formation. Further details on data analysis, methods, and findings of this study are presented in Shakhawat et al. (2024; 2025; 2026).

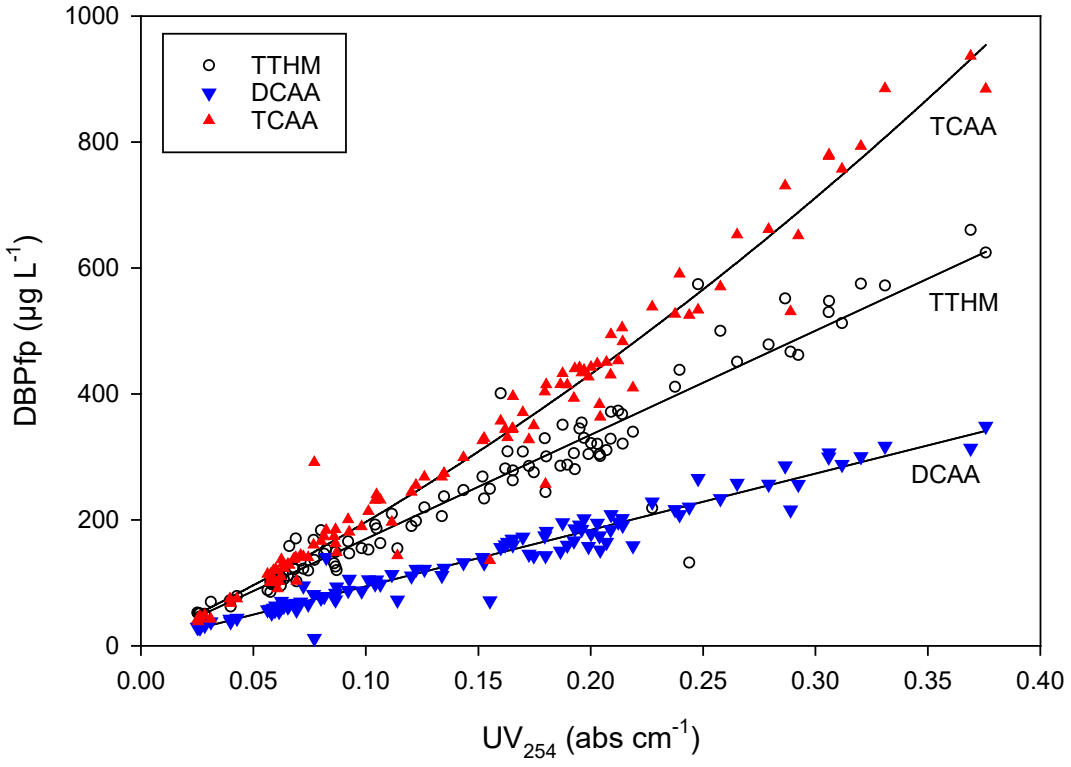


Figure 7.21 Relationship between UV254 and formation potential of DCAA (dichloroacetic acid), TCAA (trichloroacetic acid), and TTHM (total trihalomethane) at the site

NCG on Neversink River as observed during monitoring of five storm events in Neversink watershed during 2019 – 2024.

7.4 Turbidity

Relative contributions of turbidity loading from Shandaken Tunnel and Esopus Creek watershed into the West Basin of Ashokan Reservoir were evaluated. Average Shandaken Tunnel contribution to the overall loading was ~ 5% during 2020-2024 period (Figure 7.22).

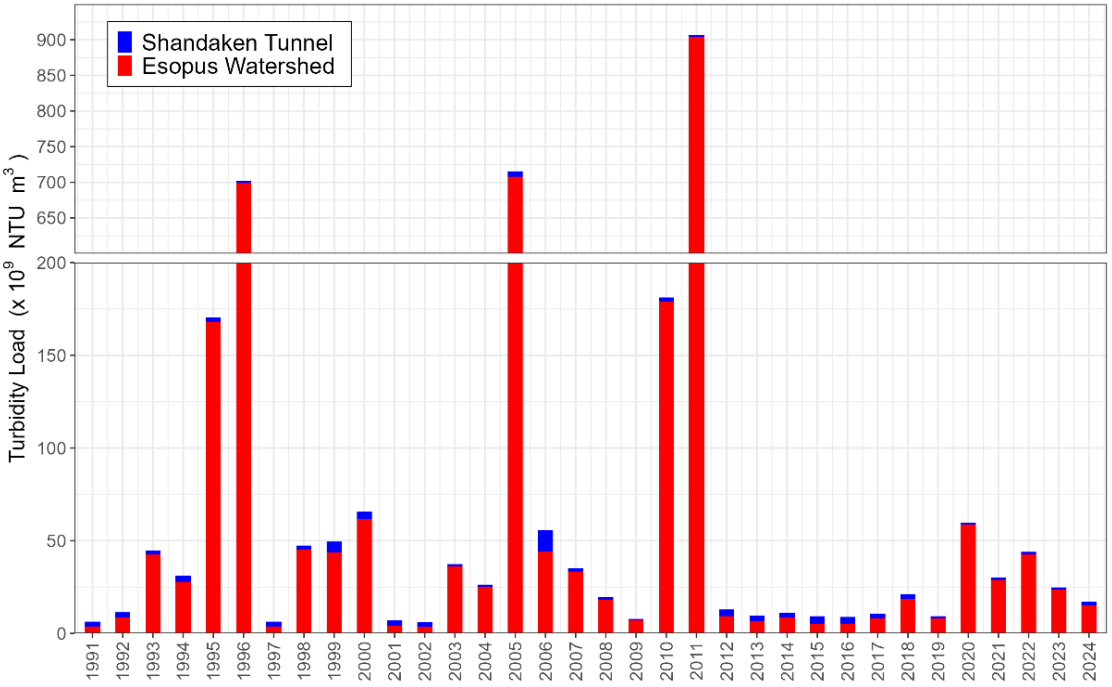


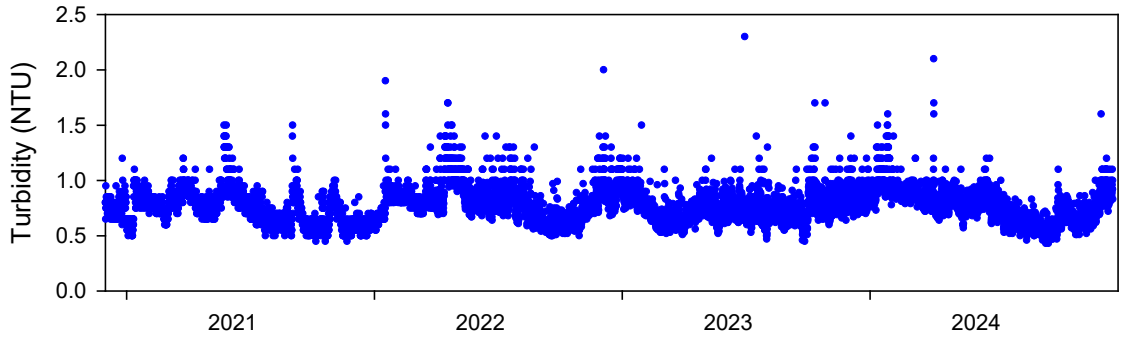
Figure 7.22 Turbidity loading from Shandaken Tunnel discharge and Esopus Creek Watershed to the West Basin of Ashokan Reservoir.

7.4.1 Application of Turbidity Models using OST

During the current FAD assessment period, DEP performed over 150 OST-water quality model simulations to assist in managing reservoir operations following rainfall events in the watershed. These simulations helped managers address key questions, such as determining the optimal diversion volumes from specific reservoirs to maintain the best possible water quality and estimating the time required for affected reservoirs to return to normal water quality conditions. Specific rainfall events that caused high turbidity in some of the Catskill/Delaware reservoirs are summarized in Table 7.11. The data presented pertains to Esopus Creek watershed/Ashokan Reservoir, though these events also impacted other reservoirs to a varying degree. The modeling-guided reservoir operations successfully managed turbidity in Kensico Reservoir without the need for alum treatment (Figure 7.23).

OST-W2 runs during RWBT Shutdown Project: OST-water quality runs were routinely conducted during RWBT shutdown project in October 2024. These runs allowed DEP to evaluate and forecast turbidity in Kensico Reservoir frequently and ensured that a low baseline turbidity (< 1.5 NTU) in the reservoir was maintained. Results of a run with Catskill Aqueduct inflow turbidity of 5 NTU, and Delaware Aqueduct inflow turbidity of 4 NTU are shown in Figure 7.24. The model simulation projected that Kensico diversion turbidity would exceed 1.5 NTU but with the addition of alum at CatAlum, it would remain < 1.5 NTU (Figure 7.24).

Table 7.11 Rainfall events impacting turbidity in Catskill/Delaware reservoirs during 2020-2024.

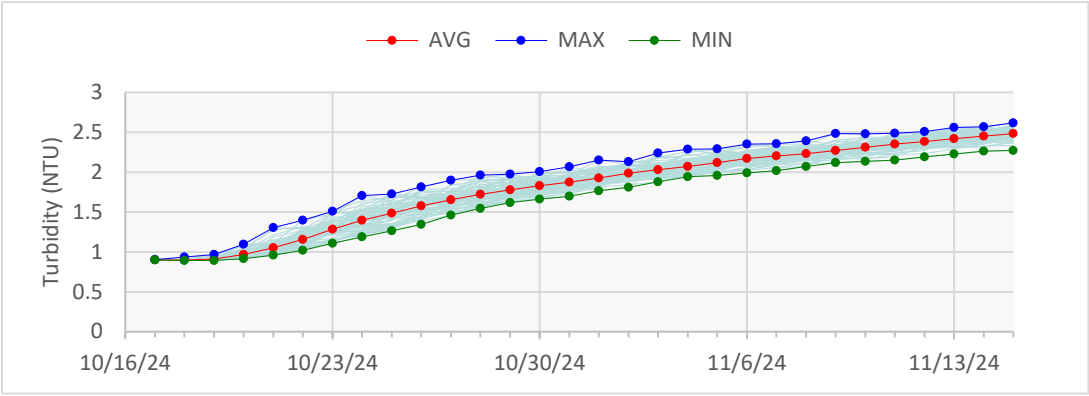


No.	Date of Peak Flow	Peak Flow (CFS)	Ashokan West Basin Turbidity (NTU) (Date)
1	12/25/2020 4:00	39100	450 (12/28/2020)
2	4/8/2022 1:30	15900	13 (4/14/2022)
3	12/18/2023 8:45	21800	20 (12/26/2023)
4	1/10/2024 7:15	6150	16 (1/16/2024)
5	1/13/2024 8:30	5770	16 (1/16/2024)
6	8/9/2024 19:40	5030	9 (8/12/2024)

The instantaneous peak flow is recorded at E16i on Esopus Creek, and turbidity is recorded at keypoints (WS, WM, WB) in the West Basin of Ashokan Reservoir.

Figure 7.23 Observed Kensico Reservoir diversion turbidity at Del18DT (4-hour laboratory samples).

(a)



(b)

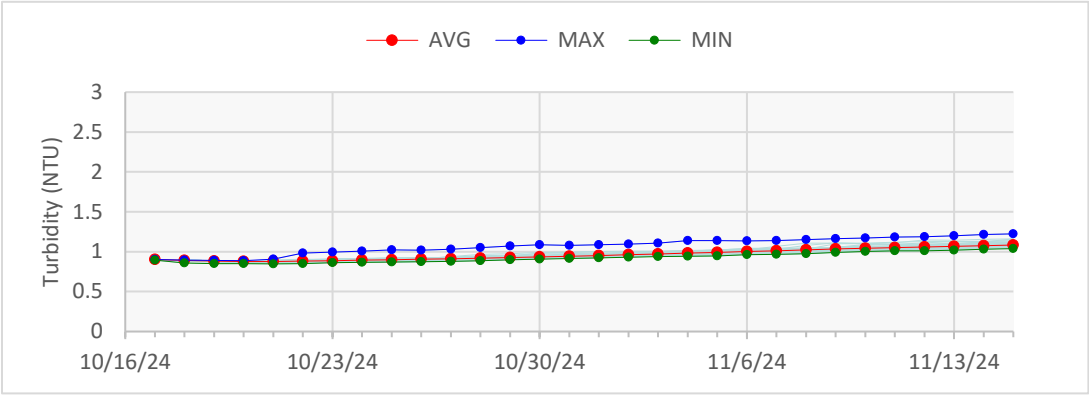


Figure 7.24 Projections of Kensico Reservoir diversion turbidity at Shaft-18: (a) without alum at Catskill Aqueduct inflow, and (b) with alum.

7.5 Climate

7.5.1 Climate Change Indicators

The impacts of climate change on the watershed water quality and water quantity are of particular concern to DEP. Higher temperatures and more intense precipitation events are predicted for the region. These changes will alter streamflow patterns and potentially affect water quality. DEP has been working to leverage the long-term hydro-meteorological datasets to describe how climate change is manifesting in the watershed. During the current FAD assessment period of 2021-2025, DEP continued evaluating climate change indicators and associated extreme meteorological (e.g., annual mean maximum daily temperature, tropical nights) and hydrologic (e.g., 30-day minimum flow, 7-day maximum flow) indices (DEP 2025).These indices describe the degree of extreme conditions for a given year relative to the reference period of 1970-2000. This reference period is used to calculate the 10^{th} and the 90^{th} percentiles for each indicator, with any indicator outside these values tagged as ‘extreme’.

Counts of these extreme values are summed for each year to generate the indices timeseries. See DEP (2025) for a list of the indicators used in the calculation of extreme climate indices.

The meteorological extreme index plot (Figure 7.25) shows that while the index for the baseline period (1970-1999) does not show a significant trend, the analysis period does show a clear and significant increase ($p < 0.003$). Further, the meteorological index continues to show high variability in the underlying meteorological indicators relative to the reference period, with 47% of the indicators outside the 10^{th} – 90^{th} percentile range in 2024 (as compared to 20% during the reference period). The hydrologic extreme index does not show significant trends during the analysis period, either at an aggregated level or at individual stream gages (Figure 7.26).

