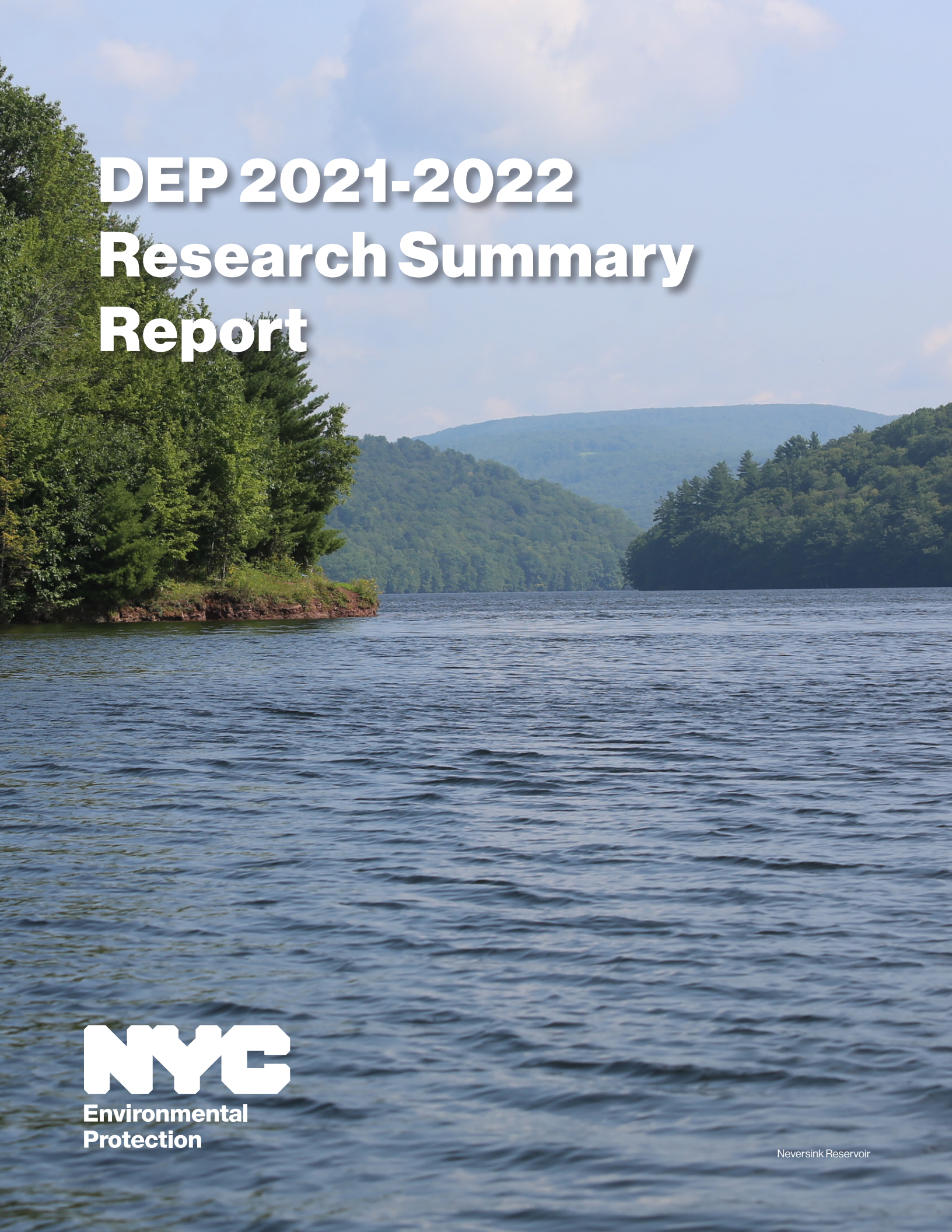
DEP 2021-2022 Research Summary Report



NYC Environmental Protection

Neversink Reservoir

Dear Friends:

All of us at the New York City Department of Environmental Protection (DEP) are proud to share this 2021-2022 research summary report, detailing the extraordinary efforts our engineers and scientists are working on to ensure the agency's leadership in environmental stewardship well into the future.

As we continue dealing with and learning about new challenges, from climate change to the abundance of forever chemicals, building upon the agency's long history of prominence in research and innovation remains a top priority of our team. Starting well over a century ago, our predecessors set worldwide examples of innovative leadership with vast and extraordinary water supply and wastewater collection systems that still inspire to this day. Through an emphasis on research, DEP is well positioned to continue that example of leadership in the years ahead.

This report highlights how DEP's teams of skilled engineers, scientists, and other experts are exploring techniques and technologies to better manage current and future challenges and protect and improve the health, environment, and the quality of life for all New Yorkers.

Research detailed within this report covers a vast array of disciplines including such areas as predictive data modeling, hardening and managing critical infrastructure through an increasing number of extreme storms, and developing chemical and structural engineering solutions for waste and stormwater management, and protecting our precious drinking water from potential contaminants. Additionally, we continue emphasizing innovative strategies increasing sustainability and producing renewable energy from our water, sun, and human waste resources.

Perhaps most timely and critical is the research dealing with impacts of climate change on our water supply infrastructure and surrounding ecology. From advanced computer modeling predicting changes to our water supply and waste management systems, and dealing with invasive species, sea level changes, and dissolved organics, learning about and preparing for impacts from climate change remains a top priority today and clearly for the years to come.

With this report, it is my sincerest hope for all New Yorkers to come to realize the tremendous talent, expertise, and dedication of our workforce here at DEP, and the pride they take in the extraordinary services they provide.

Sincerely,

Rohit T. Aggarwala, Commissioner

NYC Chief Climate Officer

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2021-2022 Research Summary Report

DEP continues its journey to becoming a sustainable, world-class water and wastewater utility while building a sustainable future. To stay at the forefront of the industry, DEP continued to conduct innovative research while building on a tradition of long-term planning. Our focus on the future is reflected in the broad range of research taking place within DEP.

To ensure accountability to our ratepayers and other stakeholders, DEP convened representatives from our bureaus of Sustainability, Wastewater Treatment, Water and Sewer Operations, Water Supply, Engineering Design and Construction, and the Office of Energy and Resource Recovery Programs to coordinate research priorities across bureaus. The 2021-2022 Research Summary catalogues the research conducted or completed over the past two years. Our efforts in 2021 and 2022 included work to optimize the quality of our drinking water and harbor water, maximize the efficiency of our resources (both people and dollars), prepare for the impacts of climate change, and minimize our greenhouse gas emissions.

DEP expanded its research efforts in several ways. First, DEP has increased its engagement with The Water Research Foundation through workshops, scholarships, working groups, research proposals, and participation on the Board of Trustees and Project Advisory Committees. In addition, the agency is strengthening its relationships with academic partners.

Taken together, these efforts set a strong foundation for our priority-based approach to research. The following report is a summary of the 2021 and 2022 research and the state of science within DEP. Projects are organized within four core subject areas: Environment, Innovation, Public Health, and Sustainability. Each is further broken down by research area to define the specific scientific discipline.

Figure 2: Research Projects Overview

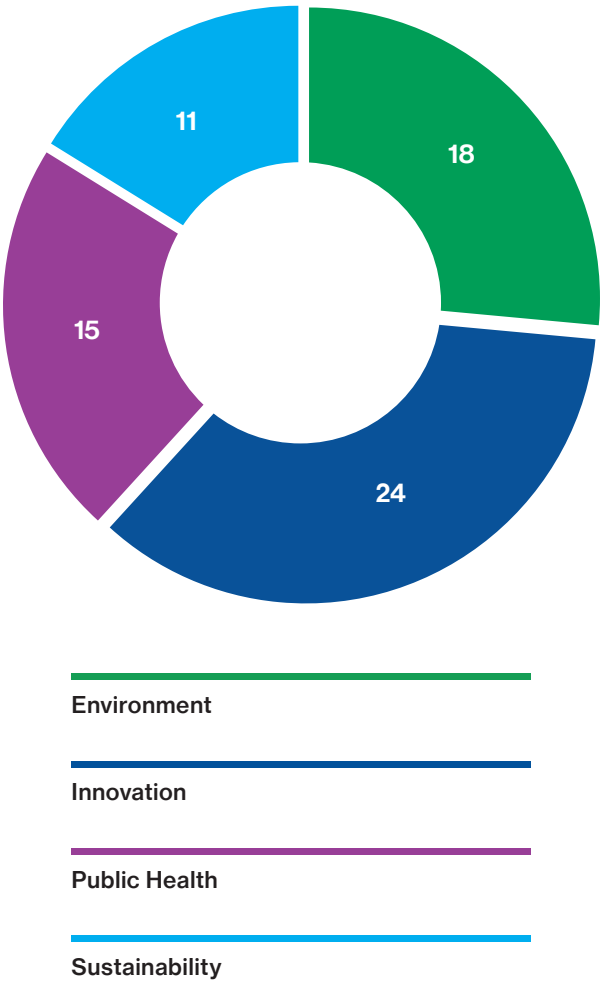


Figure 1: Research Framework

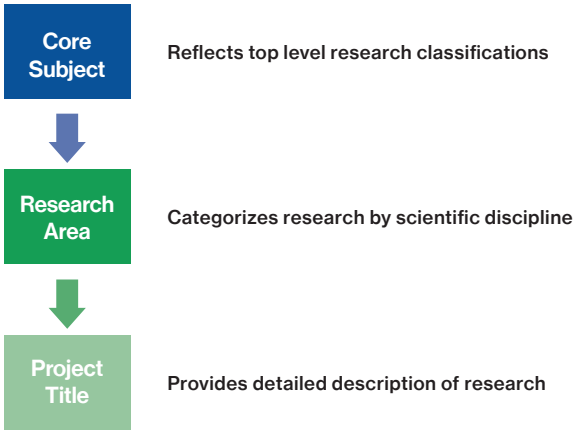
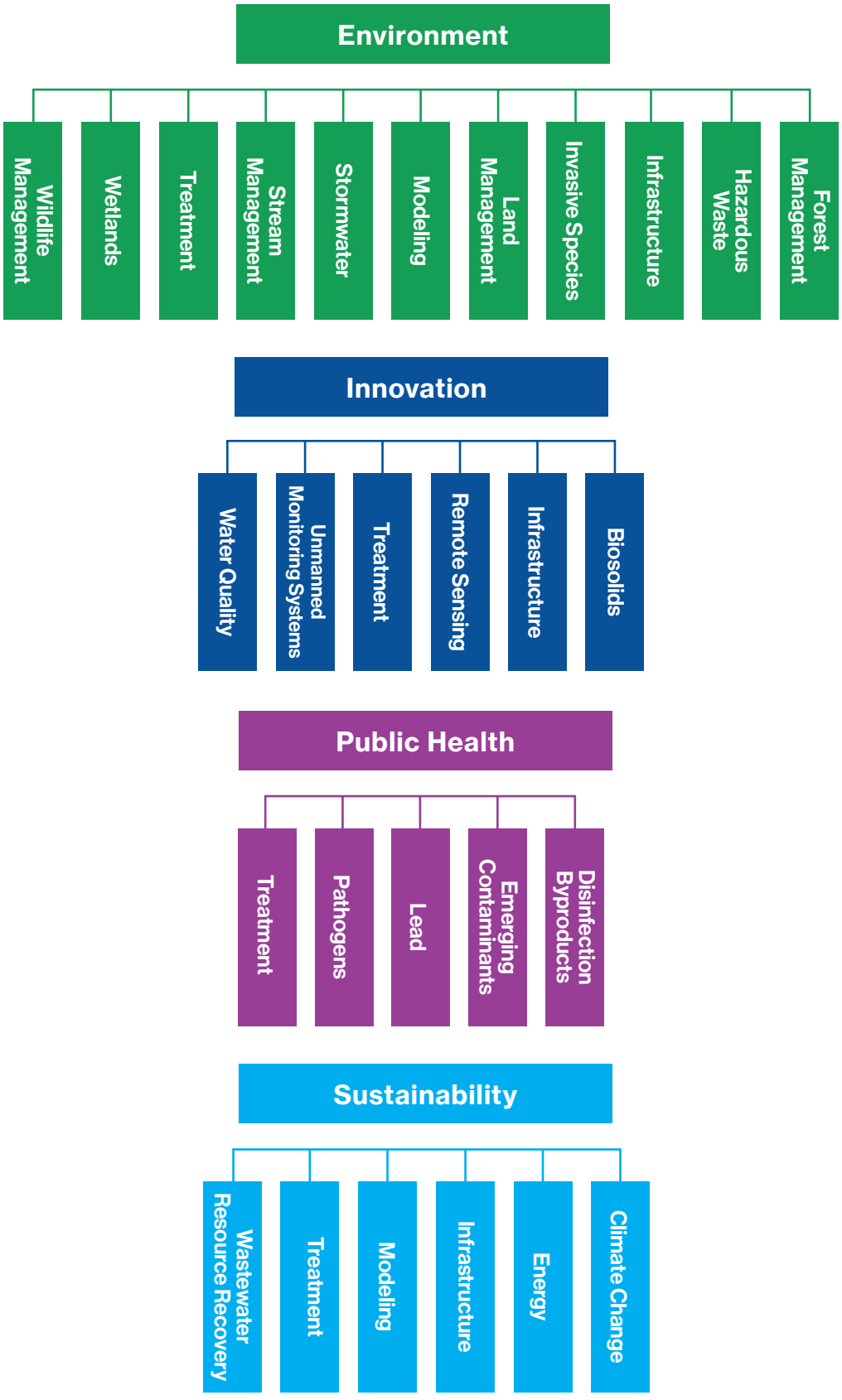


Figure 3: Research Areas by Core Subject



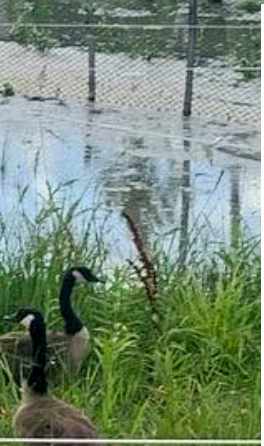
Digester eggs at the Newtown Creek Wastewater Resource Recovery Facility

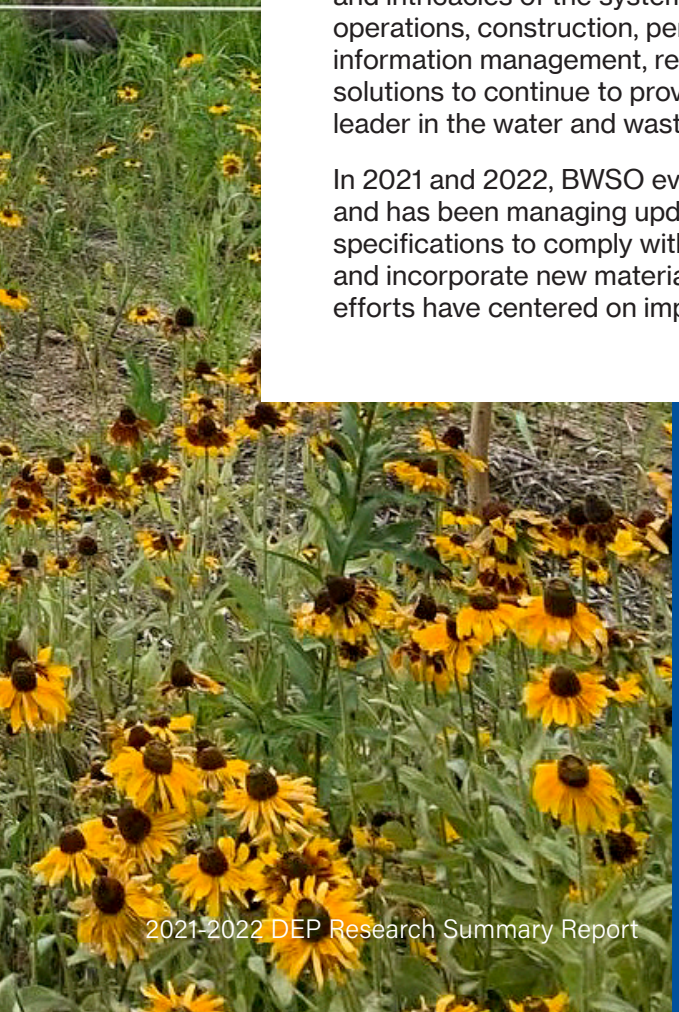
Bureau of Wastewater Treatment

The Bureau of Wastewater Treatment's (BWT) research priorities focus on sustainably meeting our core mission of protecting public health, while complying with regulatory mandates and stewardship goals by developing and demonstrating innovative conveyance and treatment technologies, configurations, and skill sets that are aligned with DEP goals.

BWT research is divided into three areas of focus: liquid conveyance and treatment, solids processing/biogas treatment, and odor/air emissions. The three areas are interrelated within the wastewater treatment system at the level of facility design, process engineering, economics, regulatory compliance, and social impacts. BWT's tri-pronged approach addresses DEP's goals of advancing sustainability, public and environmental health, and innovation. The bureau continues to develop and update its portion of the research summary as it applies to innovations. It will explore next-generation technologies and techniques that are successful worldwide, adapting them to the New York City (NYC) ecosystem and serving as a global leader in the industry.

New Creek Bluebelt, Midland Beach,
Staten Island, NY





Bureau of Water and Sewer Operations

The Bureau of Water and Sewer Operations (BWSO) is making strides to optimize its approach to operating and maintaining the City's potable water and wastewater collection systems. The increased frequency of severe weather events due to climate change, and the need to limit impacts to communities during construction, adds layers of complexity to the current and emerging issues presented by the age, scale, and intricacies of the systems. Overcoming these challenges, in the critical tasks of operations, construction, permitting, drainage and modeling, capital planning, and information management, requires proactive planning, novel thinking, and innovative solutions to continue to provide quality services to the people of NYC and remain a leader in the water and wastewater industry.

In 2021 and 2022, BWSO evaluated and piloted various innovative technologies, and has been managing updates and revisions to DEP's standard drawings and specifications to comply with latest industry standards, eliminate obsolete practices, and incorporate new materials and methods. Over the last few years BWSO's research efforts have centered on improving infrastructure and construction practices.

Alley Creek tidal restoration project,
Little Neck Bay, Queens, NY

Bureau of Sustainability

The Bureau of Sustainability (BOS) is an interdisciplinary policy, planning, and environmental enforcement group composed of two bureaus and one office: the Bureau of Environmental Planning and Analysis (BEPA); the Bureau of Environmental Compliance (BEC); and the Office of Superfund and Hazardous Materials Analysis. BOS engages in cutting-edge applied research that integrates artificial intelligence, advanced computer analysis and modeling, field studies, and policy development to support and inform DEP's mission. BOS ensures that DEP's investments, policies, and enforcement activities balance and maximize environmental, social, and economic benefits for the City of New York and our stakeholders.

BOS's ongoing research is part of larger programmatic initiatives including, but not limited to, development of the largest green infrastructure program in the country, our response to 311 air and noise complaints, and analysis of hazardous waste contamination. Examples of BOS research projects include the following:

- Assessing green infrastructure technologies to design, construct, and assess green infrastructure practices.
- Piloting technologies that use artificial intelligence to monitor noise levels and classify potential sources for improved responses to noise complaints.
- Modeling potential chemicals of concern at large cleanup sites to analyze contamination at Superfund sites.

BOS research projects represent the broad-ranging responsibilities of the bureau as they relate to environmental compliance, environmental planning and analysis, and hazardous waste analysis.


Cannonsville Reservoir

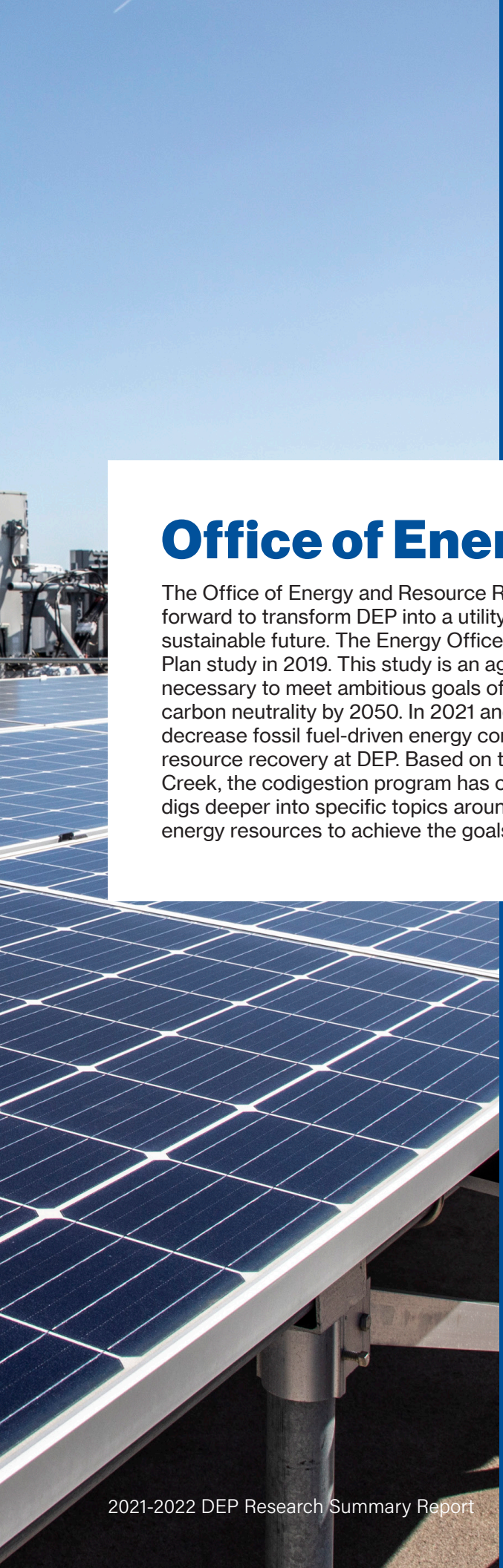
Bureau of Water Supply

In 2021 and 2022, the Bureau of Water Supply (BWS) continued collaborations with research and peer-learning organizations to stay abreast of industry trends and research. These collaborations underscore the bureau's commitment to operating, maintaining, and protecting the nation's largest municipal drinking water supply. This commitment is demonstrated by the bureau's research areas including disinfection byproducts, the Lead and Copper Rule long-term revisions, understanding the causes of taste and odor issues in the Croton System, and climate change.

To assess ongoing research, the BWS Research Advisory Council conducted a gap analysis to evaluate and align research with bureau and agency goals. The gap analysis was completed in 2021 and identified new research needs in the existing areas of emerging contaminants, invasive species, water treatment, and disinfection byproducts. In addition, BWS leveraged existing partnerships to convene two expert-panel workshops: Disinfection Byproducts and Taste and Odor issues.

BWS continued or completed numerous studies in 2021 and 2022, all of which are categorized along the four core subject areas of Sustainability, Innovation, Public Health, and Environment.