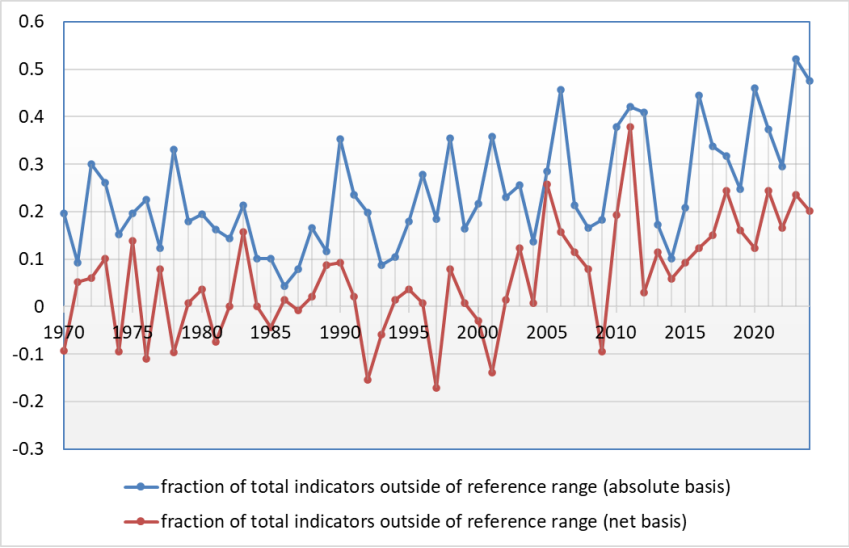


Figure 7.25 Meteorological extreme index results averaged across seven airport locations (Albany, Binghamton, Burlington, Hartford, Newark, Scranton, White Plains) for all indicators.

When calculated on a net basis, a negative index value suggests that more indicators fell below the 10^{th} percentile than above the 90^{th} percentile.

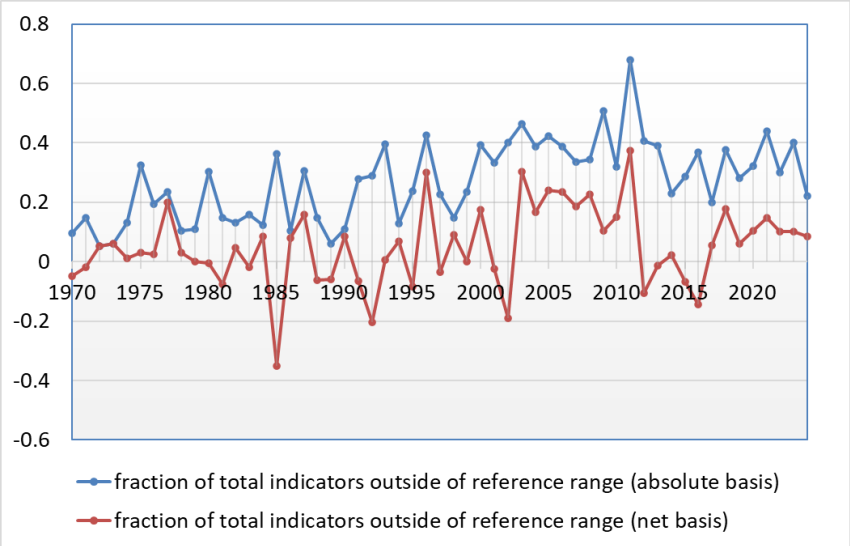


Figure 7.26 Hydrologic extreme index results averaged across all stream gages at reservoir inflows.

When calculated on a net basis, a negative index value suggests that more indicators fell below the 10th percentile than above the 90th percentile.

7.5.2 CMIP6 Climate Scenarios

During 2021-2025, DEP developed climate scenarios for impact assessment models using CMIP6, the most recent set of available climate projections. Downscaled CMIP6 projections from 24 GCMs from National Aeronautics and Space Administration (NASA) (Thrasher et al. 2022) and 30 GCMs from LOCA (Pierce et al. 2014) were obtained. To determine representative watershed-level data from these gridded GCMs output, area-weighted average of the temperature and precipitation values from all contributing grid cells, considering their respective areas within the watershed, were computed. Then a secondary bias correction method was applied using equidistant quantile mapping method (Gelda et al. 2019), which corrects for mean and sub-annual variability. The reference period for this secondary bias correction was 1985-2014 (30 years), and the reference observation datasets used were 4 km-gridded PRISM data.

An example of comparison of MACA CMIP5 RCP8.5 with NASA CMIP6 SSP585 and LOCA CMIP6 SSP585 for Cannonsville watershed is presented in Figure 7.27. Both of the CMIP6 scenarios project greater increases in temperature than the CMIP5 scenarios, while LOCA CMIP6 precipitation scenarios are almost the same as those of CMIP5 but NASA CMIP6 scenarios are projected to be wetter than CMIP5. Future work will use these scenarios to project impacts on watershed hydrology, water supply and system operation, and water quality.

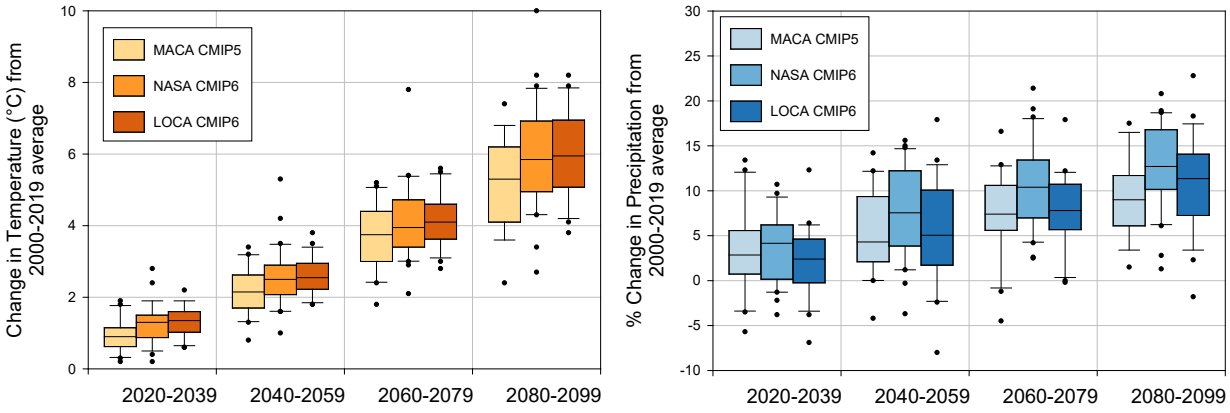


Figure 7.27 Changes in future temperature and precipitation as projected by MACA, NASA, and LOCA datasets for Cannonsville Reservoir watershed.

The boxplots (whiskers at 10th and 90th percentiles; all outliers shown) indicate intermodel varibility.

7.5.3 Multiyear Precipitation Variability Bias Correction

DEP has previously reported that GCMs tend to (1) underestimate historical multiyear precipitation variability compared to observations, and (2) project an increase in multiyear precipitation variability during the remainder of the 21st century compared to the historical period (Frei et al. 2022). The implication of these tendencies is that in some regions, including the WOH, GCMs do not capture the true magnitudes of multiyear drought or pluvial events, leading to a potential underestimation of the challenges in managing the water supply system.

During the current FAD assessment period, a methodology was proposed to correct for GCM underestimation of multiyear precipitation variability for the WOH watershed region. The methodology is illustrated in Figure 7.28, and presented in detail in Frei et al. (2025). The metric of "variability" is the range of precipitation values (the difference between the maximum and minimum values) for each duration. "Pluvials" and "droughts" (or, pluvial and drought "events") are defined as the wettest (highest mean precipitation) and driest (lowest mean precipitation) periods for each duration, which was calculated using running mean values.

For the GCMs used in the study, multiyear precipitation variability bias correction factor, defined as the ratio of observed to modeled range (Figure 7.28), varied between ~1 and 7, with an interquartile range of 1.5 – 3, for duration of 1-20 years.

The impact of these corrections on future multiyear extreme event scenarios can be quantified as the % change in uncorrected mean precipitation. The impacts of the correction on pluvial surpluses and drought deficits during the future period are greater than during the reference period. The correction resulted in an increase in GCM future precipitation scenarios during pluvial events of duration from 4 to 12 years between 5% and 40%, with median values for all downscaling groups between 10% and 20%. For drought scenarios the mean precipitation

deceased compared to uncorrected GCMs by as much as 50% for some models and durations, with median values between 15% and 25% (Frei et al. 2025).

These results suggest that uncorrected GCMs do not provide extreme precipitation scenarios, either drought or pluvial, that are sufficiently extreme to adequately capture the full range of scenarios that the City's water supply system may experience in the coming decades. Corrected scenarios provide more realistic extreme precipitation scenarios, providing water managers with precipitation scenarios to adequately prepare for conditions that could plausibly be encountered during the remainder of the 21st century.

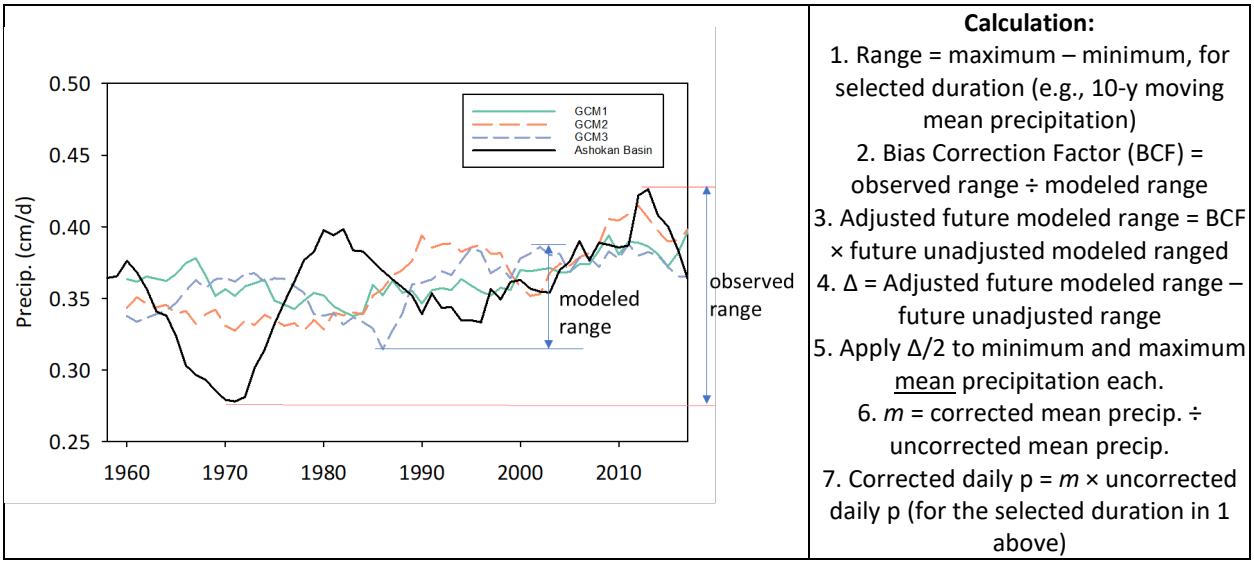


Figure 7.28 Illustration of multiyear precipitation variability (i.e., range) bias correction method.

10-year moving average precipitation from three GCMs and observations for Ashokan Reservoir watershed are shown to illustrate the method. Observed range and modeled range for one of the GCMs (GCM3) is indicated.

7.6 List of Publications

During the current FAD assessment period of 2021-2025, DEP published or submitted for publication the following 12 peer-reviewed articles.

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Appendix A Filtration Contingency Planning

Background

In 1993, USEPA issued a Filtration Avoidance Determination (FAD) for the Catskill/Delaware (CAT/DEL) System that required the DEP to proceed with conceptual and preliminary design of a water filtration facility that could be built in the event that filtration was deemed necessary.

The 1997 FAD contained deliverables requiring final design of a water filtration system and completion of a final environmental impact statement (FEIS). DEP was able to seek relief from these deliverables if DEP adequately addressed the remaining conditions of the FAD and the CAT/DEL System appeared likely to meet federal water quality standards for the foreseeable future. As contemplated by the 1997 FAD, the DEP applied for and later received relief from the final design deliverable and related environmental impact statement (EIS) activities, including the release of a DEIS and the completion of a FEIS. As conditions for relief, the DEP agreed to perform biennial updates of preliminary designs for a water filtration facility, conduct feasibility studies for ultraviolet (UV) light disinfection, and, if the technology was found suitable, design and construct a UV light disinfection facility.

The 2002 FAD required the DEP to continue producing biennial updates to the preliminary design for a CAT/DEL filtration plant in addition to constructing the CDUV, which was placed into full service in October of 2012. The 2007 FAD continued the requirement that DEP submit to USEPA and NYSDOH on a biennial basis a report updating the preliminary design of the CAT/DEL filtration facilities and discussing the analysis and re-design work.

In 2017, as the work supporting the preliminary plans was more than 25 years old, the FAD required the City to contract for a comprehensive review of filtration methods and technologies and develop a new conceptual design for a filtration facility. The water-treatment plant design developed under the prior FAD was based on a treatment train of ozone followed by direct filtration (ozone-DF). While this process was appropriate when selected in the mid-1990s, DEP was required under the 2017 FAD to evaluate whether ozone-DF remains the best filtration treatment alternative considering current available technologies. To meet the 2017 FAD requirements, DEP implemented a filtration planning study contract with two tasks: Task 1 includes a water quality and regulatory review, technology evaluation, and bench-scale testing; and Task 2 includes a more detailed evaluation of the recommended treatment alternatives, refinement of design criteria through pilot testing, and development of a conceptual design of the best treatment alternative for CAT/DEL water.