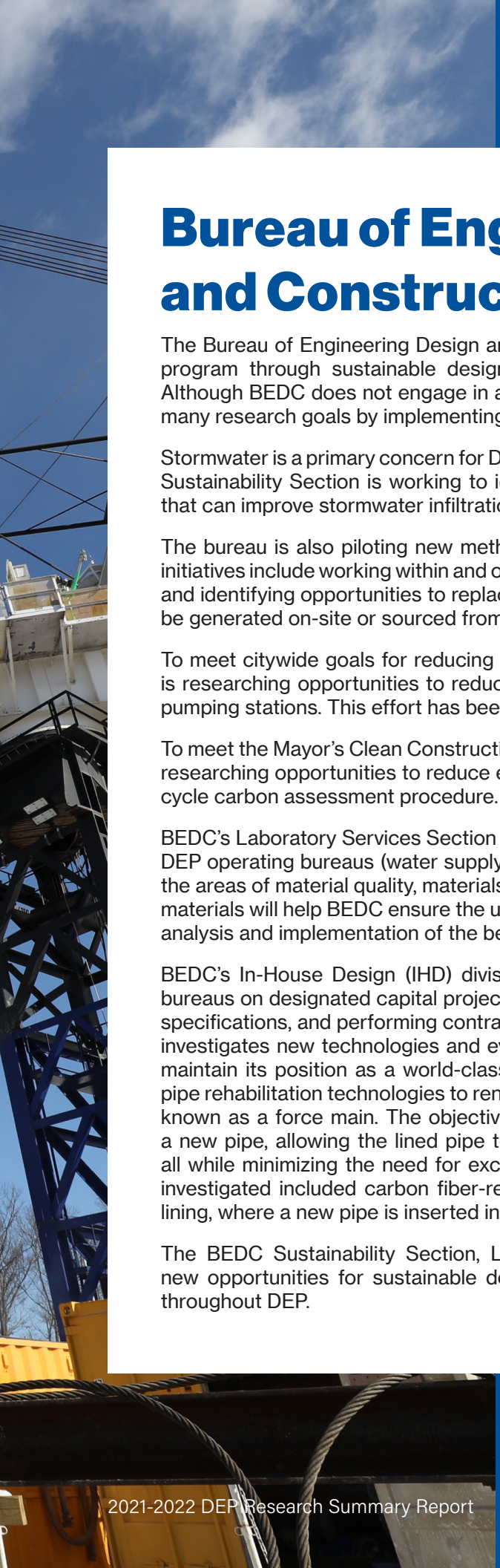
Rooftop solar panels, NYC Accelerator program,
Fairview co-op, Forest Hills, NY



Office of Energy

The Office of Energy and Resource Recovery Programs (Energy Office) is charting a path forward to transform DEP into a utility that leverages all its resources toward building a sustainable future. The Energy Office commenced its four-year Energy and Carbon Neutrality Plan study in 2019. This study is an agency-wide collaboration that has been defining the steps necessary to meet ambitious goals of achieving zero waste to landfills by 2030 and energy and carbon neutrality by 2050. In 2021 and 2022, the Energy Office continued research to further decrease fossil fuel-driven energy consumption and greenhouse gas emissions, while increasing resource recovery at DEP. Based on the positive results of the codigestion study at Newtown Creek, the codigestion program has continued to grow. The Energy Office's ongoing research digs deeper into specific topics around resource recovery and enhancement of renewable energy resources to achieve the goals of OneNYC.

Delaware Aqueduct Bypass Tunnel
shaft construction, Newburgh, NY



Bureau of Engineering Design and Construction

The Bureau of Engineering Design and Construction (BEDC) continued to support DEP's capital program through sustainable design initiatives and scientific analysis of constructed works. Although BEDC does not engage in academic research, the bureau's sustainability section fulfills many research goals by implementing innovative and sustainable design practices.

Stormwater is a primary concern for DEP facilities, as it directly impacts DEP operations. The BEDC Sustainability Section is working to identify and select permeable paver products and concrete that can improve stormwater infiltration and retention with minimal maintenance requirements.

The bureau is also piloting new methods of reducing construction and demolition waste. These initiatives include working within and outside the agency to develop an extensive soil reuse program and identifying opportunities to replace virgin aggregate with crushed rock and concrete that can be generated on-site or sourced from the New York City Department of Transportation.

To meet citywide goals for reducing energy consumption and greenhouse gas emissions, BEDC is researching opportunities to reduce ventilation rates in non-occupied spaces, such as our 96 pumping stations. This effort has been shown to result in substantial energy savings.

To meet the Mayor's Clean Construction Executive Order 23 and lower embodied carbon, BEDC is researching opportunities to reduce embodied carbon from concrete and steel and develop a life cycle carbon assessment procedure.

BEDC's Laboratory Services Section is dedicated to providing technical assistance services to all DEP operating bureaus (water supply, water and sewer operations, and wastewater treatment) in the areas of material quality, materials selection, failure analysis, and field inspection. Researching materials will help BEDC ensure the utmost quality of each capital investment through quantitative analysis and implementation of the best materials for each project.

BEDC's In-House Design (IHD) division serves as the engineer of record for DEP's operating bureaus on designated capital projects by delivering contract documents, including drawings and specifications, and performing contractor supervision during construction. When appropriate, IHD investigates new technologies and evaluates their applicability on DEP projects. This helps DEP maintain its position as a world-class utility. One recent research project involved evaluation of pipe rehabilitation technologies to renew the life of an existing large-diameter pressurized pipeline, known as a force main. The objective of this study was to provide the same level of service as a new pipe, allowing the lined pipe to function safely and effectively for another 50-plus years, all while minimizing the need for excavation and disruption of plant operations. The alternatives investigated included carbon fiber-reinforced polymer lining, cured-in-place pipe lining, and slip lining, where a new pipe is inserted inside the old pipe.

The BEDC Sustainability Section, Laboratory Services Section, and IHD continually look for new opportunities for sustainable design initiatives and scientific analysis to improve projects throughout DEP.

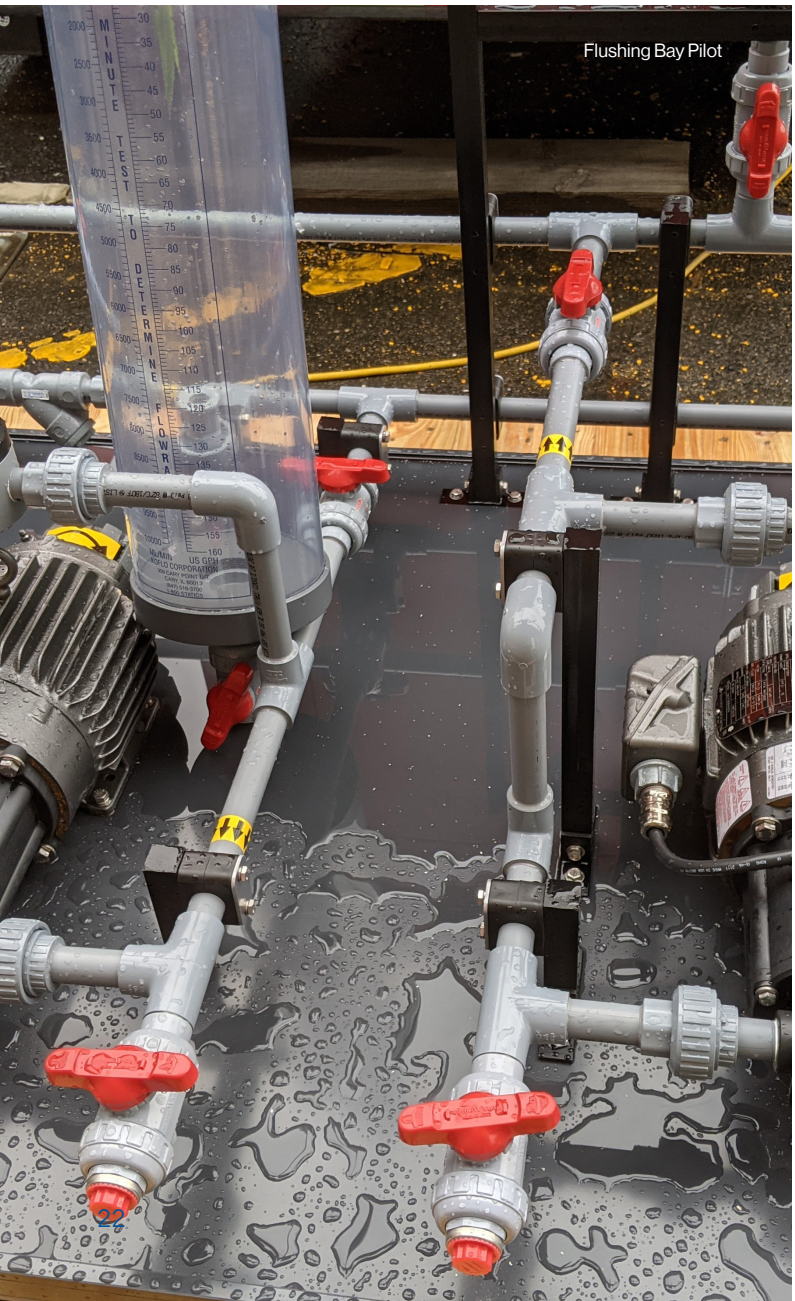
The Tibbetts Brook daylighting project,
Van Cortlandt Park, Bronx, NY

Environment

Environment is inclusive of all studies pertaining to the interface of the natural environment, ecosystem services, and the human environment including but not limited to air, water, and terrestrial resources.

Treatment > Hunts Point Biological Odor Control Pilot

To reduce odors at wastewater treatment plants, BWT implements odor control systems throughout DEP's facilities. To reduce operating costs and enhance their efficacy, BWT worked with City College of New York to design a pilot study of a biofilter at the Hunts Point Water Resource Recovery Facility (WRRF). The pilot unit is a small scale, easy to deploy biological odor control system piloted in November 2022. Preliminary results indicated the unit performed well. The City College of New York is currently in the process of finalizing the data and preparing a report to assess odor removal efficiency, operating costs, and health and safety. BWT's goal is to apply the technology at various WRRFs to lower operating costs and eliminate the need for chemical-based odor control while addressing broader odor issues.



Flushing Bay Pilot

Treatment > Flushing Bay Combined Sewer Overflow Retention Facility - Chlorination Pilot

Flushing Creek in Queens receives combined sewer overflows (CSO) during heavy rain events. A 2012 New York State Department of Environmental Conservation (DEC) consent order required BWT to consider CSO controls to attain water quality standards consistent with the federal policy. As part of the long term control plan, BWT is designing a system to disinfect CSO discharges to inactivate bacteria. The Flushing Bay Combined Sewer Overflow Retention Facility is piloting the use of sodium hypochlorite to determine when chlorination is necessary, the appropriate dose, and analyzing effectiveness by using two bacteria: fecal coliform and *Enterococcus*. Siting began in 2021, bench-scaled phase was completed November 2022 and the pilot phase of the study is underway.

Treatment > Alley Creek Combined Sewer Overflow Retention Facility - Ceramic Membrane Pilot

Alley Creek, also in Queens, was included in the 2012 DEC consent order. At this location, DEP is required to identify the CSO controls necessary to meet water quality standards consistent with the federal CSO Control Policy and related guidance. A chlorination/dechlorination facility is not feasible at this location so an alternate technology was selected by BWT: silicon carbide ceramic membrane as microfiltration. It was pilot tested at the Old Douglaston Pumping Station in 2020. Although the technology shows promise, additional research is needed.

Stormwater > Municipal Separate Stormwater Sewer System Monitoring Program

BEPA is coordinating the Municipal Separate Stormwater Sewer System (MS4) monitoring program to characterize and assess the quality of stormwater discharges at representative MS4 outfalls and identify sources of specific pollutants as required by the City's MS4 Permit. DEP metered and sampled manholes discharging to MS4 outfalls representing six land use types within NYC (mixed use, high-density residential, low-density residential, industrial, open space, and highway) to analyze whether there is a relationship between land use type and pollutant concentrations. A total of 64 wet weather events were sampled between February 2019 and June 2022. Chapter 10 of the NYC Stormwater Management Plan includes details on the MS4 Outfall Monitoring Program, and BEPA is currently analyzing the data for the development of the MS4 Outfall Monitoring Program Report.

Biofilter at the Hunts Point WRRF

Modeling > Development of Integrated Model and Graphical User Interface/Decision Support Tool for Long Island Sound

The United States Environmental Protection Agency (EPA) has awarded DEP a $6M grant to develop an integrated model for Long Island Sound (LIS). The model includes the development of new hydrodynamic and water quality model components.

The new hydrodynamic model is intended to better understand and predict how wind, tide, salinity, river discharges, and other factors affect water circulation within LIS. The new water quality model is also intended to better understand the physical, chemical, and biological processes that are influenced by nutrients and other constituents discharged to LIS from point and non-point sources. In addition, this information can be used to predict how discharges cause oxygen levels to drop, thereby affecting living resources.

Ultimately, the Graphical User Interface/Decision Support Tool will enable DEP and other stakeholders to run management scenarios, for example, predicting the effects of climate change on water quality. The integrated model will also link to the Living Resources model to allow for a better analysis of how current and future changes in water quality impact oysters or aquatic plants, or to test whether it is feasible to use living resources to remove nutrients in water.

The work is being overseen by BOS and will be completed over a 4-to-5 year period. The project will update and improve the model used to develop the 2,000 total maximum daily load reduction for nitrogen. It is also intended to ensure that any new efforts imposed upon DEP and other LIS stakeholders in the future, as part of EPA's next generation nitrogen strategy, is based on the latest science and builds upon the extensive data collection efforts undertaken by various stakeholders in the two decades since the 2,000 total maximum daily load nitrogen reduction requirements were finalized.

Infrastructure > Research and Development for Green Infrastructure to Support Green Infrastructure Implementation

BEPA is conducting a comprehensive research and development program to assess green infrastructure (GI) technologies from design through construction and maintenance. The project builds upon previous GI monitoring activities and includes several tasks:

- Continuous monitoring
- Laboratory bench scale tests
- Field experiments
- Simulated runoff testing

In addition, this program will also model a range of information for both stormwater performance and ecosystem services as co-benefits. Findings from the field activities and practice-scale modeling to date show that the monitored GI practices are generally functioning as designed, with capacity for additional stormwater management through improved construction oversight and minor design modifications. Larger scale modeling studies are also being conducted to evaluate the impact of GI on the sewer system at the neighborhood and watershed levels.

Hazardous Waste > Contaminant Modeling

Based on modeling work done for the Clean Water Act (i.e., Long Term Control Plans), BOS's Superfund group is developing models to track a wide suite of chemicals and their fate and transport in Newtown Creek. Inputs to the system include the East River, atmospheric deposition, private drainage, municipal inputs, groundwater, direct seeps of non-aqueous phase liquids (NAPL) and mixing/redistribution due to ebullitive disruption of sediments. The chemical fate and transport models rely on years of work refining the point source and regional hydrodynamic models. The results of this model are used to help EPA make decisions and guide the Superfund process in assessing and remediating risks to human health and the environment. This project is ongoing and is expected to make major strides towards completion in 2023.

Hazardous Waste > Measuring Impacts of Oil/ Non-Aqueous Phase Liquids

The inputs of specific chemicals of potential concern at large cleanup sites have often focused on point sources or large upstream and background sources. At the Gowanus Canal and Newtown Creek Superfund sites, another important input is NAPL from uncontrolled upland sites and legacy contamination from industrial activities. BOS's Superfund group has been leading work to assess and understand these compounds. Gowanus Canal and Newtown Creek both have upstream parcels with NAPL seeps and spills (e.g., oil refineries, former manufactured gas plants).

Rain garden in Queens, NY

Since NAPL floats and is redistributed via tide and wind, it is relatively common for a slick oil sheen to cover the entire surface of both waterbodies. Eventually, NAPL sheens break up and sink to the sediment bottoms of waterbodies, which can directly expose organisms to potentially harmful chemicals. Further, ebullition can mix and redistribute NAPL. As such, ebullition is also a contamination transfer mechanism. By developing specific devices to capture and measure contaminant flux and load, this information can be used to help guide the remediation and ensure a safe and successful clean up. Preliminary results have been analyzed and the process is being further refined in 2023.

Stormwater > MS4 Floatables Loading Rate Study

A loading rate study is underway to determine the amount of trash and debris draining from MS4 areas to floatables-impaired waterbodies. This study will allow BEPA to estimate the volume of trash and debris discharged from MS4 drainage areas to floatables-impaired waterbodies. The loading rate study is a hybrid approach that combines monitoring (field data collection) and modeling (statistical analysis).

The study measured trash and debris discharged from 63 catch basins based on key factors affecting floatables generation, interception, and discharges or loads for the MS4. These factors included drainage area or catchment characteristics including street litter level and street sweeping frequency; catch basin attributes including presence of a hood in a catch basin (hoods help block floatables from flowing through the outflow pipe and into the MS4 system); and unique land uses. BEPA supplemented catch basin monitoring with additional data collection including street sweeping and catch basin stenciling effectiveness measurements and street and sidewalk litter characterizations.

Monitoring and data collection were conducted from May through November 2021. BEPA is currently estimating floatables loading rates at each of the catch basins in MS4 areas draining to floatables-impaired waterbodies. The analysis will also normalize floatables loading rates based on key variables such as rainfall and curb length.

Wetlands > Light Detection and Ranging (LiDAR) Mapping of Wetlands

The objective of this BWS project was to increase the accuracy and completeness of wetland data for the watershed by using modern automated techniques and light detection and ranging (LiDAR) data as compared to traditional photo interpretation-based methodologies. LiDAR data provides accurate topographic information that complements aerial photography. The East of Hudson and West of Hudson watersheds were analyzed, and wetlands mapped in collaboration with the University of Vermont Spatial Analysis Laboratory, with input from the U.S. Fish and Wildlife Service National Wetlands Inventory.

Wetlands restoration project, Armonk, NY

The results were manually reviewed for accuracy and the final product is a fully classified National Wetland Inventory (NWI)-compliant map for the watersheds. The study found that wetland acreage nearly doubled as compared to the previous NWI maps West of Hudson and increased by 70% East of Hudson. This project also analyzed how wetlands connected to other wetlands or waterbodies. These connections were digitized using LiDAR surface data and aerial photos. The end result was an updated map with over 400 miles of new connecting features. Ultimately, the percentage of wetlands estimated to be unconnected to the stream network decreased from 10% to 2% East of Hudson, and from 8% to 3% WOH. BWS will complete an in-house accuracy assessment to evaluate the results and how they may be applied to watershed protection programs.

Little Brown Myotis Bats

Wetlands > Season Pool Wetland Monitoring and Research

This is a multi-faceted, long-term study of seasonal pool wetlands – including vernal and woodland pools. These wetlands are typically less than an acre in area, occur in a variety of forest types, and often are not protected by state, local, or federal regulations. Despite their relatively small size, seasonal pools are important areas of water storage, nutrient cycling, and they are critical habitat for a large, diverse assemblage of wildlife and plants. They may be vulnerable to disturbances from land management practices and climate change. This research seeks to increase understanding of their extent in the NYC watersheds, response to changes in climate and land use, and support of sensitive species as aquatic habitat.

The work being conducted by BWS involves collecting information on wildlife and plants, soils, hydrology, water quality, and bathymetry. Data analysis consists of statistical testing to observe trends and relationships and computer-based modeling of local (individual pool) watersheds. The information will inform BWS and watershed stakeholders of watershed ecological health as well as guide best management practices on watershed lands.

Wildlife Management > Acoustic Monitoring of Bats

BWS Wildlife Studies Section conducts bat surveys to determine the presence or absence of Indiana (*Myotis sodalis*) and northern long-eared bats (*Myotis septentrionalis*), which are listed as endangered by the U.S. Fish and Wildlife Service and the state Department of Environmental Conservation.

Acoustic monitoring technology is deployed to record bat calls. Recordings are then analyzed with software that can identify the species of bat present. DEP is a regional leader on the application of this technology to provide information on population distributions of these species throughout the NYC watershed. These data are used to inform project design and enable the development and implementation of habitat protection strategies in accordance with state and federal established guidelines.

Modeling > Watershed Runoff and Nutrient Modeling

The BWS modeling and analysis group has completed the application and validation of the Soil and Water Assessment Tool model for the West of Hudson watersheds. This includes the simulation

of hydrology and nutrient loads into the reservoirs. A similar application to the East of Hudson watershed is underway. Once developed these models can support evaluation of watershed protection programs and climate change impacts and may also help identify land and watercourse management strategies.

In 2022, the modeling and analysis group initiated a research project to develop the capability to simulate dissolved organic carbon (DOC) in streams of West of Hudson watersheds. Initial testing of the watershed carbon model is being carried out for the Neversink watershed. Once developed these models can help understand the sources and pathways of DOC and support disinfection byproduct research in the watersheds.

- **Stream Management > Esopus Creek Watershed Stream Turbidity and Sediment Research**

BWS is partnered with United States Geological Survey (USGS) on a 10-year research project to determine whether stream restoration projects reduce stream turbidity and sediment load delivered to Ashokan Reservoir. The upper Esopus creek watershed stream turbidity and suspended-sediment research utilizes numerous inputs, including stream flow, turbidity, and sediment monitoring; source investigation methods, and stream restoration projects to inform and evaluate stream turbidity reduction efficacy across a range of spatial scales. The research started in USGS water year 2017 and will continue through water year 2026. Final reporting is a November 2027 Filtration Avoidance Determination deliverable.

In 2021 and 2022, USGS continued monitoring turbidity at 29 monitoring stations in the Esopus watershed. Streamflow and suspended sediment concentration were also measured at 13 of those sites. USGS completed a pilot study to determine if sediment fingerprinting could be used to characterize the source. Additional work on this front resumed in 2022. In 2021, BWS mapped and monitored stream erosion sediment sources in the Stony Clove watershed – the experimental sub-basin for stream restoration evaluation – following a significant flood event that caused extensive erosion and increased turbidity. The sediment source data spanning four years was processed and analyzed in 2022 to help explain geographic and temporal variations in turbidity production.

- **Stream Management > Catskill Mountain Bankfull Discharge and Hydraulic Geometry Regional Relationships**

BWS continues to update regional relationships that predict the maximum amount of water a stream can handle without overflowing in addition to the size of the stream channel as it relates to the stream drainage area. An Excel workbook was created for 25 sites, which allows staff to review this information with more refined geographic data for improved analyses.

BWS worked to re-calibrate maximum streamflow capacity at the two Schoharie Creek monitoring stations in 2021; however, field conditions limited the use of this data to revise the analyses. BWS plans to finalize this project in 2023 with a final technical report.

Esopus Creek

Forest Management > Deer Exclosure Study

Forest pests and pathogens, in conjunction with invasive species and deer browse, pose a significant threat to forest regeneration. BWS has been working with The Nature Conservancy to understand forest condition and the interaction between invasive species and plant-eating animals on forest regeneration through exclosure studies in the Ashokan basin. This study will assess forest regeneration with and without deer browse to help measure deer impacts on watershed forests.

First, areas to prevent deer access were established and data was collected on existing tree seedling density, height, and richness inside and outside the deer exclosure areas. Data were also collected on Japanese stiltgrass density and tree seedling abundance and height on experimental plots treated with Roundup and untreated control plots to similarly assess stiltgrass impacts to forest regeneration. A final report was issued by The Nature Conservancy in June 2018.

Deer fence at Bush Kill, Olive, NY

Further study of deer impacts was conducted using the Assessing Vegetation Impacts from Deer (AVID) protocol developed by Cornell Cooperative Extension. AVID is a rapid assessment methodology for evaluating deer impacts on forest regeneration. This protocol was used on four stands in the Ashokan basin. Data were collected in 2019, 2020, 2021, and 2022. All data were processed and uploaded into the statewide AVID database to support deer management decision-making by state officials.