Filtration Design Update

Consistent with the milestones specified in the 2017 FAD for the CAT/DEL filtration planning study, DEP advertised the new contract on January 31, 2017, and issued the Notice to Proceed on January 24, 2018, to a consulting engineering firm specializing in water-treatment

plant design. The consultant completed Task 1 in May 2020. Based on the results of the screening analysis and bench-scale testing, the consultant recommended three treatment trains for future pilot studies.

Train 1: Direct Filtration

Ozone → Coagulation → Flocculation → Filtration → UV Disinfection → Chlorine

Train 2: DAF/ Filtration

Ozone → Coagulation → Flocculation → DAF → Intermediate Oxidant → Filtration → UV Disinfection → Chlorine

Train 3: Ion Exchange/Membrane Filtration

Ozone → Ion Exchange → Coagulation → Flocculation → Intermediate Oxidant → MF/UF→ UV Disinfection→ Chlorine

Although UV disinfection and chlorine are noted as the final step in each treatment train, these systems are currently in the City's system and are not included in pilot testing.

Following the completion of Task 1 in May 2020, the Task 2 Notice to Proceed was delayed until June 2021 and the Task 2 pilot design effort commenced September 2021. The pilot design included the development of design criteria, specifications, Piping & Instrumentation Diagrams (P&IDs) for the process equipment skids, on-site utility connections installation details and specifications, data collection and management requirements, and equipment monitoring requirements.

The pilot facility was constructed by Mace Contracting with treatment skids fabricated by Intuitech, PWNT, Aqua-Aerobics and Burt Process. A Catskill Aqueduct connection was to pump this supply to the pilot facilities. The pilot facility construction commenced in June 2024 and was completed in June 2025.

The final pilot test protocols report was submitted September 2025. The pilot protocols provide the test plan for the one-year pilot study with details about individual investigations and parameters that will be varied. The full-scale pilot testing of Train 1 and Train 2 commenced in October 2025, following NYSDEC approval of the SPDES discharge permit and initial commissioning. Train 3 will be piloted for a 6 month duration and the testing is anticipated to commence summer 2026.

Appendix B Rondout-West Branch Tunnel

Efforts to complete the preparatory work for the dewatering and repair of the RWBT have continued from 2020 through 2025, and include the following major components:

- Construction of the 2.5-mile bypass tunnel and ancillary facilities, under the BT-2 contract.
- Commencement of two pre-connection dewatering exercises in 2023.
- RWBT shutdown commencement and subsequent bailout in 2024.
- Establishment of the BT-3 contract to rehabilitate the Shaft 6 Pumping Station and complete the connection of the RWBT bypass tunnel.

Hydraulic Investigations, Remote Inspections and Risk Assessments of the RWBT

Historical investigations of the RWBT have demonstrated that leakage in the Roseton and Wawarsing areas have remained stable and well characterized through an integrated program of hydraulic testing, continuous monitoring, and surface investigations. Hydrostatic and backflow testing, along with routine flow-rate tracking, have consistently indicated steady exfiltration rates. Complementary field investigations conducted by the USGS in Wawarsing and consultant teams in Roseton documented groundwater conditions and surface leakage expressions. Interior condition evaluations were completed through autonomous underwater vehicle (AUV) inspections in 2003, 2009, and 2014, which produced extensive photographic records of the tunnel liner, as well as targeted ROV inspections in Wawarsing that identified liner cracking and active leakage zones used to support the planning of subsequent grouting repairs.

A comprehensive risk assessment undertaken by a Technical Review Committee in 2011–2012 synthesized all available monitoring data, hydraulic test results, surface observations, AUV imagery, and historical construction records. The committee concluded that the risk of tunnel collapse during a full unwatering was negligible and estimated tunnel inflow at approximately 20 MGD. These conclusions provided the technical basis for the design and advancement of the dewatering systems that proceeded into construction, ensuring that future repair activities could be executed with an appropriate understanding of the tunnel's hydraulic performance.

RWBT Tunnel and Shaft Rehabilitation Program

The Tunnel and Shaft Rehabilitation Program construction contract began in 2007. The work included substantial site improvements at various shaft locations to provide improved access to and ventilation of the tunnel, procurement of most of the "long-lead" items that would be required for a tunnel emergency (such as steel liner and special vehicles for use in the tunnel), and dives to replace the existing bronze gate valve and to investigate the bronze door both within Shaft 6 of the RWBT.

The DEL-185 contract work was substantially completed in September 2014 and resulted in the Shaft 6 RWBT unwatering pump station being operable and ready to unwater the RWBT for inspection and repair of the tunnel during the RWBT connection shutdown.

The 50 million gallons per day pumping station, which is capable of dewatering the RWBT under any expected conditions, was completed under the DEL-185 contract, and was successfully used for tunnel dewatering during the BT-2 contract.

RWBT Shutdown Management Plan

During the RWBT shutdown periods, Delaware System Reservoirs west of the Hudson River will be unavailable. In preparation for these outages, and loss of these key reservoirs, DEP has developed a Rondout-West Branch Tunnel Shutdown Management Plan. This plan includes operational guidelines and procedures for management of the water supply system in order to meet water demands, maintain high-quality water and mitigate risks to both water quality and supply reliability. The shutdown management plan was completed and issued in July of 2021.

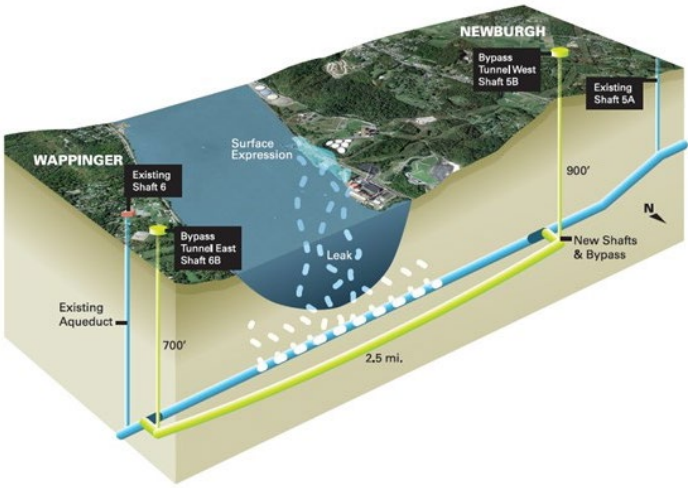
Roseton Bypass Tunnel and Leak Repairs

Planning for the Roseton Bypass Tunnel commenced in 2009 with the selection of an engineering consultant team tasked with evaluating conditions and developing a new tunnel segment to circumvent the most severe leakage zones in Roseton, New York. The bypass design was completed in 2012, and construction activities began in 2013. Implementation of the bypass was divided into two primary contracts: BT 1, covering the construction of new access shafts, and BT 2, encompassing excavation of the 2.5 mile bypass tunnel, installation of ancillary systems, and execution of the final connection to the existing RWBT.

During the RWBT connection phase, crews will connect the new bypass tunnel with the existing alignment and seal the compromised section of the RWBT. Concurrently, personnel will access the RWBT in the Wawarsing area to perform internal leak grouting operations.

BT-1 Contract – Access Shafts

Work under the BT 1 contract commenced in 2013. This contract encompassed the excavation of two deep vertical access shafts located in the Towns of Newburgh and Wappinger Falls, enabling entry to the subsurface for subsequent construction activities. The shafts, measuring approximately 900 feet and 700 feet in depth, were completed in 2016. These structures provided the essential access points required for



excavation of the bypass tunnel and for the eventual connection of the new tunnel segment to the existing RWBT.

BT-2 Contract – RWBT Bypass Tunnel

After completion of the BT-1 shafts, work began on the BT-2 contract in 2015. This contract encompassed construction of the 2.5-mile bypass tunnel, construction of ancillary and supporting equipment/facilities such as; dewatering pump systems, release enhancing siphons at Rondout Effluent Chamber, shaft access chambers and final connection of the RWBT bypass tunnel.

Excavation and construction of the bypass tunnel via tunnel-boring machine (TBM) was completed in October 2021. Final lining of the 5B and 6B access shafts was completed in July 2022, and construction of the access chamber superstructures was significantly completed in December 2025. The 20 MGD Shaft 6B drainage tunnel pump station installation was completed and tested in June 2022.

In preparation for final connection of the RWBT bypass tunnel DEP conducted two partial dewatering exercises of the RWBT in 2023. During those dewatering exercises, DEP dewatered the RWBT to elevations -90’ and -250’ respectfully. As a result of those exercises, DEP found that infiltration rates into the RWBT were higher than anticipated during initial tunnel dewatering, however this was found to be a transient condition and at full dewatering the infiltration rates were within the capacity of the Shaft 6B drainage tunnel pumping station.

DEP began connection dewatering of the RWBT in October of 2024. The RWBT was dewatered to the full elevation of approximately -600’, this was the first total dewatering of the RWBT since 1958, and the contractor began progressing excavation of the East and West Connection Tunnels as well as the Shaft 6B Drainage Tunnel. Due to drought conditions within the NYC water supply DEP made the decision to bailout of the connection shutdown and the RWBT was returned to service on December 13th, 2024.

BT-3 Contract – Shaft 6 Pump System Rehabilitation & Bypass Tunnel Connection

Post-2024 shutdown inspections of the Shaft 6 RWBT dewatering system noted issues with the dewatering pumps that would require rehabilitation of the pumps prior to beginning another shutdown. DEP has begun progressing the design of a BT-3 contract which will encompass rehabilitation of the Shaft 6 dewatering system and completion of the final connection of the bypass tunnel. This contract is currently in the design phase with an expected completion of the design in 2029, and a connection shutdown in 2031.

Water for the Future Program

Planning for an extended shutdown of the RWBT to make necessary repairs and bypass led to formation of the Water for the Future (WFF) Program. The program manages in a coordinated fashion all projects related to completion of the RWBT bypass and repair to ensure successful completion and track projects that could delay the RWBT construction. Two major

portions of the WFF Program include repair and rehabilitation of the Catskill Aqueduct and Demand Management.

During the RWBT connection period, the Catskill Aqueduct will be required to operate at maximum capacity for up to eight months duration. The CAT-RR project focuses on the section of the aqueduct between Ashokan Reservoir in Ulster County and Kensico Reservoir in Westchester County. The project's scope focuses on inspection of the entire aqueduct, repairing deficiencies (including concrete and mechanical components), and removing a biofilm layer on the interior walls to improve the hydraulic characteristics of the tunnel and restore tunnel capacity. CAT-RR construction commenced in August 2018. The fourth and final shutdown was carried out between October and mid-December 2021 with significant scope achieved, including the stabilization of the Catskill Influent Weir at Kensico Reservoir, biofilm removal, valve replacement and repair of several steel pipe siphon locations, and wall and invert repairs in the Reynolds Grade Tunnel.

Two related projects include building chemical addition facilities at the Ashokan Screen Chamber (CAT-213E) and the Pleasantville Alum Plant (CAT-213F) to deliver chlorination and dechlorination chemicals and alum, respectively. CAT-213E reached substantial completion in October 2021. Substantial completion of CAT-213F was reached in March 2023. Both projects have since been completed and are currently under operation by BWS.

Another measure to make up the loss of water from the Delaware System when the RWBT is out of service is to enhance demand management. Several projects have been implemented to reduce overall water demand in the City and upstate communities that rely on the City's water supply. Projects include toilet replacements with higher efficiency units, park spray shower enhancements, education programs, and enhanced leak detection.

Appendix C Water Quality Status and Trends Data Analysis

Introduction

Given the general environmental conditions as a backdrop, the effectiveness of watershed protection programs were examined to maintain a clean water supply through a series of analyses. These include the status and trends of water quality in streams and reservoirs as indicated by various analytes or indices, a macroinvertebrate bioassessment of stream conditions, the trophic response of reservoirs compared to standard regressions, and pathogen assessment. The objective was to look for central tendencies and trends in the water quality data over an extended period that includes before, during, and after watershed protection program implementation.

The water quality data used in this analysis represents time periods with different watershed conditions. The data record begins in the early 1990s, marking the outset of Filtration Avoidance when many watershed protection programs were in their infancy. The water quality data from this time period represent conditions with fewer watershed protection programs in place than post-Filtration Avoidance and the decades that follow. Many programs were implemented in the decade between 2000 and 2010, and this can be considered a period of non-equilibrium between observations and environmental conditions. The following decade was a phase when reservoirs could reach dynamic equilibrium between new watershed conditions (due to program implementation) and water quality in the reservoirs. The most recent time period of 2020 to 2024 was a period with new and unique challenges that could affect water quality. The COVID-19 pandemic slowed best management practice implementation and reduced monitoring. The flexibility of the water supply was heavily utilized in preparation for and during various capital projects which changed the operating conditions and residence time of key reservoirs. Finally, this time period was capped by a drought at the end of 2024.

Sites

Sites selected for water quality status and trends are listed in Appendix C Tables 1 and 2 as well as shown pictorially in Appendix C Figures 1 and 2. Reservoirs in this assessment include all Catskill and Delaware System reservoirs, West Branch Reservoir (acting as a balancing reservoir for water received from Rondout Reservoir), Cross River and Croton Falls Reservoirs (can be pumped into the Delaware Aqueduct prior to entering Kensico Reservoir), and Kensico Reservoir (normally the main source reservoir for the entire system sans the New Croton System).

For each of these reservoirs, the primary goal was to select sites that are identifiable as the primary inflows and outflows for each reservoir system. For all reservoirs except Kensico Reservoir, the inflow sites selected are surface-water main channels located immediately upstream of the reservoirs, and when appropriate, aqueducts delivering water from upstream

reservoirs. Rondout, West Branch, and Kensico reservoirs receive aqueduct inflows from upstream reservoirs. Reservoir outflow locations are normally aqueducts except for West Branch, Cross River and Croton Falls, where the reservoir outflows are releases.

This report excludes the Kensico Reservoir outflow as the water enters the Catskill Aqueduct (CATLEFF). Sampling at this location was discontinued in 2012 after the Catskill/Delaware UV Plant came online, and available data have been sufficiently described in previous reports.