Invasive Species > Hemlock Woolly Adelgid Control

The hemlock woolly adelgid is an invasive, aphid-like insect that attacks North American hemlocks, and has been identified in much of the City's watershed. BWS is currently conducting research to determine how effective predatory insect species from the Pacific Northwest can be when used as biocontrol agents to control hemlock woolly adelgid populations. In 2022, DEP continued collaborating on the Cornell Hemlock Initiative to establish populations of *Laricobius nigrinus* (beetle) and *Leucopis* spp. (silver fly) at several experimental release sites in both the East and West of Hudson watersheds. Populations are being monitored for signs of successful reproduction.

Land Management > Roles of Cover Crops on Dissolved Phosphorus Runoff

In 2022, BWS partnered with the Cary Institute of Ecosystem Studies and the University of Albany to evaluate the potential role of winter cover cropping to phosphorus loading in the Cannonsville watershed. This will be studied by determining the rate of phosphorus release from representative cover crops and soil types and exploring the factors governing phosphorus release and mobilization. It is believed that plant type and age, in addition to weather, control the rate of phosphorus released from crop biomass, and phosphorus runoff is largely regulated by the soil's ability to adsorb phosphorus. The impacts of cover crops on phosphorus loss from soils are the result of complicated interactions between cover crops, soils, and hydrology. The research is ongoing, and the findings are anticipated in 2023.

Research on the role of cover crops on dissolved phosphorus runoff

Robotic water monitoring
at Ashokan Reservoir

Innovation

Innovation includes methods, resources, technologies, or processes that are novel in their use or application for the agency or industry.

Infrastructure > Centrifugally Cast Fiberglass Reinforced Polymer Mortar Pipe Viability for DEP Sewer Installations

BWSO is evaluating alternative materials for sewer construction projects. Large diameter reinforced concrete pipes, tend to be cost-prohibitive and difficult to transport and install, due to their heavy weight. Based on recommendations from New York City Department of Design and Construction (DDC), BWSO has been using centrifugally cast fiberglass reinforced polymer mortar pipe (CCFRPMP) on a case-by-case basis to evaluate it's potential for acceptance as a standard sewer material. The primary benefits of this pipe material are its inherent corrosion resistance and lighter weight, making it easier to transport. In late 2020 and early 2021, DEP and DDC conducted test installations for the use of CCFRPMP in two projects in Queens for micro-tunneling and slip-lining applications. A direct bury pilot of CCFRPMP is in the planning phase.

BWSO is also compiling information on CCFRPMP, such as testing reports, material properties, and other previous applications to verify if this material can be approved for standard sewer pipes and to develop specifications for its installation as a liner for sewer repair.

Infrastructure > Evaluation of Various Innovative and Non-Standard Piles for Sewer/Water Main Installation Projects

In 2021-2022 BWSO continued reviewing non-standard piling methods including helical piles, drilled-in displacement micropiles, and drilled displacement piles, for different construction sites.

Helical piles are typically used as deep foundation piles for building foundations. More recently, it is believed that this technology can also be used for buried infrastructure. If the geotechnical calculations for the soil conditions at the site are suitable for helical pile installation, the piles can provide the necessary design capacity to support the infrastructure without the need for grout or creating spoils that require disposal, allow for the use of smaller equipment, require much less time and labor to install, and at a reduced cost per linear foot compared to standard continuous flight auger piles or mini-piles.

Over the last two years, BWSO has considered requests to substitute standard piling methods with helical piles in situations where site limitations make using the piling method, called for in the contract drawings, difficult. Following review of the geotechnical and structural calculations and a successful load test to validate the theoretical capacity of the piles, helical piles have been piloted at multiple locations with differing soil characterization. Long-term monitoring is required to determine if the helical piles are suitable for consideration as a DEP standard piling method.

Microtunneling for CCFRPMP sewer installation

Drilled-in displacement micropiles are another alternative to standard continuous flight auger piles as they similarly have no spoils, are more cost efficient, and can be installed in tight access and low overhead environments. In 2020, these piles were proposed as a substitution to continuous flight auger piles on a DDC managed infrastructure contract. Following thorough review of the theoretical structural and geotechnical calculations, use of the piles was validated by a load test. The substitution request for this project was approved and in 2021, the drilled-in displacement micropiles piles were installed to support new sewers and watermains in Queens.

Drilled displacement piles are another emerging pile technology that offers increased shear strength, improving the load capacity per unit length of the pile. In 2021, following evaluation and successful load tests, drilled displacement piles were approved for use in lieu of standard continuous flight auger piles on a Staten Island sewer construction project. With this substitution, the number of piles was reduced, the pile spacing was increased, and the individual pile capacity was doubled.

BWSO is working with DDC to further improve quality assurance and quality control procedures for review of substitution requests for use of non-standard materials and methods, including piles.

- **Infrastructure > Pilot Installation of a Radial Collection System to Alleviate Flooding in Southeast Queens**

As part of BWSO's effort to address flooding in Southeast Queens, a feasibility study was conducted in 2018 to determine if a radial collection system could be a viable option to lower the groundwater table in the most affected areas. This technology consists of horizontal slotted pipes buried below the current groundwater table.

The modeling suggested that the concept may lower the groundwater table, but is dependent on numerous variables including slope, diameter, and slotting of the collection pipes, as well as the permeability of the soil. In 2019, groundwater elevations and water samples were collected from several monitoring wells to provide information for pilot study design and to evaluate water disposal needs. In 2020, these efforts were used to design a small-scale pilot system. Following completion of the design, a pilot system, consisting of two radial collection systems discharging to an existing storm sewer, was installed by BWSO in May 2022, along with monitoring equipment to measure the flow of groundwater drawn into the pipes. Data collected during the pilot installation will be analyzed to determine the effectiveness of the radial collection system for wide application.

- **Infrastructure > Pilot Study: Spray Applied Polyurethane and Heat Shrink Sleeves for Trunk Water Mains**

The DEP standard specifications for trunk main work call for steel trunk mains to be coated with polyolefin tape. With a decrease in the supply of this tape coating, pipe manufactures are turning toward using spray-applied polyurethane coating for steel pipes, with polyolefin heat shrink sleeves to coat the joints. To help BWSO and DDC evaluate polyurethane coating and heat shrink sleeves, a vendor was secured to perform a field application demonstration for both polyurethane spot repair and shrink sleeves. Following positive feedback from the demonstration, BWSO proceeded to pilot the coating and sleeves on two DDC contracts with trunk main replacement work. BWSO determined the specific criteria to be evaluated including the durability of the polyurethane coating in the field, ability of field staff to perform quality spot repair, product life expectancy, and satisfactory corrosion protection for the pipe. The two installations were completed in April 2022, with the consensus being that the materials are as effective as the polyolefin tape.

Polyurethane-coated steel trunk water main with heat shrink sleeve on joint

Infrastructure > Carbon Fiber System Lining for Water Main Rehabilitation

BWSO and DDC are planning to rehabilitate multiple trunk water mains in Brooklyn near the Long Island Railroad and other MTA facilities, where tunneling is restricted and open trenching cannot be used.

Carbon Fiber System CFS is a high strength, thin composite stand-alone pipe or mesh, capable of resisting high operating pressures and external loads. A CFS liner can be inserted into an existing pipe or shaft (pipe-in-pipe) and fixed in place by an epoxy or resin. An installed CFS liner restores functional capacity to the existing pipe, with minimal reduction in pipe diameter and without excavating the pipe. BWSO approved the carbon fiber system liner to be piloted by DDC on a project which began construction in autumn 2022.

Infrastructure > Geopolymer Lining Pilot Study

BWSO evaluated a pipe-lining product made of a high-performance, fiber-reinforced geopolymer mortar. This geopolymer liner is spray applied to deteriorated sewer pipes and manholes to create a new structural pipe. Its potential advantages over traditional Gunite methods include greater structural integrity, corrosion resistance, and longevity, as well as faster cure times. In 2021, two pilot applications of geopolymer were performed on partially deteriorated sewer pipes. Gunite and geopolymer were applied to adjacent manhole runs in the same sewer line, allowing for a side-by-side comparison of the products under the same conditions. Samples of the geopolymer lining product were also collected to perform laboratory tests for its compressive, flexural and bond strengths. Now that the liners have been in place for two years, BWSO intends to perform post-construction inspections at the pilot locations to observe how the liner is performing over time. If the lining appears to be performing as well as or better than Gunite at the pilot locations, the material may be considered for inclusion into the DEP Standard Specifications as a viable alternative to Gunite.

Infrastructure > Grease Trap Food Waste Data Traceability Pilot Project

BWT is working with Waste Management on a pilot project to apply supply-chain traceability technology to the feedstocks used for co-digestion. The goal of the pilot is to demonstrate that data collection can be performed during material collection to provide insights into feedstock composition, origin, collection method, etc. The pilot relies on EPA-funded technology to track brown grease as it is collected from restaurants and brought to Waste Management's facility. There, it is combined with food scraps and blended into a bioslurry, before its conversion to biogas through co-digestion at DEP's Newtown Creek WRRF.

Brick sewer after geopolymer rehabilitation

At the conclusion of the pilot, the project team will write a whitepaper that provides examples of how the data could be used. For example, demonstrating compliance with mandatory organics collections, or as the basis of ownership of the environmental attributes of the renewable natural gas made from the feedstocks. The pilot began collecting data in September 2022 and conclude the collection phase at the end of December 2022. A whitepaper is expected in the first quarter 2023.

Water Quality > Enhanced Source Tracking in Alley Creek - Drone Survey

BOS, in partnership with BWT, is exploring options for an enhanced source tracking of illicit discharges in Alley Creek. Direct observations and measurements are difficult as there are accessibility issues created by the presence of wetlands, muddy conditions, and shallow waters at low tide. BWT had successfully eliminated many sources of illicit discharges, but this new effort incorporates modern technologies to build on those past efforts, including the use of drones.

Illicit discharges are typically warmer than the receiving waterbody and this temperature difference is captured by thermal sensors installed on the drone. The goal of a drone survey is to find areas with relative water temperature differences where BWT can investigate further for potential illicit discharges.

Treatment > Evaluation of Thermal Hydrolysis Process Effects on Biogas Production, Digestibility, Dewaterability

This BWT project evaluates thermal hydrolysis process as a pretreatment process to sterilize wastewater sludge and allow it to biodegrade more easily. It also increases the loading rates for anerobic digestion.

There are numerous energy benefits to this process: higher production of biogas for energy generation; improved sludge dewaterability; higher digester solids loading rates which result in increased digester treatment capacity; and production of enhanced quality biosolids.

During the first two phases of the project, a series of experiments to evaluate the effect of various combinations of temperatures and contact times on thermal hydrolysis, as well as the impact each hydrolysis level has on biodegradability or methane production potential, were conducted. The third phase of the project involved running several bench-scale anaerobic digesters in parallel at several solids retention times and feed solids concentration to monitor their performance. The pilot evaluated biogas production, volatile fatty acid concentration, and dewaterability.

The results showed that the digester receiving hydrolyzed sludge outperformed the control digester not receiving hydrolyzed sludge in volatile solids reduction, biogas production, and dewaterability. The fourth phase involved modeling different configurations and comparing against each other. From this exercise it was determined that thermal drying downstream of dewatering is attractive when in combination with thermal hydrolysis process. Thus far, four technical workshops have been held with the technical advisory committee. The project is expected to conclude in 2023.