Croton Falls Reservoir status and trend assessment includes available data from all basins of Croton Falls, instead of only the main basin and middle basin, as was reported in previous reports. This change was made to be consistent with data handling of all other reservoirs included in this report.

Appendix C Table 1. Inflow (surface-water and aqueduct keypoints), reservoir, and outflow (aqueduct keypoints and reservoir releases) monitoring locations included in the water quality status and trends analysis.

System/District	Inflows[1]	Reservoirs[3]	Outflows[1]
Catskill	S5I[s]	Schoharie (SS)	SRR2CM
	E16I[s]	Ashokan (West—EAW)[2]	—
	—	Ashokan (East—EAE)[2]	EARCM
Delaware	NCG[s]	Neversink (NN)	NRR2CM
	PMSB[s]	Pepacton (EDP)	PRR2CM
	CBS	Cannonsville (WDC)	WDTOCM
	NRR2CM[k], PRR2CM[k], WDTOCM[k], RDOA[s]	Rondout (RR)[2]	RDRRCM
East-of-Hudson	DEL9[k], BOYDR[s], HORSEPD12[s]	West Branch (CWB)[2]	WESTBRR
	CATALUM[k], DEL17[k],	Kensico (BRK)[2]	DEL18DT
	CROSS2[s]	Cross River (CCR)[2]	CROSSRVVC
	WESTBRR[s]	Croton Falls (CCF)[2]	CROFALLSVC

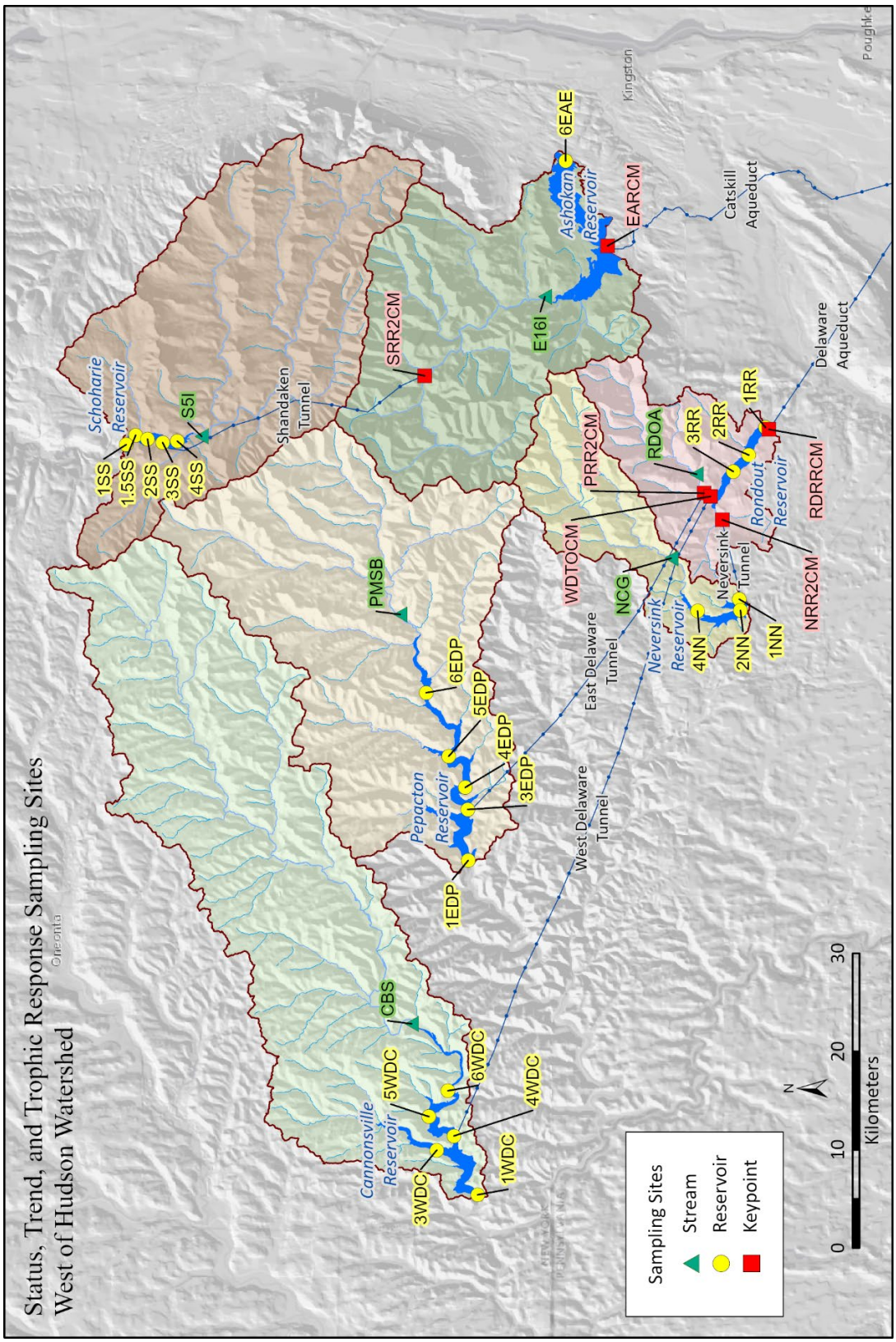
[1] The superscripts s and k refer to surface-water and aqueduct keypoints, respectively; all outflows are aqueduct keypoints except for WESTBRR, CROSSRVVC and CROFALLSVC which are reservoir releases.

[2] Indicates a source or potential source water.

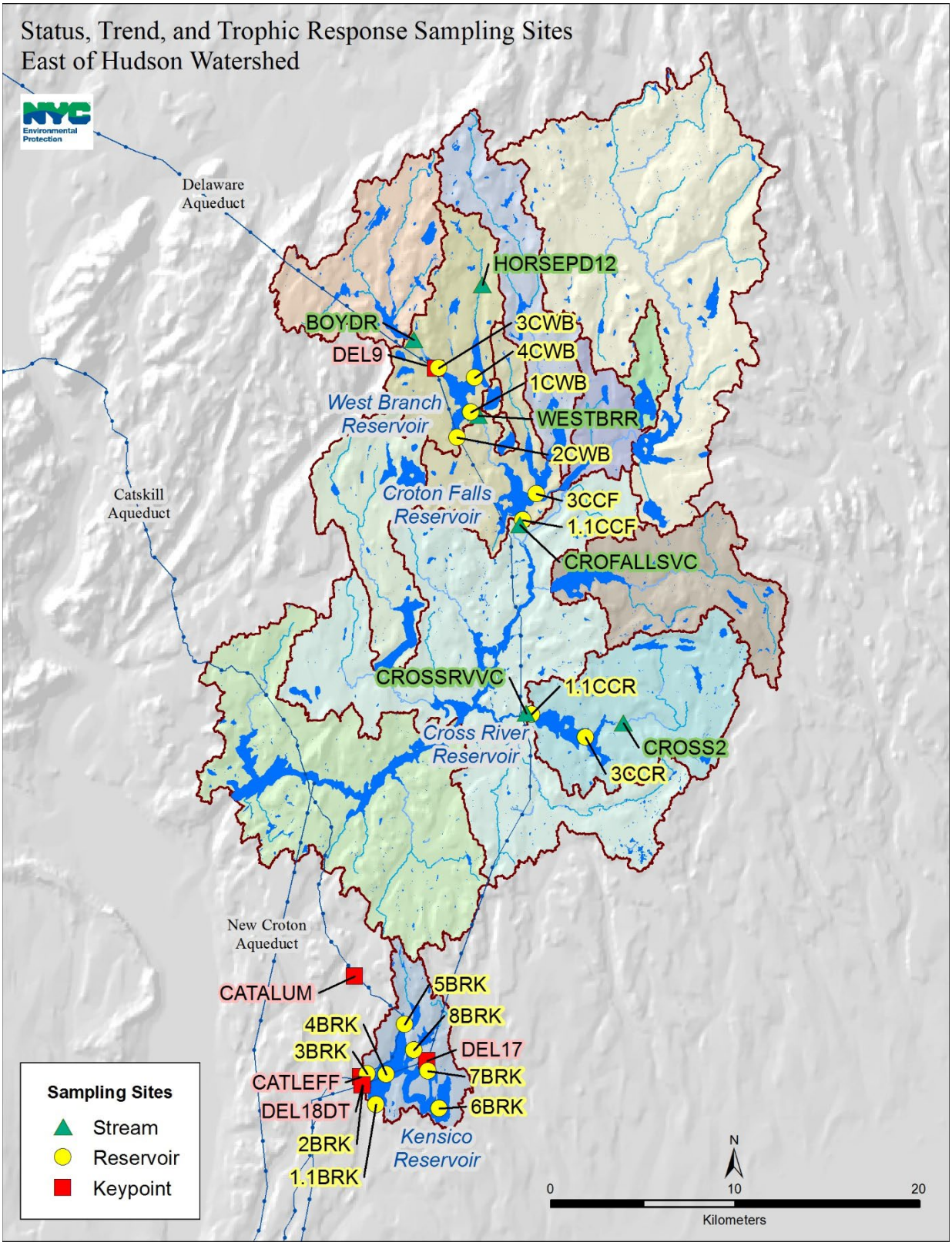
[3] Reservoir designations represent an amalgam of multiple locations and depths (see text).

Appendix C Table 2. Median number of samples collected per month for status and trend analysis, 1993-2024.

Site	Type	Fecal coliform	TP	Conductivity	Turbidity	Chlorophyll *a*
DEL17	Keypoint	22	4	22	24	0
DEL18DT	Keypoint	31	1	31	31	0
DEL9	Keypoint	4	4	4	4	0
EARCM	Keypoint	19	1	22	22	0
NRR2CM	Keypoint	11	1	13	13	0
PRR2CM	Keypoint	15	1	18	19	0
RDRRCM	Keypoint	19	1	22	23	0
SRR2CM	Keypoint	16	4	20	21	0
WDTOCM	Keypoint	11	1	13	14	0
BRK	Reservoir	22	22	22	22	8
CCF	Reservoir	8	8	8	8	3
CCR	Reservoir	6	6	6	6	2
CWB	Reservoir	8	8	8	8	4
EAE	Reservoir	8	8	8	8	3
EAW	Reservoir	9	9	10	10	3
EDP	Reservoir	16	16	16	16	5
NN	Reservoir	12	10	12	12	4
RR	Reservoir	10	10	10	10	3
SS	Reservoir	11	11	11	11	4
WDC	Reservoir	15	15	16	15	5
BOYDR	Release	1	1	1	1	0
CROFALLSVC	Release	1	1	1	1	0
CROSSRVVC	Release	1	1	1	1	0
WESTBRR	Release	1	1	1	1	0
CBS	Stream	1	1	1	1	0
CROSS2	Stream	1	1	1	1	0
E16I	Stream	1	1	1	1	0
HORSEPD12	Stream	1	1	1	1	0
NCG	Stream	1	1	1	1	0
PMSB	Stream	1	1	1	1	0
RDOA	Stream	1	1	1	1	0
S5I	Stream	1	1	1	1	0



Appendix C Figure 1 Sampling sites for the West of Hudson status and trends analysis.



Appendix C Figure 2 Sampling sites for the East of Hudson status and trend analysis

Data collection

The Directorate of Water Quality (DWQ) performs routine monitoring of the NYC water supply according to the Watershed Water Quality Monitoring Plan (WWQMP). The DWQ lab and field operations staff routinely monitor the reservoirs, streams, reservoir releases, and keypoints. Keypoint, stream, and reservoir release routine monitoring used for this report are collected year-round at a specified location. Reservoir routine monitoring used for this report are collected from April-November from multiple depths at the dam, mid-reservoir, near major stream influent areas, and at other important sites, such as near aqueducts. Differences in sampling strategies may partially account for differences observed in trends across site types.

To ensure the accuracy of trend analysis it is important to maintain consistency in sampling and analytical methodology throughout the period of record. Unfortunately, several changes were instituted for the collection of reservoir surface samples that may affect trend results. From 1993-2001 surface samples were composited from the air-water interface down to the depth of the 1% light level. In 2002, these integrated surface samples were replaced by a 3-meter discrete sample collected using a Van Dorn sampler. The depth of integration also changed. From 1993-1998 the 1% light depth was based on an initial light measurement made in the air above the water surface. From 1999-2001 the location of the initial light measurement was corrected to begin just below the air-water interface. Because of this change, the depth of the photic zone increased by 10-20%. For the purpose of this report, DEP assumed that these sampling changes had minimal effect on water quality measurements, but in reality, the effect is not known.

Analytes

The analytes considered for status and trends analysis are turbidity, fecal coliform, total phosphorus (TP), and conductivity, plus reservoir trophic state index (derived from chlorophyll a measurements). These are considered the most important water quality indicators for the DEP water supply. Although ELAP-approved methods were used, several changes occurred during the period of record that could affect trend results. Important method changes for this period of interest include:

- 1999

  Turbidity – Instrument change from the Hach Ratio X/ turbidimeter to the Hach 2100AN turbidimeter.

- 2000

  Chlorophyll a - Instrument change from the fluorometer to HPLC.

  Total Phosphorus – Change in digestion method prior to analysis.

- 2007

  Chlorophyll a – Analysis moved from Grahamsville Laboratory to the Ben Nesin Laboratory.

- 2007-2008

  Total Phosphorus – Instrument change from Alpkem to Lachat.

- 2008

  Total Phosphorus – Analysis moved from Grahamsville and Ben Nesin Laboratories to the Kingston Laboratory.

- 2009

  Conductivity – Changed from in-situ measurements using multiparameter field sondes for routine monitoring (1993 – 2010) to collecting a grab sample for analysis in the laboratory. Requirement of the Quality Assurance program for ELAP certification of conductivity results. In-situ limnology profile measurements continue to be performed with multiparameter field sonde. The effect has not been determined but initial comparisons indicate the effect to be minimal.

- 2014

  Bottle Change – To meet ELAP requirements, in August 2014 all bottles used for preserved samples, except trace metals, were switched from polypropylene (PP) to high density polyethylene (HDPE).

In addition to the above method changes, phosphorus contamination in sample bottles inflated results from late 2014 to 2017 and was most significant in 2016 and 2017 in the Delaware and Catskill systems. Phosphorus contamination was found to be minimal in samples collected in EOH FAD basins.

Trophic State Index (TSI) was calculated from the chlorophyll a concentration using the following equation (Carlson, 1977):

$$TSI = 9.81 \times \ln(\text{chlor } a) + 30.6$$

where chlor *a* = chlorophyll a concentration ($\mu g\ L^{-1}$).

Only samples collected from the photic zone (either integrated samples taken from the surface to the 1% light level, or discrete samples taken at 3m depth) were used to calculate TSI.

Methodology

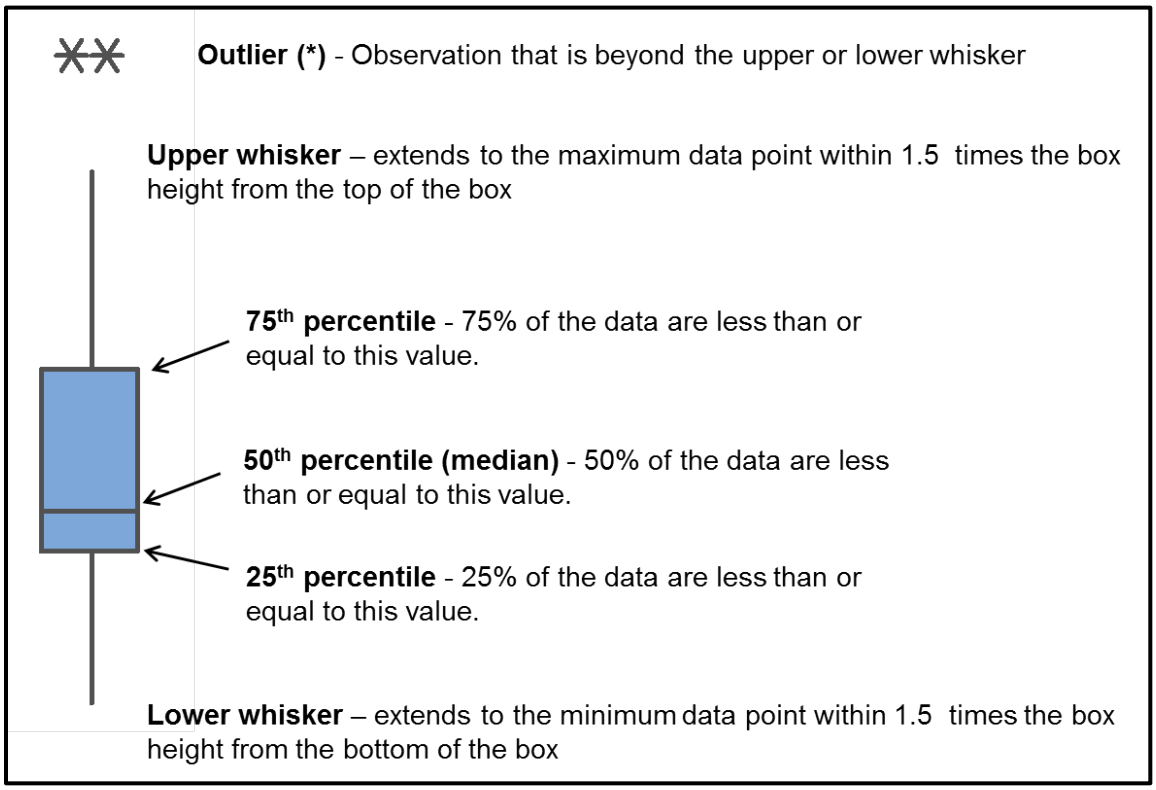
To create a balanced dataset, steps were taken to minimize potential impacts of changes in sampling frequency during the period of record which may produce a bias in the data, thereby obscuring or enhancing a trend. The following steps were used:

1. Eliminating all special investigations and restricted data.
2. Coliform results with left censoring greater than <5 coliforms 100 mL^{-1} (<10, <20, <100, etc…) were converted to missing.
3. Right censored coliform results were converted to the value of the limit (e.g. >120 coliforms 100 mL^{-1} was converted to 120 coliforms 100 mL^{-1}).
4. Calculate a monthly median value for each month for each analyte of interest for all sites. Values below the detection limit were converted to one-half the detection limit for statistical analysis. Future work will explore using more robust methods, like the R Statistical package NADA, to calculate median values without converting censored data.
5. Ensure consistent representation. If less than 75% of the normal reservoir monthly sample load was not available for reservoirs with 4 or more sites, a monthly median was not calculated for that particular month for that reservoir, and the month set to missing. For reservoirs with 3 sites or less, 50% of the sample load was required.

Status Methods

In an assessment of water quality status, the time period used has to be sufficiently short so that any trends are minimized, but sufficiently long to minimize short-term fluctuations. A three-year time period was considered appropriate and monthly medians from the years 2022–2024 were used. Values below the detection limit were converted to one-half the detection limit for statistical analysis. Box plots have been used as a visual aid to graphically display water quality status based on select analytes. See Appendix C Figure 3 which provides a key for interpreting the box plots. The analytes chosen were those most important for the SWTR and meeting the requirements of the 2017 revised Filtration Avoidance Determination.

A guidance value of 200 coliforms 100 mL^{-1} based on a calculation developed for streams by the New York State Department of Environmental Conservation (6 NYCRR Part 703.4(b)) is included in the discussion of stream fecal coliform status. For reservoirs, fecal coliform data are compared to Surface Water Treatment Rule (SWTR) standards (20 coliforms 100 mL^{-1} for fecal coliform) as a benchmark value. While these standards do not apply to source water reservoirs, they are used for reference purposes. Similarly, the TP benchmark in the status plots (15 µg L^{-1} for potential source water or terminal reservoirs and 20 µg L^{-1} for headwater or non-source reservoirs) is based on phosphorus-restricted "target values" developed by DEP. The calculations for phosphorus-restricted basins are different and covered in the Watershed Water Quality Annual Report, so the use here is for comparative purposes. Trophic state index (TSI) benchmarks, where reservoirs with values <40 are considered oligotrophic; those with values between 40 and 50 are mesotrophic; and values >50 are eutrophic, were based on Carlson (1977).



Appendix C Figure 3 Description of the boxplot statistics used in status evaluations

Trend Methods

Two independent techniques were used to detect trends. In the first approach, locally weighted scatterplot smoothing (LOWESS) curves were fit to the data to visually describe both the long-term and intermediate data patterns (Cleveland 1979). The second approach used the non-parametric Seasonal Kendall Test (SK) to test for monotonic change (Hirsch et al. 1982).

LOWESS curves were constructed in R using the ggplot2 and stats packages with a smooth factor of 0.4. Curves were fitted to monthly medians of the data to describe long-term and prominent short-term trends. If more than 50% of the month's data were left censored, the median was set to ½ the instrument detection limit. The non-parametric LOWESS technique was chosen because, unlike parametric methods such as linear regression, it provides a robust description of the data without pre-supposing any relationship between the analytes and time, and because the distribution of the data does not need to be of a particular type (e.g., normal). The LOWESS technique is also preferable to parametric methods because it performs iterative re-weighting which lessens the influence of outliers and highly skewed data.

The occurrence of long-term monotonic trends was tested for statistical significance using the non-parametric SK test (Hirsch et al. 1982). The magnitude of detected trends was determined using the Seasonal Kendall Slope Estimator (SKSE) (Hirsch et al. 1982).

The SK tests were performed using the EnvStats package in R. The Seasonal Kendall test poses the null hypothesis that there is no trend; the alternative hypothesis being that there is in fact an upward or downward trend (a two-sided test). The p-values for all trend tests are symbolized as follows:

p- value	Significance	Symbol
$p \geq 0.20$	None	NS
$p < 0.20$	Moderate	*
$p < 0.10$	High	**
$p < 0.05$	Very High	***

The lower the p value, the more likely the observed trend is not attributable to chance. Note that the term "NS" does not mean that there is no trend but rather that the null hypothesis of no trend cannot be rejected (at the p = 0.2 level of significance—80% confidence level), and that any apparent trend could be attributed to chance.

A strong advantage of the non-parametric test is that there are no assumptions made, apart from monotonicity, about the functional form of any trend that may be present; the test merely addresses whether the within-season/between-year differences tend to be monotonic. Outliers also have a lesser effect on the non-parametric tests because non-parametric tests consider the ranks of the data rather than actual values. The effects of serial correlation are always ignored; this is justified because the scale of interest is confined to the period of record (Loftis et al. 1991, McBride 2005).

The SKSE technique is used to estimate trend magnitude (i.e., amount of change per year). In this technique, slope estimates are first computed for all possible data pairs of like months. The median of these slopes is then determined. This median is the Seasonal Kendall Slope Estimator. Note that it is possible to obtain a statistically significant trend with the Seasonal Kendall Test yet obtain a zero change per year using SKT. This is an odd feature of the procedures and is a function of the fact that the trend test and the slope estimate are performed independently of each other. It occurs when there are many tied values in the dataset, e.g., many non-detects. When that happens, the trend slope computation, which is based on the median of all slopes between data pairs of the same month, produces a value of zero, even though the trend analysis, which is based on median data ranks, may produce a significant result.

Note that in practice one can rarely, if ever, say that there is no trend. All one can say is that you have failed to detect a trend at a certain level of confidence. In fact, there is nearly always a trend and the null hypothesis of no trend is nearly always false to begin with. Note also that p values produced with data having different n values are not comparable (McBride, 2005).

As discussed in Helsel (Helsel et al. 2020) new techniques have been developed for presenting results from trend assessments (e.g., McBride, et al. 2014, McBride 2019) and are being used more widely used in the scientific literature. In the trend detection assessment, the focus is on determining the direction of the trend (increasing or decreasing) regardless of its magnitude and uses descriptive words to provide describe an estimate of the likelihood of the detected direction being correct. The method assumes over time there is always a trend. The traditional trend analysis can categorize trends as "insignificant' if they fail to satisfy a predetermined significance level, e.g. 0.05, and thus miss out on information that may be help decide if water quality is improving or not. McBride's methodology estimates a Sen slope from the data, then uses Bayesian Credible Intervals to compute confidence intervals around the slope to calculate probabilities that the trend is either increasing or decreasing. Breakpoints, instead of a single probability, e.g., 0.95, are used on scale and assigned descriptive language (e.g., a trend is "likely increasing" or "very likely increasing") to convey the likelihood of the trend direction being correct (see table below). The methodology of McBride (2019) was used to perform the trend detection assessment using the likelihood scale below:

Confidence Limits (%)	Slope Direction probability	Term
99	>=0.995	Virtually certain
95	>=0.975	Very likely
90	>=0.95	Likely
67	>=0.835	Possible
33	>=0.665	About as likely as not
10	>=0.55	Unlikely
5	>0.525	Extremely unlikely
1	<=0.505	Exceptionally unlikely

OECD Methods

The trophic response of reservoirs to the combined effects of watershed protection programs and major environmental events was examined through four relationships selected from the Programme on Eutrophication sponsored by the Organization for Economic Cooperation and Development (OECD). These four relationships include:

1. chlorophyll vs total phosphorus,
2. maximum chlorophyll vs total phosphorus,
3. Secchi depth vs total phosphorus, and

4. Secchi depth vs chlorophyll.

Annual geometric means of each analyte were plotted on the OECD standard lines that were developed from over 100 other northern temperate zone waterbodies. Annual geometric means were used (as in the 'standard' regressions) to best represent the central tendencies without undue influence of the few extreme high values typically recorded. These standard regressions provide a context to identify true outliers and identify the causes for their variation from behavior of the standard relationships. These analyses highlight the biological responses to major environmental drivers such as hurricanes and floods. By matching the year of major environmental events to a particular response, patterns in the types and extents to which environmental drivers affect water quality can be identified. The identification of years can also indicate overall shifts in nutrients, algal biomass, and transparency over the course of time, and in this instance over the past several decades, to help evaluate the collective effects of the many watershed protection programs.

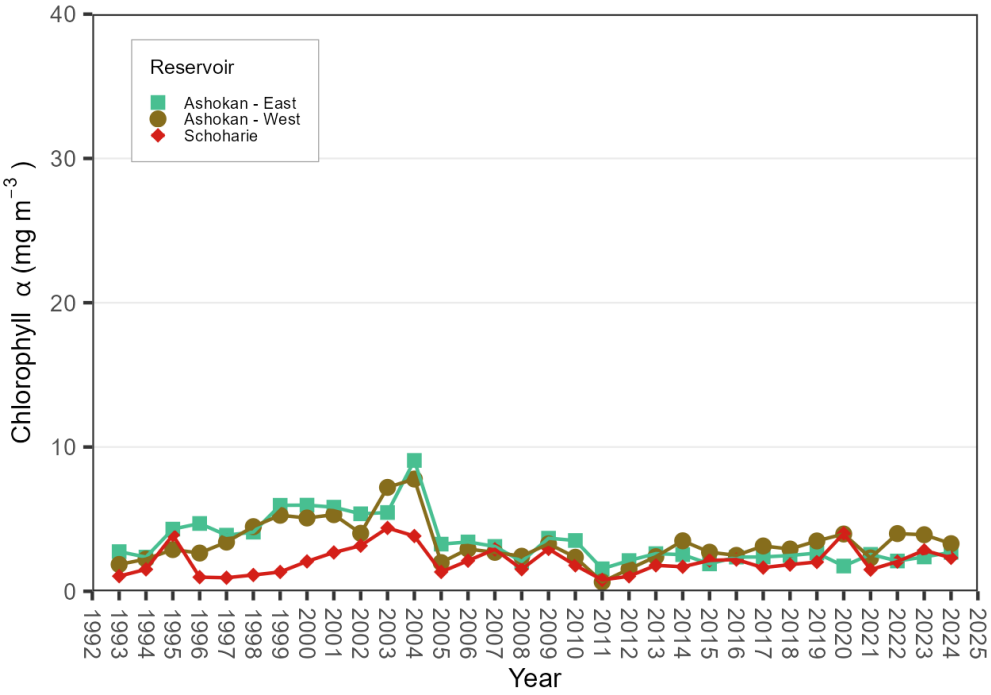
Biomonitoring Methods

Macroinvertebrate indices were calculated to provide insight into the ecological conditions of streams and changes in water quality. Macroinvertebrates biologically integrate conditions over time, so they are seen as important indicators of stream water quality. The impact of the waterfowl management program and its ability to control and reduce fecal coliform bacteria have been demonstrated over the past 32 years and selected case studies are presented to demonstrate the effectiveness of this program. Notably, terminal reservoirs (i.e., those with the potential to be the last open water prior to treatment and distribution) receive the greatest attention in terms of program implementation. Programs are tailored to provide greatest protection near Kensico Reservoir and the distribution system, so it is by design that program intensity is highest in the downstream basins. Waterfowl Management is a prime example of that strategy with emphasis on Kensico due to its importance in controlling coliform bacteria for SWTR compliance.