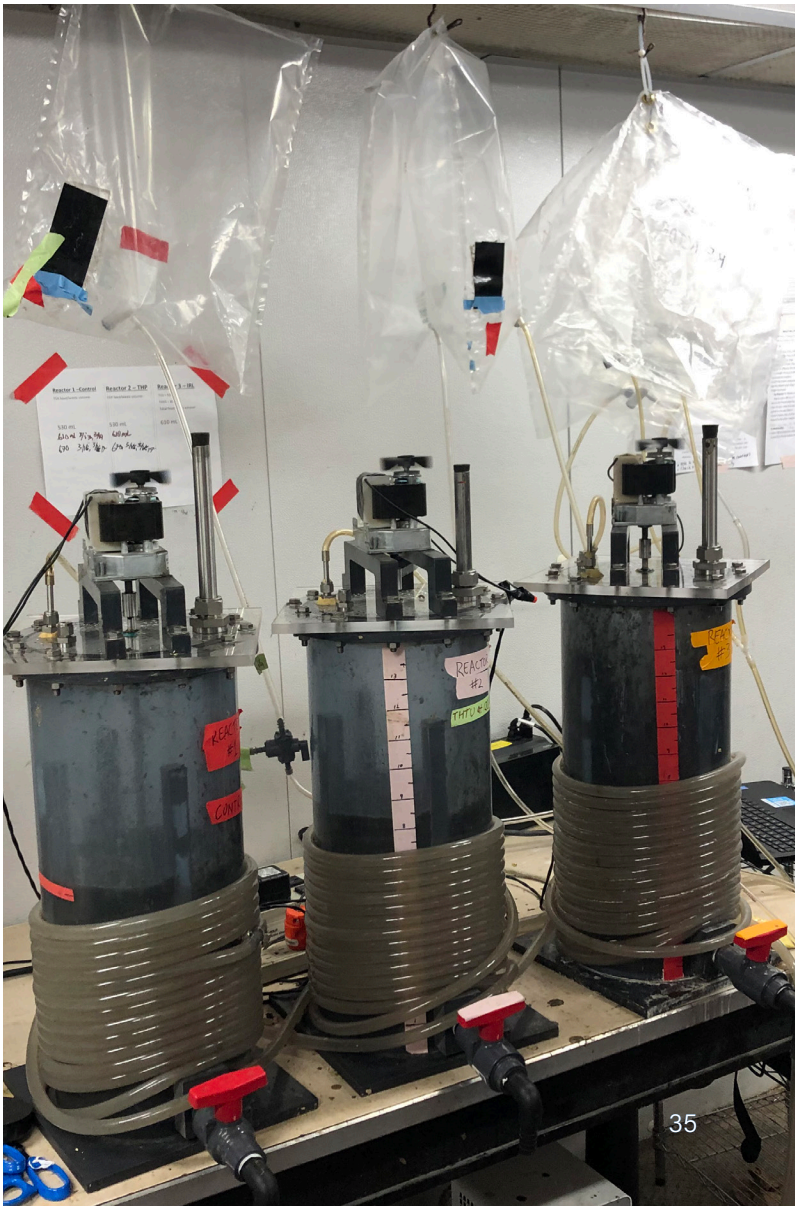
Treatment > Evaluation of Phased Anaerobic Digestion Configurations

Treatment of wastewater is often limited by the breakdown of tough sludge left over from conventional treatment. To overcome this problem, BWT is reviewing different technologies to produce higher-quality biogas and biosolids from digesters. The benefit would be a smaller footprint and lower operating and maintenance costs.

One of these technologies aims to separate the different phases of anaerobic digestion that include the recovery of a mineral called struvite.

In collaboration with the University of Massachusetts, Amherst, BWT will evaluate a two-phase anaerobic digestion process. This consists of high temperature phase, mineral (struvite) harvesting phase, and medium temperature phase. This technology will be tested with sludge from the Newtown Creek WRRF and the Wards Island WRRF.

THP reactors



Filter system at Margaretville Wastewater Resource Recovery Facility, Margaretville, NY

Treatment > Balancing Ammonia vs Nitrogen Oxides for Process Control

Conventional treatment of wastewater can be complicated and energy hungry. Balancing and controlling the two major components of nitrogen (ammonia and nitrogen oxides) during treatment is a new and creative process. It works by targeting a specific ratio of the two. This approach dubbed AvN (Ammonia vs NOx) leads to better performance and lower energy use.

In September 2020, BWT completed a draft white paper reviewing continuous-flow aerobic granulation using different AvN techniques. BWT is installing the prerequisite equipment to field test AvN technology at one of its facilities.

It is predicted that AvN will be one of the leading advances in a group of technologies for biological nitrogen removal. Additional research will be performed to investigate the best ways forward for equipment and strategies.

Treatment > Evaluation of Performic Acid Disinfection

The purpose of this BWT study is to evaluate performic acid as a disinfectant for secondary effluents and CSOs. Compared to the traditional disinfectants, performic acid offers high disinfection efficacy, low operational costs, and no formation of hazardous byproducts. Preliminary bench scale studies have been performed, and a research and development plan that includes both laboratory and pilot scale study of performic acid is under evaluation.

Treatment > Hunts Point Magnesium Hydroxide Slurry Centrifuge Dewatering Pilot

The BWT project seeks to improve dewaterability of cake solids and reduce dewatering polymer demand through the addition of magnesium hydroxide slurry (MgBalance) prior to dewatering. MgBalance addition at this step is a possible means of achieving higher cake dryness, achieving total suspended solids reduction in filtrate, and can also reduce polymer consumption. Baseline sampling and analysis is currently being conducted on the various locations that will be impacted by this pilot. Site preparations are underway at the facility and the experimental protocol is being finalized.

Treatment > Pre-Disinfection Chlorination for Increased Compliance and Cost Effectiveness

To meet a proposed State Pollutant Discharge Elimination System effluent limit for enterococci, BWT will pilot a two-step disinfection process by repurposing an existing chlorination dosing system at Bowery Bay WRRF. In the first stage, sodium hypochlorite will be introduced to final effluent from one of the two batteries to produce disinfectants (free chlorine residual or chloramine), to inactivate both bacteria and viruses. At second stage, additional chlorination will be added at disinfection contact tanks, for additional disinfection and inactivation of fecal and enterococci bacteria.

The two-step disinfection process is also intended to reduce the overall chemical consumption and to achieve improved disinfection without incurring new construction costs.

Treatment > Thickening Centrifuge Pilots

BWT will pilot a new thickening centrifuge technology to assess reduction on polymer/energy usage at two locations: North River and Hunts Point WRRFs. Working in partnership with the vendor, Centrisys, BWT will test performance, and corroborate reduction in order to consider this technology for future mechanical thickening projects.

Biosolids > Characterization of Bureau of Wastewater Treatment Biosolids

To increase beneficial reuse of biosolids, the Energy Office characterized the biosolids currently generated across the six WRRFs with dewatering capabilities by analyzing monthly samples. The results summarized nutrient value, carbon content, and selected historical and emerging compounds of concern across DEP's biosolids sources, as a precursor for further research as to the optimal beneficial use of this resource based on its characteristics. The report was finalized in 2022.

Water Quality > Ribbed Mussel (*Geukensia demissa*) Pathogen Reduction Project

BEPA is conducting multi-objective research to mitigate the influence of pathogens derived from CSO events in marine surface waters. This consists of cultivating and deploying large ribbed mussel populations that will provide bacterial filtration within tributaries of Jamaica Bay and other water bodies. As part of this project, a literature review indicated that ribbed mussels (*Geukensia demissa*) are capable of filtering out particles as small as bacteria (less than 1 micron at varying levels of efficiency) from the water column. The bureau has tested the ability of ribbed mussels to filter *E. coli*, *Enterococcus* and other fecal coliform bacteria commonly found in the water after CSO events. The literature review, and laboratory-based trials, including mesocosm simulations, were all completed by 2021. Field trials will begin in Bergen basin in spring 2023.

Water Quality > Tidal Wetlands (Spartina alterniflora) Pathogen Reduction Project

BEPA is evaluating tidal wetlands and their ability to mitigate pathogens. Fecal-indicator bacteria, which consists of total coliforms, *Escherichia coli*, and *Enterococcus*, are used as indicators of possible sewage contamination because they are commonly found in human and animal feces. DEP has initiated a study to determine the efficacy of wetlands at specifically reducing environmental fecal indicator bacteria. Within a tidal environment, marshes can dissipate tidal flow energies approximately one order of magnitude when the flows encounter the

Alley Creek tidal restoration project, Little Neck Bay, Queens, NY

vegetated marsh surface and flow velocity continues to decrease as vegetation density increases. The single marsh system case study will use a one-acre tidal marsh in Alley Creek, Queens, developed by DEP, which will provide a better controlled environment for monitoring and local data collection. The goal is to determine the appropriate spatial configuration of wetland and tidal channels for maximum water quality benefits. Instrumentation was installed in autumn 2022 for calibration purposes and additional sensors will be installed in spring 2023 along with a water and sediment grab sampling program.

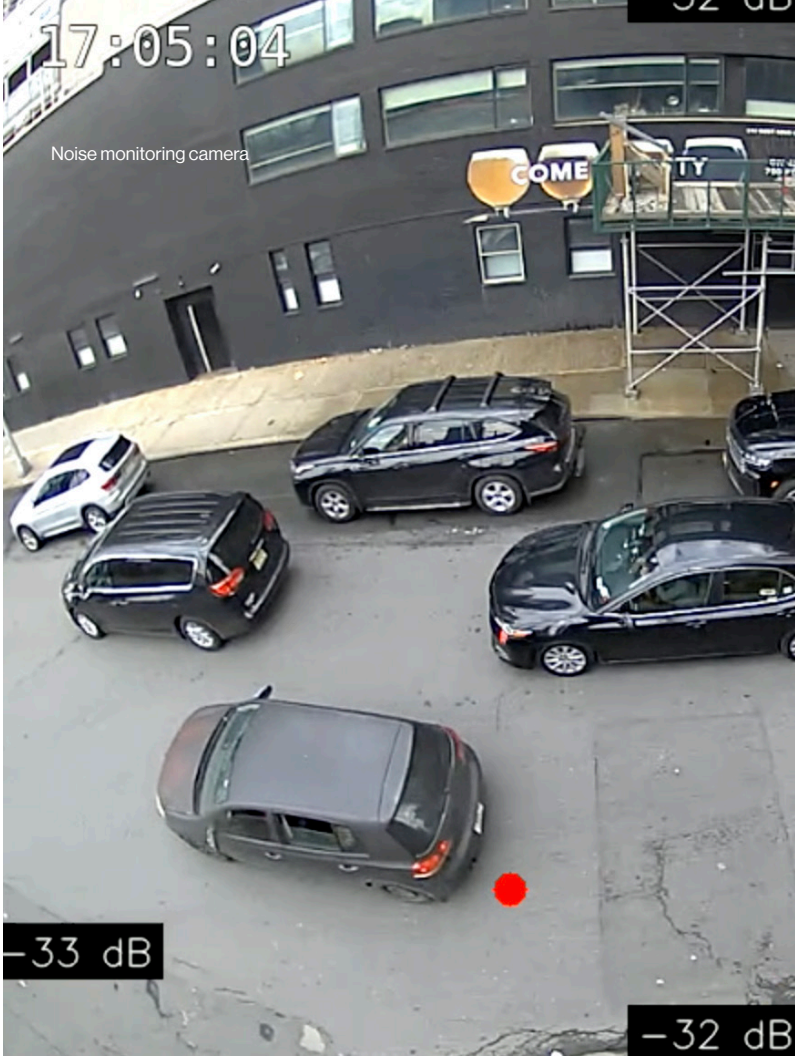
Remote Sensing > NoiseAware Sensor Research

BEC piloted noise level monitoring technology in residential areas to assist inspectors in responding more quickly to intermittent noises, especially commercial music and construction noise. The results demonstrated that this technology is helpful to residents in areas that face chronic noise challenges. In 2019, BEC placed sensors throughout the City, including locations selected in partnership with the NYC Office of Nightlife, and is in the process of implementing sensors for enforcement in areas with construction and nightlife.