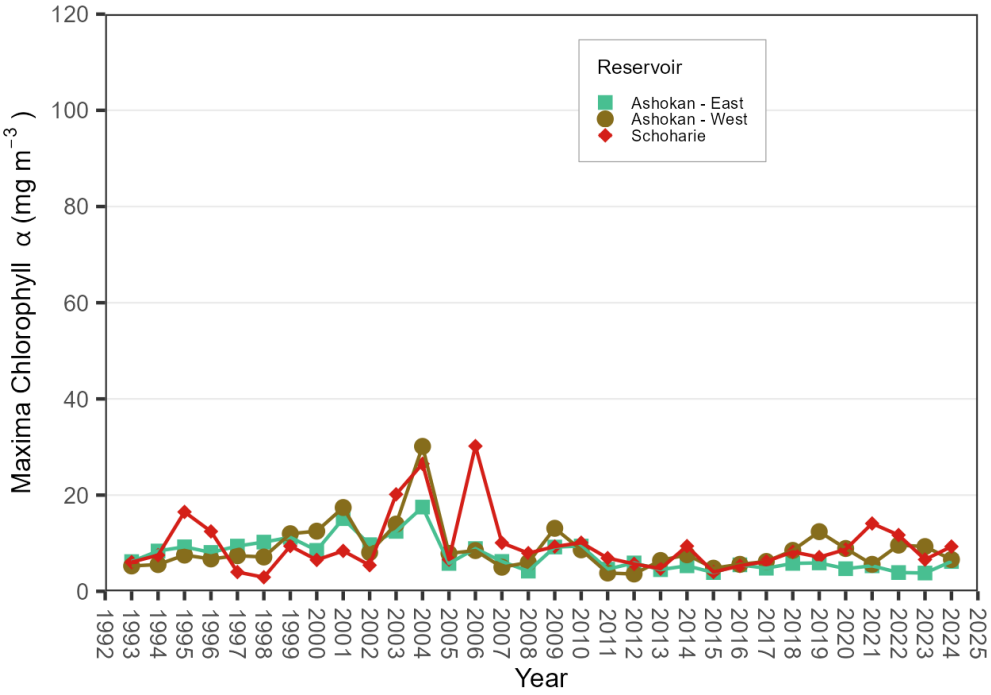
The New York City stream biomonitoring program uses protocols developed by the NYSDEC to assess the health of stream macroinvertebrate communities in NYC watershed streams. Samples are collected annually between July and September using the "traveling kick" method, which consists of disturbing the stream bottom of a riffle habitat area and holding a net downstream to catch macroinvertebrates released into the water column by this disturbance (NYSDEC 2025a). A subsample of approximately 100 organisms is taken from each sample and the macroinvertebrates in it are identified and enumerated NYSDEC 2025b). From these data, a series of five metrics is generated which yield five independent metric values: species richness (SPP), the total number of taxa identified in the subsample; EPT richness (EPT), the total number of taxa in the subsample belonging to the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies); Hilsenhoff Biotic Index (HBI), the average of the biotic index values for all individuals identified in the subsample (a taxon's biotic index value corresponds to the taxon's assumed tolerance to organic pollution)); Percent Model Affinity

(PMA) the similarity of the subsample's composition to the ideal composition of an undisturbed stream riffle community as defined by NYS DEC; and the Nutrient Biotic Index-Phosphorus (NBI-P) the average of the NBI-P values for all individuals identified in the subsample. The NBI-P tolerance value is a measure of a taxon's assumed tolerance to phosphorus loading. The results of these metrics are averaged to produce a multimetric Biological Assessment Profile (BAP) score ranging from 0-10. These scores correspond to four levels of stream impairment (non-impaired, 7.5-10; slightly impaired, 5-7.5; moderately impaired, 2.5-5; severely impaired, 0-2.5) (NYS DEC 2025c).

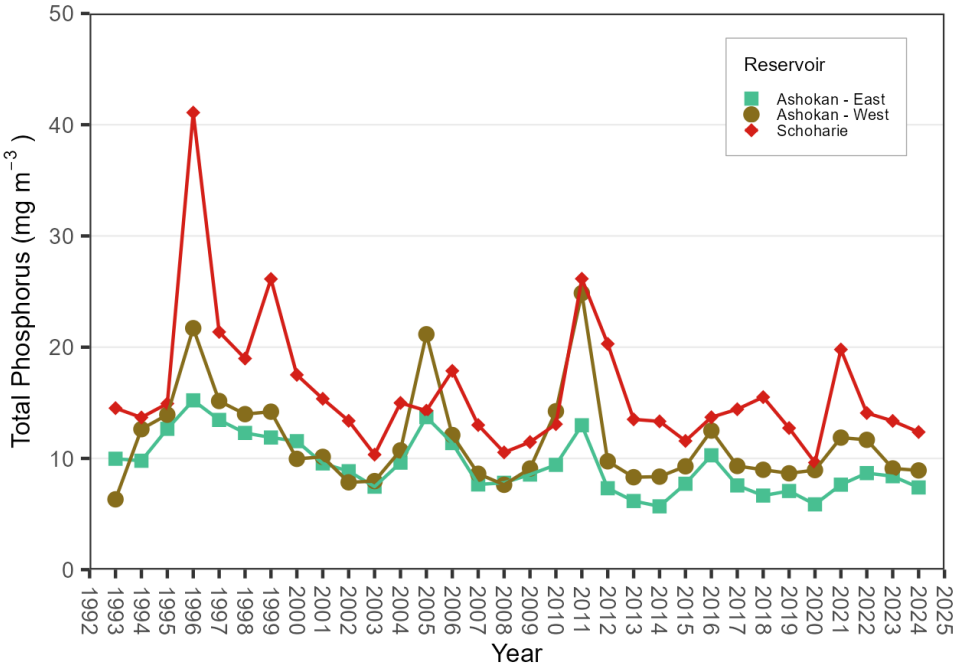
Adjustments are made for headwater sites as per DEC protocols (NYS DEC 2025c). Headwater sites in the Croton Watershed are defined as having a drainage under 16km^2, and a 1.3x multiplier is calculated for samples collected using the statewide traveling kick method and statewide BAP score metrics. Headwater sites for the Catskill region are defined as having a drainage under 16km^2 and elevation over 366m. Catskill headwater sites replace NBI-P from the statewide method with a Percent Model Affinity based on Functional Feeding Group composition (PMA-FFG), along with adjustments to the thresholds for HBI, SPP, and EPT metrics.



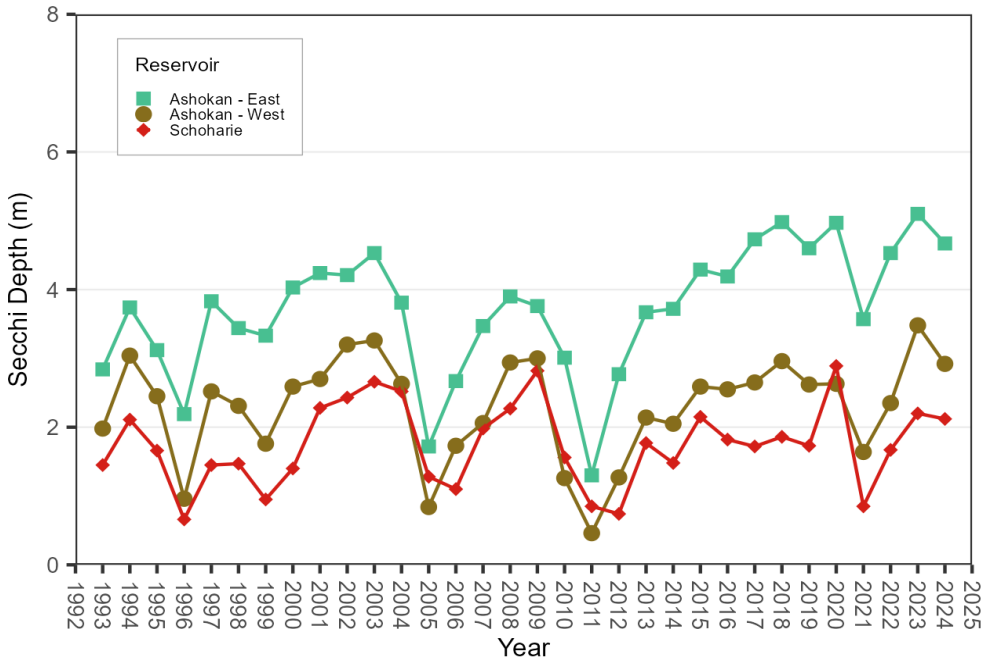
Appendix C Figure 4 Annual geometric means for Chlorophyll *a* at Catskill reservoirs (1993 - 2024).



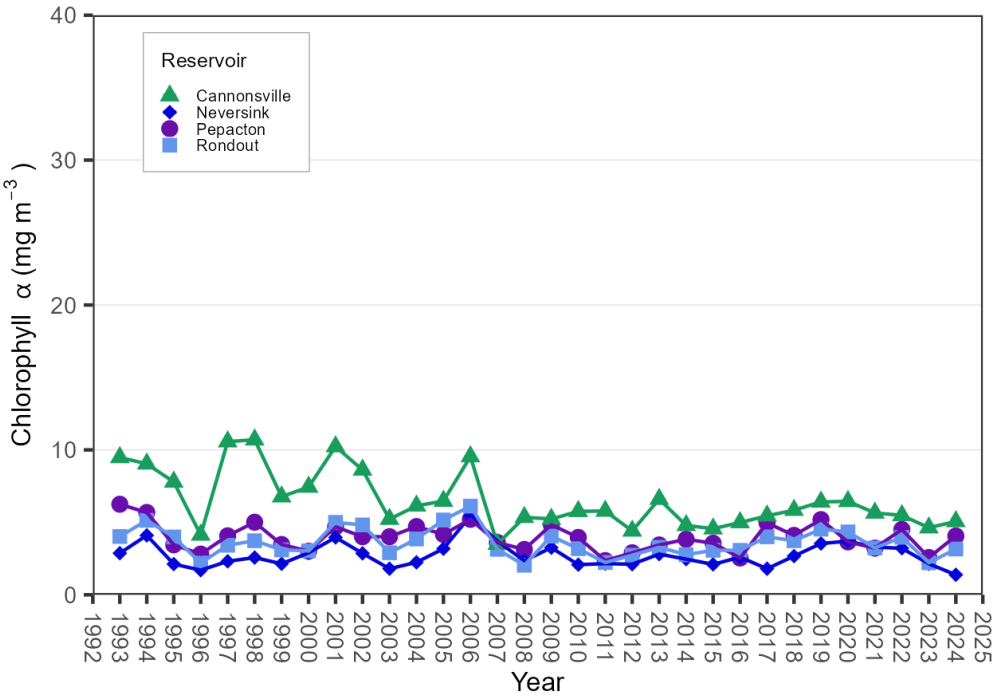
Appendix C Figure 5 Annual maxima for Chlorophyll *a* at Catskill reservoirs (1993 - 2024).



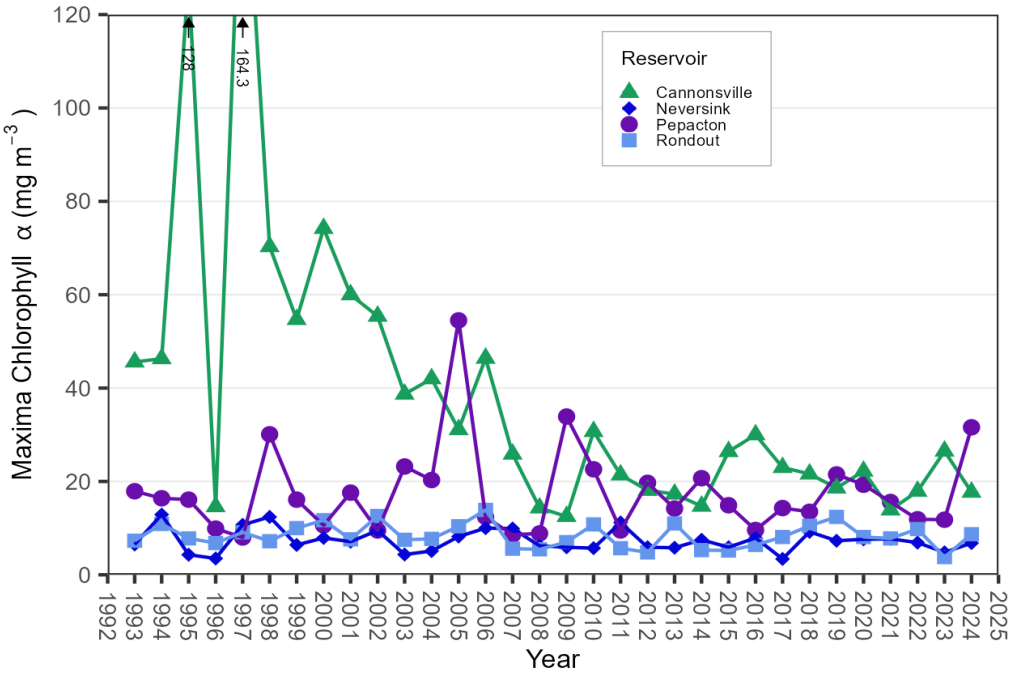
Appendix C Figure 6 Annual geometric means for total phosphorous at Catskill reservoirs (1993 – 2024).



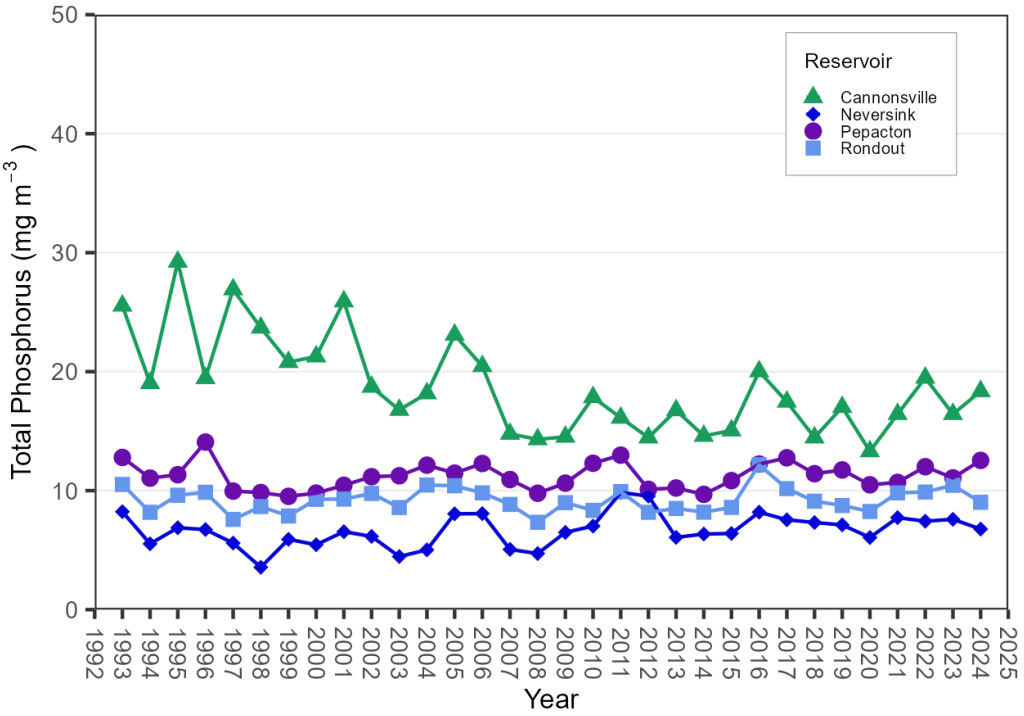
Appendix C Figure 7 Annual geometric means for Secchi depth at Catskill reservoirs (1993 - 2024).



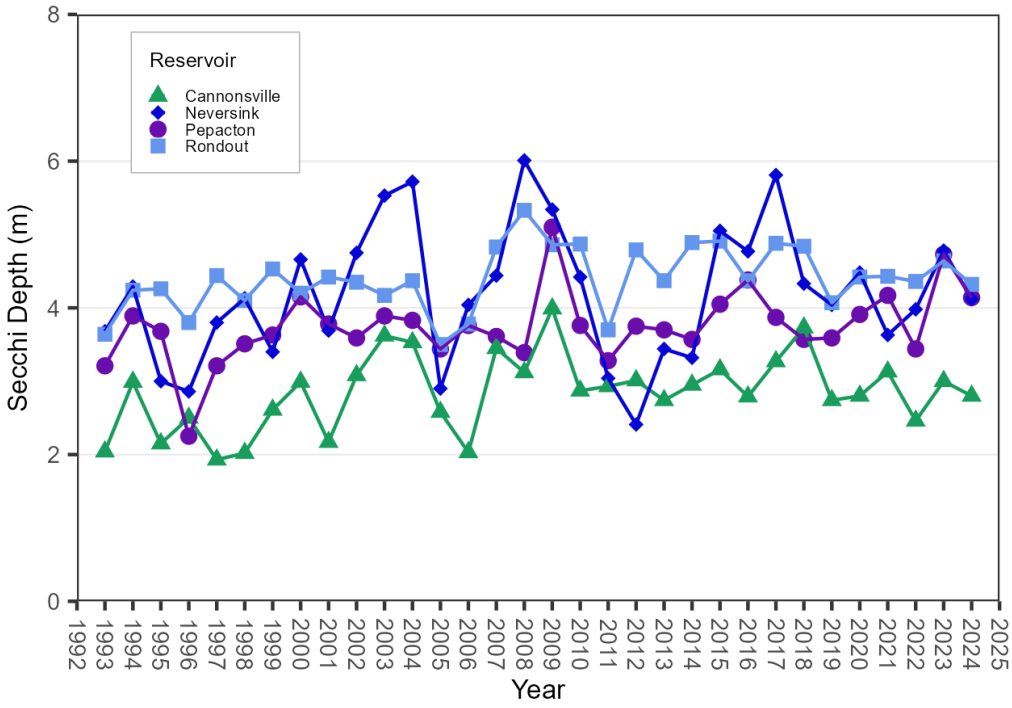
Appendix C Figure 8 Annual geometric means for Chlorophyll *a* at Delaware reservoirs (1993 - 2024).



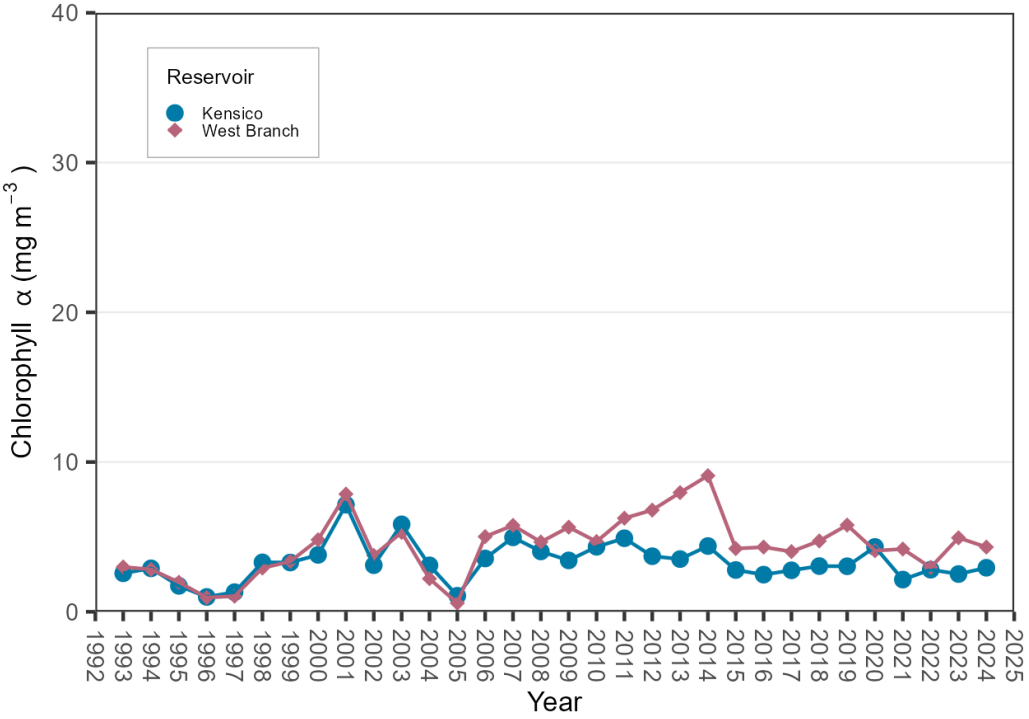
Appendix C Figure 9 Annual maxima for Chlorophyll *a* at Delaware reservoirs (1993 - 2024).



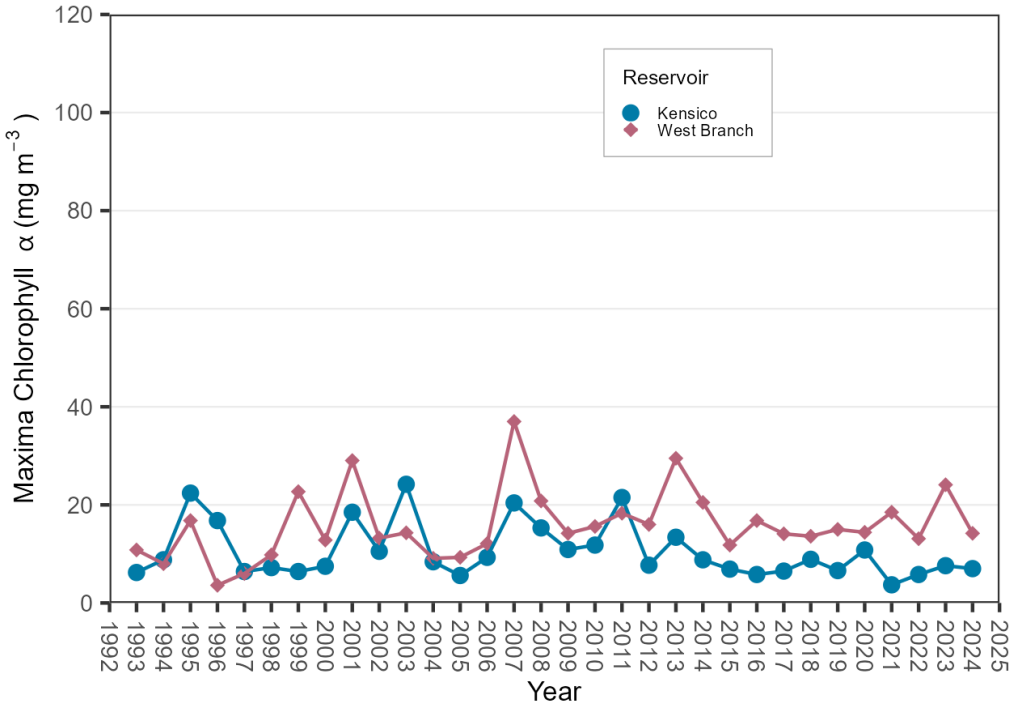
Appendix C Figure 10 Annual geometric means for total phosphorus a at Delaware reservoirs (1993 - 2024).



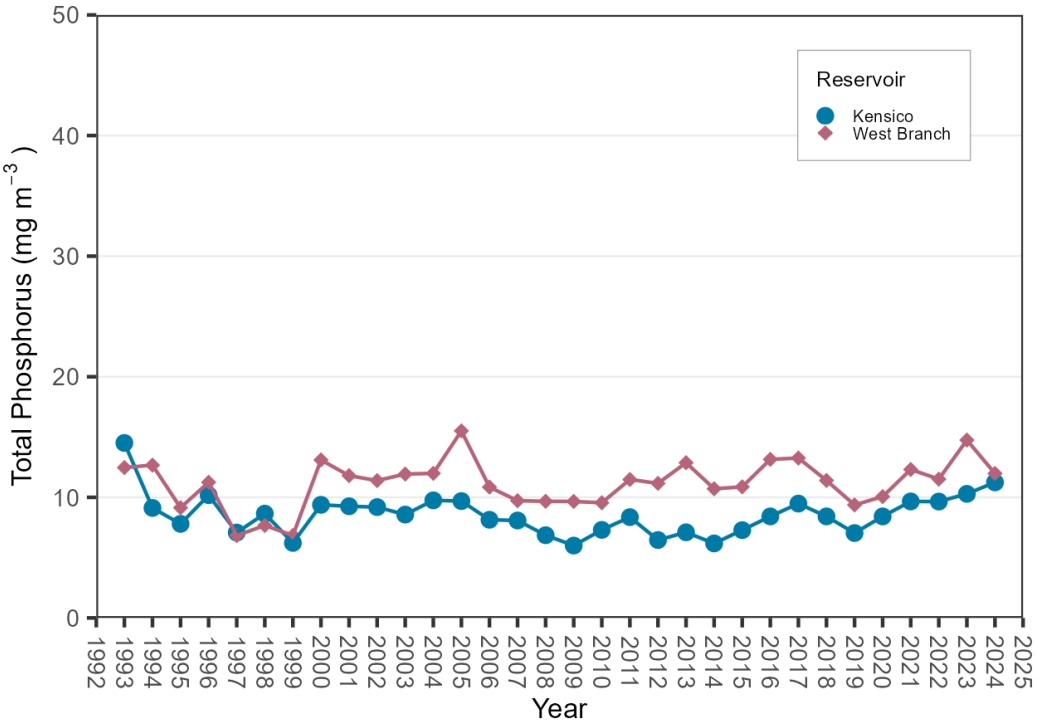
Appendix C Figure 11 Annual geometric means for Secchi depth at Delaware reservoirs (1993 - 2024).