Remote Sensing > Noise Pollution and Motor Vehicle Enforcement

Noise emissions from loud vehicle engines or mufflers can impinge on the quality of life in NYC. Some vehicle noise is so loud that it can even be a source of harmful public health impacts, such as from sleep deprivation and hearing loss. In recent years, there has been an uptick in activity around loud engines and mufflers resulting in noise complaints from elected officials, communities, and individuals to 311.

As a result of increased noise complaints related to muffler and engine noise on passenger cars, DEP's BOS and the New York Police Department (NYPD) joined forces in enforcement. However, these joint operations can only capture a small amount of the vehicles in violation of the noise code. In June 2021, DEP started a one-year pilot program to evaluate the use of remote sensing to improve enforcement of the noise code and control noise from modified mufflers on motor vehicles. As part of this work there were two outcomes: 1) DEP evaluated the existing regulatory framework to regulate muffler noise and implemented rule changes to be able to better enforce and 2) procured one noise monitoring camera as a pilot to evaluate the ability of this technology to enforce our code remotely.



The initial pilot ran from July 2021 through June 2022. The pilot has shown that remote sensing is a viable tool for noise enforcement. The cases that have had hearings at the Office of Administrative Trials & Hearings have been upheld, showing that this method of enforcement is defensible. Two challenges are related to license plates that are not readable and noise emitted from sources not covered in piloting. DEP is extending the pilot to evaluate using the noise camera to enforce against loud music from cars and car horns in addition to muffler/engine noise.

Water Quality > Using Environmental DNA (eDNA) to Identify Taste and Odor Compounds

Since 2018, there have been recurring periods of increased 311 calls related to musty/stale taste and odor complaints that coincided with the introduction of water from the Croton System into City distribution. These taste and odor events increase when 2-methylisoborneol (MIB), a metabolite produced by a range of algae and bacteria, is present above certain thresholds. In recent years, BWS has been conducting research and pilot testing of technologies to identify the source(s) of MIB in an effort to understand and mitigate these events.

In 2022, BWS partnered with Cardiff University to pilot eDNA as a means of investigating the potential source or sources of MIB in New Croton and Muscoot reservoirs. eDNA is nuclear or mitochondrial DNA that is released from an organism into the environment. If successful, the data from this analysis has the capability to describe the relative abundance of bacterial species present in the samples collected at eight locations across New Croton and Muscoot reservoirs. An additional analysis using RNA testing is being considered in order to indicate whether genes that produce MIB are active or inactive in the samples collected. These findings could allow BWS to implement appropriate source water and treatment strategies to mitigate or prevent future events.

Water Quality > Croton Reservoir Copper Sulfate Treatment

DEP has experienced episodes of taste and odor events stemming from the Croton System since 2018. Through its extensive water quality monitoring program, DEP has noted the presence of certain types of algae capable of producing the taste and odor compounds, geosmin and 2-methylisoborneol (MIB). BWS is conducting a research study to determine the effectiveness of controlling the growth of these algae with the application of copper sulfate.

DEP piloted treatment with copper sulfate to control algal growth at New Croton and Muscoot reservoirs in 2022. The first treatment, on June 22, targeted two areas near the intakes of New Croton Reservoir to study the algal response. A second treatment followed on June 27 at a section of Muscoot Reservoir near the Muscoot weir. The third treatment on September 22 treated the inflow of the New Croton Reservoir from the Muscoot weir down to the Croton Lake Gate House. These pilot studies helped DEP begin to understand the impact of copper sulfate treatment of algal communities and taste and odor compounds.

Unmanned Monitoring Systems > Drone Pilot Testing

Unmanned aerial systems, or drones, can be outfitted with a variety of imaging sensors that have until recently been the domain of satellite or airplane image collection missions. This technology lowers the cost of spatial imagery data acquisition and enables an expanded frequency of image collection and analysis.

The Water Innovation and Research group within BWS recently engaged the University of Vermont Spatial Analysis Lab to pilot a drone use case for a DEP-relevant problem: identifying the spatial extent and coverage of an invasive aquatic plant *Eleocharis dulcis*, or water chestnut, in East of Hudson reservoirs. Spatial imagery data was collected using a drone flown at a height of 400 feet above the reservoir surface. The coverage extent of water chestnut was successfully quantified using this drone imaging platform, producing an unsupervised pixel classification of the imagery data showing that water chestnut covered 6.4% of the imaged 48-acre reservoir area.

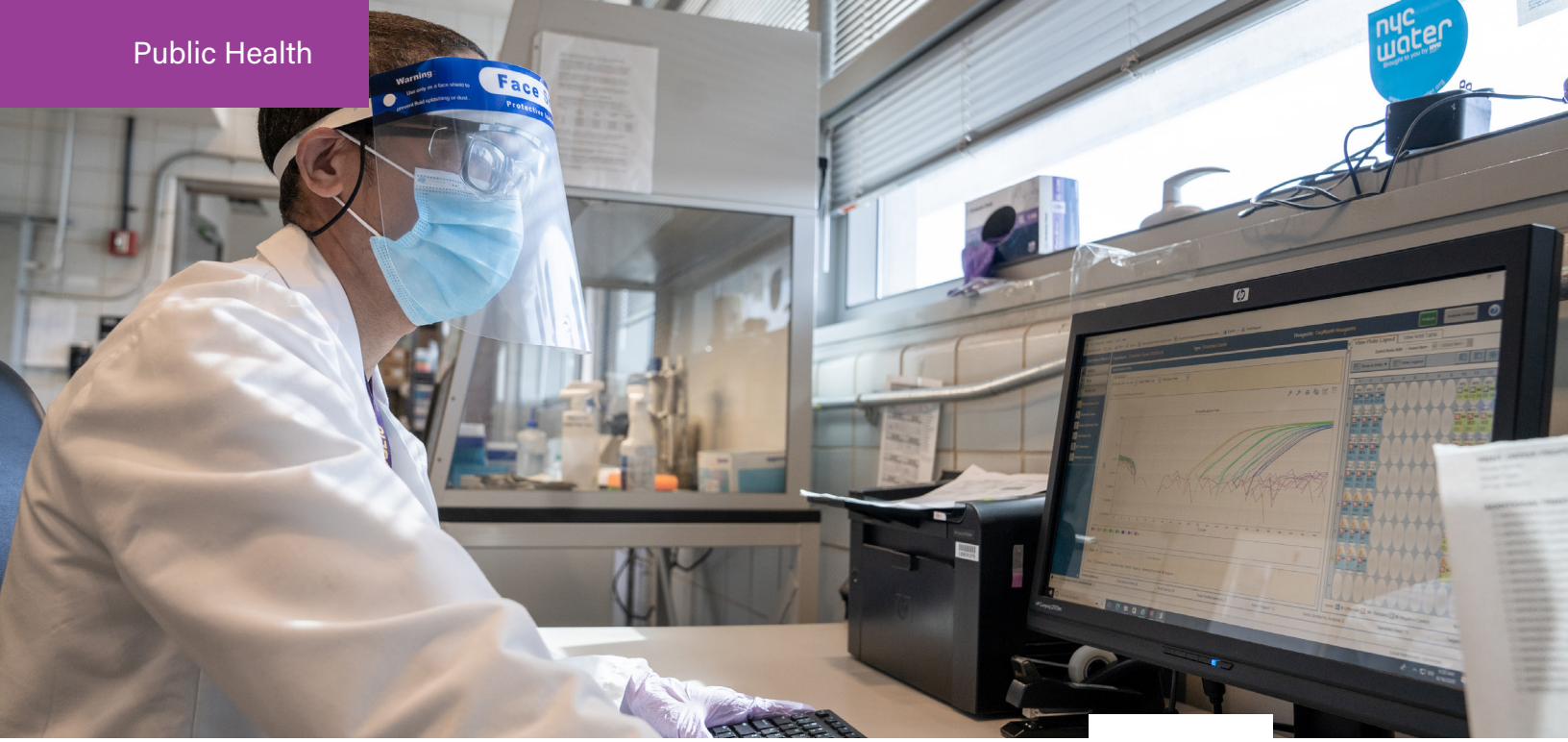
In addition, drone pilots have been conducted for other DEP-relevant missions, including visual and thermal imaging of the New Croton dam and mapping of forest height structure change in water supply watersheds following tree knock-down events. Future potential missions include underwater drone use (or remotely operated vehicle, ROV) for drinking water intake structures and pipe crawling drone (robot) use for smaller-diameter pipe inspections. Drones are proving to be a versatile, cost-effective, and data-rich platform, meriting future investigations and implementations by DEP.

DEP drone over Ashokan Reservoir

DEP scientists taking water samples at Ashokan Reservoir

Public Health

Public Health includes protecting and improving the health of New Yorkers through improved water quality, water treatment, and regulatory compliance.



DEP scientist conducting SARS CoV-2 testing at the Newtown Creek Microbiology Laboratory

Pathogens > Wastewater Based Epidemiology: Monitoring of SARS CoV-2, Monkeypox, and Polio

In 2020, BWT joined scores of utilities worldwide to monitor levels of the virus that causes COVID-19 in untreated wastewater. The Newtown Creek Microbiology Lab set up a new molecular biology platform for determining SARS-CoV-2 RNA concentrations in wastewater. Testing is ongoing for BWT's 14 WRRFs and the results are provided to New York City Department of Health and Mental Hygiene and to New York State Department of Health.

In addition, DEP has been providing the RNA extracted by the Newtown Creek Microbiology Lab to New York City Department of Health and Mental Hygiene for sequencing the SARS-CoV-2 RNA to determine the presence and concentration of variants of concerns, and other variants, in wastewater. BWT's wastewater-based epidemiology efforts are expanding, with the studies of the presence and quantification of monkeypox and polio, in collaboration with the New York State Department of Health, SUNY Syracuse, and the Center for Disease Control, respectively. The wastewater-based epidemiology approach is less costly than monitoring a pathogen by testing clinical samples as many fewer wastewater samples have to be analyzed to determine the prevalence of a pathogen of concern in a sewershed. In addition, the approach and analytical technique are amenable to monitoring other pathogens such as influenza viruses, enteric pathogens, and antimicrobial resistance.

Disinfection Byproducts > Development of Reservoir Models for Disinfection Byproducts Precursors

BWS is continuing to work on a multi-year project to develop Disinfection Byproduct (DBP) formation potential models for source water streams, fate and transport models for DBP precursors in reservoirs, and a DBP model for the NYC distribution system. As an alternative to direct simulation of DBP formation potential in reservoirs, BWS is investigating simulation of a surrogate measurement, UV_{254}. UV_{254} has been found to be strongly correlated to DBP formation potential; and it can be measured easily, frequently, and inexpensively, making it an excellent choice to model. Currently, BWS is developing and testing models for Cannonsville and Neversink reservoirs.

Disinfection Byproducts > Watershed Dissolved Organic Carbon (DOC) Modeling

In 2022, BWS initiated a research project to develop the capability to simulate dissolved organic carbon for streams in West of Hudson watersheds. Currently, BWS is developing and testing the Soil and Water Assessment Tool DOC model for the Neversink watershed. Once developed these models can support DBP research in the watersheds.

Disinfection Byproducts > Step Chlorination

BWS conducted a 60-day pilot study to evaluate the effects of step chlorination on disinfection byproducts. The pilot study involved pre-treating Delaware water upstream of Kensico Reservoir using the chlorination facility at Delaware Aqueduct Shaft 10 and dechlorination facility at Delaware Aqueduct Shaft 17 prior to discharge into Kensico Reservoir. Samples were collected and analyzed for disinfection byproducts (haloacetic acids and trihalomethanes), and other water quality parameters at various locations to determine if or to what extent concentrations changed. Sample collection dates and times considered travel times from Delaware Aqueduct Shaft 10 to Shaft 17 as well as travel time through Kensico Reservoir based on flows from the Delaware Aqueduct. BWS conducted an analysis to evaluate the effectiveness of the pilot treatment and determined that the treatment had no impact on disinfection byproduct concentrations observed further downstream in the water supply system.