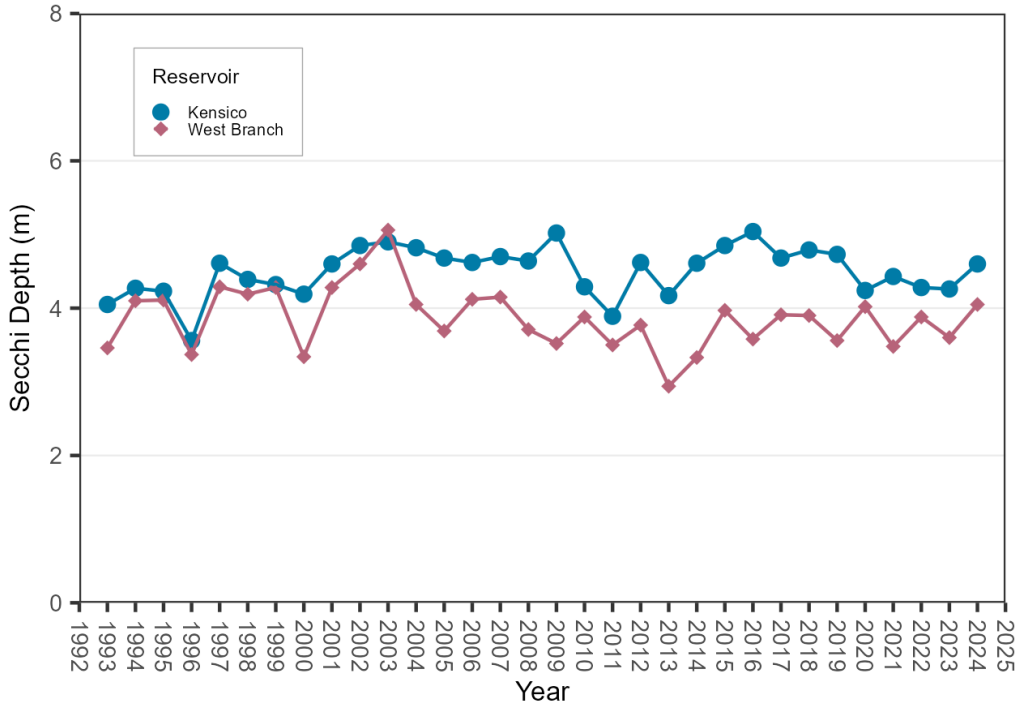
Appendix C Figure 12 Annual geometric means for Chlorophyll a at West Branch and Kensico Reservoirs (1993 - 2024).



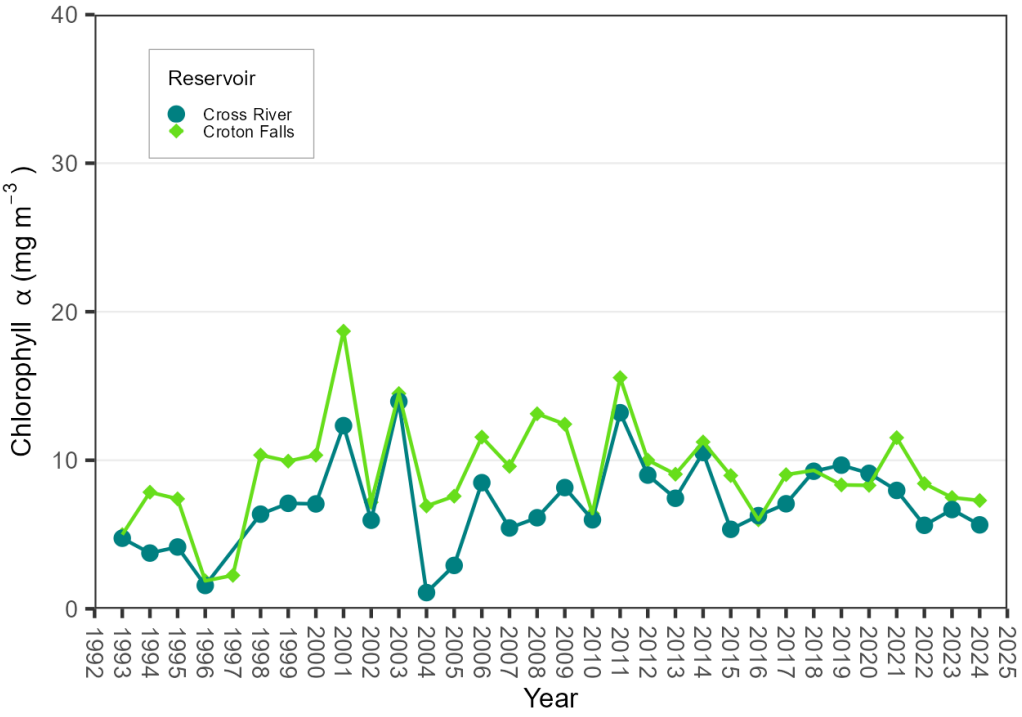
Appendix C Figure 13 Annual maxima for Chlorophyll *a* at West Branch and Kensico Reservoirs (1993 - 2024).



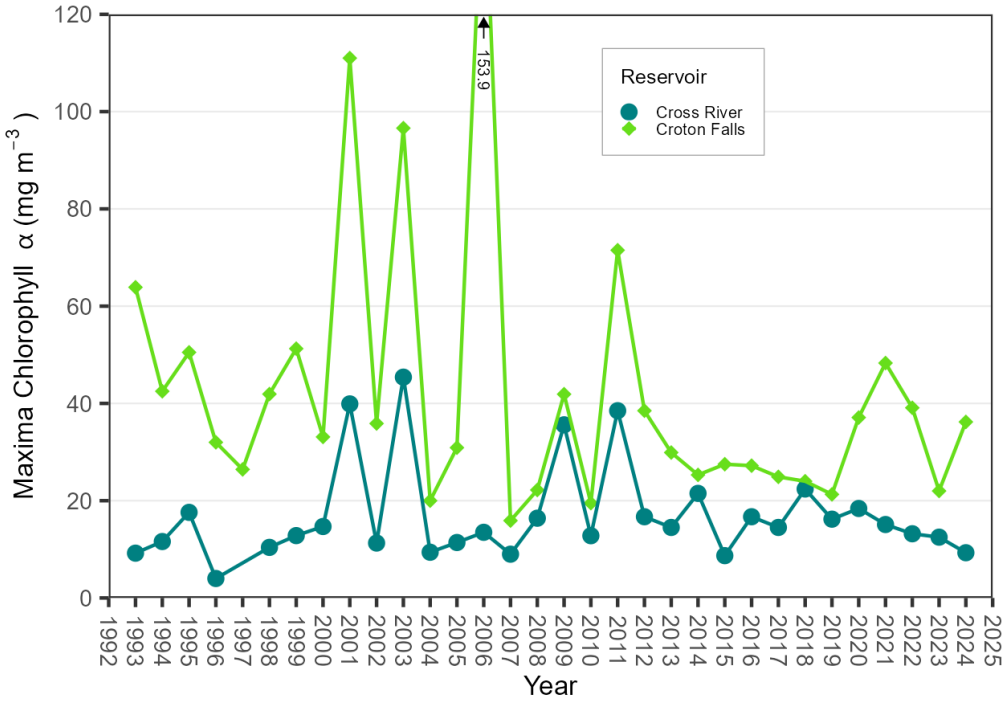
Appendix C Figure 14 Annual geometric mean for total phosphorous at West Branch and Kensico Reservoirs (1993 - 2024).



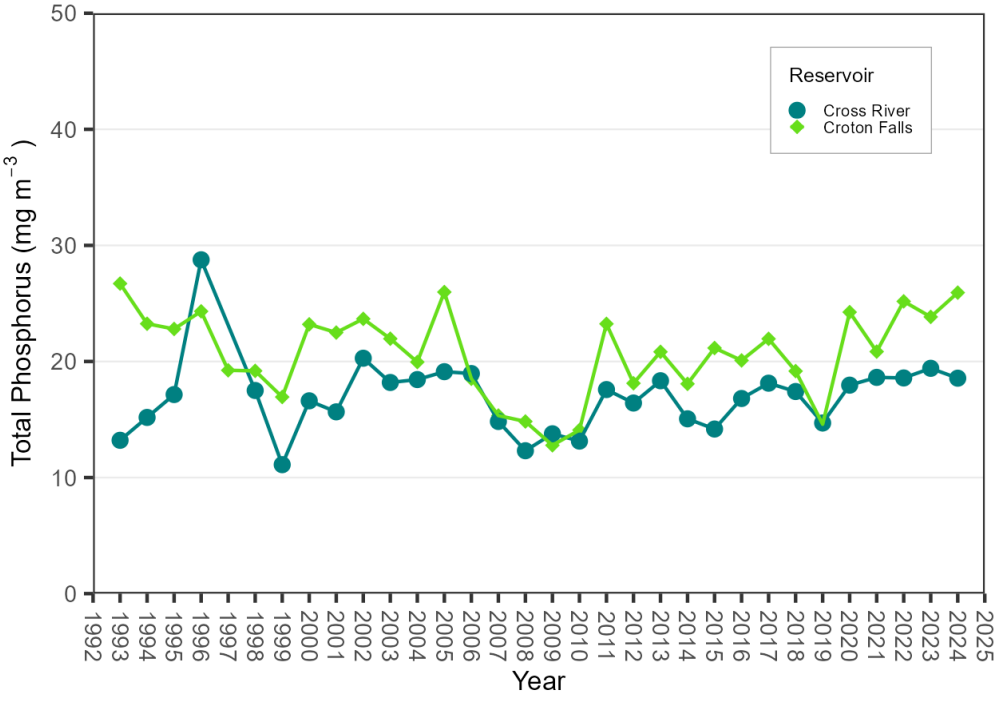
Appendix C Figure 15 Annual geometric mean for Secchi depth at West Branch and Kensico Reservoirs (1993 - 2024).



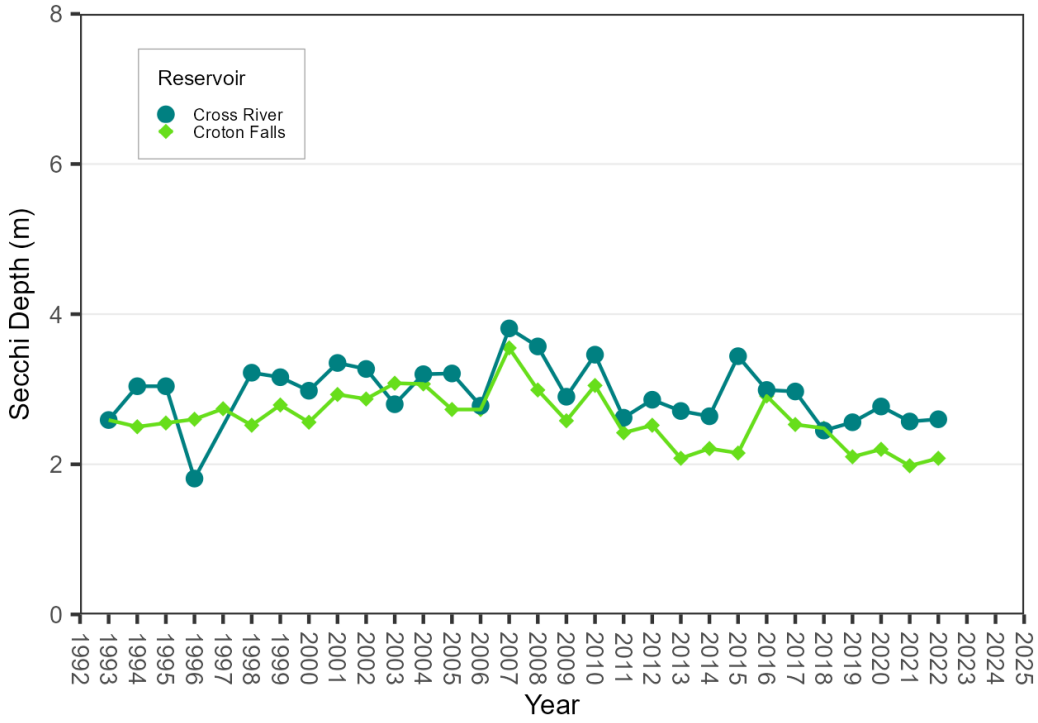
Appendix C Figure 16 Annual geometric means for Chlorophyll *a* at Croton Falls and Cross River Reservoirs (1993 - 2024).



Appendix C Figure 17 Annual maxima for Chlorophyll *a* at Croton Falls and Cross River Reservoirs (1993 - 2024).



Appendix C Figure 18 Annual geometric means for total phosphorous at Croton Falls and Cross River Reservoirs (1993 - 2024).



Appendix C Figure 19 Annual geometric means for Secchi depth at Croton Falls and Cross River Reservoirs (1993 - 2024).

Appendix D Drought Management

In 2025, the monthly average precipitation was above normal for one month, otherwise it was slightly below or significantly below normal, based on historical average for the period (1993-2022). The NYC Delaware Basin Reservoir System (PCN) storage stayed above the "Normal" storage level for the year, and the probability of refill did not fall below 50% for the Catskill or Delaware Systems.

The Drought Management Plan (DMP), which was revised effective September 1, 2024, incorporates DEP's Water Shortage Emergency Rules (15 RCNY Chapter 21). The rules govern water shortages emergencies caused by natural conditions, as well as planned and unplanned infrastructure outages and repairs.

The Drought Management Plan has three phases — Drought Watch, Drought Warning, and Drought Emergency — that are invoked sequentially as conditions dictate. The Drought Emergency phase is further subdivided into four stages with increasingly severe mandated use restrictions. Guidelines have been established to identify when a Drought Watch, Warning, or Emergency should be declared and when the appropriate responses should be implemented. These guidelines are based on prevalent hydrological and meteorological conditions, certain operational considerations and other factors. In some cases, other circumstances may influence the timing of drought declarations.

Drought Watch - Drought Watch is declared when there is less than a 50% probability that reservoirs in either of the two largest systems, the Delaware (Cannonsville, Neversink, Pepacton, and Rondout Reservoirs) or the Catskill (Ashokan and Schoharie Reservoirs), will fill by June 1, the start of the water year.

Drought Warning - A Drought Warning is declared when there is less than a 33% probability that reservoirs in either the Catskill or Delaware System will fill by June 1.

Drought Emergency - A Drought Emergency is declared when there is a reasonable probability that, without the implementation of stringent measures to reduce consumption, a protracted dry period would cause the City's reservoirs to be drained. This probability is estimated during dry periods in consultation with the New York State Drought Management Task Force and the New York State Disaster Preparedness Commission. The estimation is based on analyses of the historical record, the pattern of the dry period months, water quality, subsystem storage balances, delivery system status, system construction, maintenance operations, snow cover, precipitation patterns, use forecasts, and other factors. Because no two droughts have identical characteristics, no single probability profile can be identified in advance that would generally apply to the declaration of a Drought Emergency.

DEP continues to encourage consumers to conserve water and to observe the City's year-round water use restrictions, which remain in effect. These restrictions include a prohibition on watering sidewalks and lawns between November 1 and March 31 and illegally opening fire hydrants.