Croton Water Filtration Plant

Emerging Contaminants > Emerging Contaminant Research

BWS monitors for emerging contaminants within the NYC watershed and distribution system. In 2019, DEP monitored for per- and polyfluoroalkyl substance compounds as part of a larger emerging contaminant project. In 2021 and 2022, as a follow-up to the 2019 monitoring, DEP conducted quarterly monitoring at the Catskill-Delaware and Croton source water monitoring locations and annual monitoring at Kensico Reservoir tributaries and an in-reservoir Kensico Reservoir location.

Treatment > Adenosine Triphosphate Testing of Granular Activated Carbon

In 2020, DEP changed the filtration media at the Croton Water Filtration Plant from anthracite/sand to granular activated carbon (GAC). One of the characteristics of GAC is its ability to grow a diverse community of microbes, or biofilm, on the grain surface, which can remove a wide range of contaminants from drinking water and extend the usable lifespan of the GAC.

In order to understand the biofilm community on the GAC, BWS is pilot testing measurements of biological activity using adenosine triphosphate (ATP). The pilot test of ATP testing for biological activity continues, and results to date have shown that adjustments are needed to allow enough incubation time for biologic activity.

Treatment > Maximizing Treatment Effectiveness at Croton Filter Plant

Natural waters contain organic constituents that are filtered out as part of the Croton Filtration Plant's treatment process. These organics have a negative charge and can be removed by adding positively charged treatments like aluminum compounds. The subsequent reaction creates particles large enough to be lifted to the surface by air and then filtered out.

Research is underway to study how well the measure of overall charge in the water – the Zeta potential – can be used to predict the treatment needed. By measuring Zeta potential, operators can measure the actual charge on the particles and adjust treatment so that the charge in the water is close to neutral, allowing positive and negatively charged particles to cling together. The greater number of particles that cling together allows for better treatment.

In 2021 and 2022, Zeta potential was used to adjust the filter configuration and the results are currently being analyzed.

Treatment > Source Water Selection – Water Quality Index

BWS developed a water quality index to identify and optimize withdrawals from source water reservoirs. The water quality index is created by scoring numerous water quality parameters to create an index that succinctly conveys overall water quality in a single number. The Catskill, Delaware, and Croton water supply systems each have unique indices based upon the parameters evaluated and incorporated into the index. For example, the Catskill/Delaware water quality index evaluates parameters such as turbidity and UV_{254} data to aid selection of the highest quality source water for distribution. The Croton water quality index evaluates a suite of parameters that aid in the selection of the optimal location and depth to withdraw water from New Croton Reservoir to meet treatment efficacy and efficiency at the Croton Filtration Plant. The index went live in July 2022 and is available daily to all staff via a web browser, email, or via the Power BI application on mobile devices.

Treatment > Croton Filter Plant Distribution to City Tunnel 2

With the construction of a connection between the Croton Filter Plant and City Tunnel Number 2, research is underway to understand the maximum flow that can be distributed throughout the water supply system at different times of the year. This value will be developed by evaluating the role of temperature, pH, and free chlorine residual at different times of the year and under various flow scenarios. The result will provide BWS with the information needed to meet water quality requirements for inactivation and disinfection as the new operational configuration is brought online. Additional testing is planned for 2023.

Treatment > Maximizing Lamp Usage at Catskill-Delaware Ultraviolet Treatment Facility

The Catskill-Delaware Ultraviolet Treatment Facility (CDUV) has a requirement to replace each ultraviolet (UV) lamp after 10,000 hours of use based on an agreement with New York State Department of Health. In-house testing of the lights' throughput, measurement of each UV lamp's intensity, and a quarterly evaluation of each lamp's performance has shown that the UV lamps should be able to achieve disinfection up and until the lamp reaches exhaustion. BWS staff have worked with a consultant engineer to review existing data and develop a plan to test lamp longevity while operating the plant. A meeting with NYSDOH will take place in spring 2023 to present the plan and develop the timing requirements to test the lamps.

Lead > Lead Premise Plumbing Studies

During a DEP review of tapping records for city-owned infrastructure in 2018, a number of single-family homes owned by the New York City Housing Authority (NYCHA) were identified as having lead service lines (LSLs) which were replaced by DEP in coordination with NYCHA. In addition to these NYCHA homes, DEP replaced about 600 LSLs at private homes of low-income homeowners under a grant funded by the state. The LSL replacement for these additional homes was completed in November 2022.

To better understand the impacts of LSL replacements on lead concentrations in premise plumbing, DEP provided residents with lead test kits for sampling between 30 and 90 days after the LSL replacements. Preliminary results indicate that flushing may not be needed for more than a month post replacement, but DEP plans to continue evaluating lead levels post-LSL replacement and has included an additional one-year follow up sample. The first phase of the flushing results will be reported early 2023.

Lead service line replacement, Queens, NY

Lead > Evaluation of Optimizing Corrosion Control in the New York City Water Supply

DEP BWS and BWSO are studying the impact of increasing the orthophosphate (PO_4) dose in a limited, isolated area of the Bronx, City Island. DEP currently adds PO_4 at an operational maintenance dose of 2 parts per million (ppm), and adjusts pH to control lead release from plumbing into drinking water. The objective of the study is to assess impacts on lead release from LSLs and premise plumbing (e.g., copper pipe with lead solder) at increased PO_4 concentrations up to 4 parts per million, with varying temperature and source water supply. Data from water quality instrumentation on City Island is continuously monitored for PO_4, specific conductivity, turbidity, temperature, pH, and chlorine residual levels.

The study area includes 30 homes on City Island and two lead pipes installed in the BWT pump station in the Bronx. Also included in the study are pipes in Queens, which are being used as a control as it is not receiving an increased PO_4 dose or change in source water.

In 2022, a PO_4 dose of 4 parts per million was evaluated for Croton cold water conditions and Catskill and Delaware cold and warm water conditions. Additionally, two Catskill and Delaware source water runs were completed at lower PO_4 concentrations in 2022. A final report will be prepared in spring 2023 after the Catskill and Delaware cold water sampling event is completed with a PO_4 dose of 2 parts per million.

Pathogens > *Cryptosporidium* analysis of Wildlife Excrement Samples

To maintain an understanding of potential pathogen sources within the NYC watershed, BWS, in collaboration with the New York City Department of Health and Mental Hygiene, continued mammal and bird excrement collection and pathogen analyses into 2021 to identify the prevalence of *Cryptosporidium* oocysts in a variety of wildlife species throughout the watershed and at Hillview Reservoir. Samples were collected by the BWS Wildlife Studies Section by means of trapping, roadkill collections, and surface collection. Scat samples were catalogued and shipped on ice by the Watershed Impact and Pathogen Assessment team to the Centers for Disease Control and Prevention Laboratory in Atlanta, Georgia, for molecular analysis.

Results have been received and data analysis is underway to be completed in 2023.

Pathogen monitoring at East Branch Delawere River

DEP scientist conducting water testing, Queens, NY

Pathogens > Testing of NYC Resident Cases of Cryptosporidiosis

This research effort seeks to identify species and subtypes of *Cryptosporidium* oocysts recovered from NYC residents that tested positive for cryptosporidiosis and compare them to species and subtypes of oocysts found in the NYC watershed. Detection in the source water is rare, and there has been no evidence to suggest the water supply as a source of NYC cases of cryptosporidiosis. Investigators sought to compare findings from these sources to determine any similarities or differences with types found in human cases of cryptosporidiosis in NYC.

Cryptosporidiosis positive specimens of NYC residents already obtained by the New York State Department of Health Wadsworth Laboratory were tested with molecular methods to identify species and genotypes to determine predominant species and compare with species and genotypes previously identified in the watershed. Sample analysis and data evaluation were completed. Findings revealed that the vast majority of NYC resident cases of cryptosporidiosis in samples where a species was able to be identified (95%) were C. hominis and C. parvum, which is not consistent with the majority of types found in the watershed.

Disinfection Byproducts > DBP Formation Potential in Watershed Sources

BWS is conducting research in the Neversink and Cannonsville watersheds to evaluate potential proxy measurements for DBP precursors to support water supply operations and water quality modeling efforts. Samples from major stream inputs, along with reservoirs and reservoir diversions, are being analyzed for total trihalomethane formation potential, haloacetic acid formation potential, and potential proxy analytes. The proxy analytes include total and dissolved organic carbon, UV_{254}, fluorescent dissolved organic matter, S::CAN multi-spectral absorbance, chlorophyll a, and phycocyanin.

The study, which includes a combination of laboratory, field, and robotic monitoring, will assist BWS in developing a water quality index and models to optimize the quality of water being delivered to the City. Empirical models of DBP formation potential in streams are being developed using UV_{254} as a surrogate. In 2022, BWS also partnered with the Cary Institute of Ecosystem Studies and Rensselaer Polytechnic Institute to conduct additional monitoring to study DBP precursor sources and formation potential in Neversink watershed streams.

Fixed-depth robotic buoy deployment in Schoharie Reservoir

Green roof garden, Nicotra building, Staten Island, NY

Sustainability

Sustainability includes opportunities to be self-sustaining in the areas of energy, infrastructure, financing, and hydrology, in addition to efforts to improve quality of life through water conservation, preparing for extreme weather and climate change, and understanding the water-energy nexus.

Energy > DEP Energy and Carbon Neutrality Plan

DEP's Energy and Carbon Neutrality Plan is a four-year effort that will develop a roadmap for achieving energy and carbon neutrality by 2050. The project is comprised of five major tasks and deliverables: (1) an Energy Neutrality Plan for the 14 in-City WRRFs, including five conceptual designs for innovative energy efficiency and renewable energy systems that will be replicable at multiple locations; (2) a Solids Handling and Biosolids Beneficial Use and Residuals Optimization Plan for both the upstate and in-City WRRFs; (3) a DEP-wide Energy and Carbon Neutrality Plan, including an 80% reduction in greenhouse gas emissions, and a 20% reduction in energy usage; (4) an Energy, greenhouse gas (GHG), and Biosolids Management Scenario Modelling Tool and data management support; and (5) a report on highly innovative, fringe technologies related to energy, GHG emissions, and biosolids beneficial use that DEP could demonstrate.

In late 2019, DEP's project partners were on-boarded. Throughout 2020 - 2022, the team undertook several first-ever analyses for DEP, such as food waste co-digestion capacity system-wide, solar PV potential over process tanks, hydropower potential from effluent outfalls, and thermal energy recovery from wastewater. Drafts of the WRRF Energy Neutrality study and the Biosolids Master Plan are currently under DEP review. Work on the agency-wide carbon neutrality work started in Fall 2022.

Wastewater Resource Recovery > Feasibility Screening for District Heating Systems Centered Around WRRFs

DEP is working with New York State Energy Research and Development Authority to investigate the feasibility of setting up community district heating systems centered around in-City WRRF effluent water. As New York City and New York State move to achieve deep carbon reductions, most of the City's building stock will need to move to electrification of their heating needs through energy efficient heat pumps. Acknowledging that heat pump systems that exchange energy with the ground and/or temperate water are more efficient than air source heat pumps, and that DEP treats over one billion gallons of temperate wastewater each day, DEP is investigating whether there is sufficient building stock adjacent to our WRRFs where a heat pump system exchanging energy with plant effluent water could be part of a district heating system that will help neighboring buildings efficiently decarbonize. This project kicked off in autumn 2022 and is expected to conclude in spring 2023. If a site is determined to be viable, DEP and New York State Energy Research and Development Authority will develop a preliminary design to further advance the concept.

Sludge-drying greenhouses at the Margaretville Wastewater Resource Recovery Facility

Energy > Model the Carbon Footprint of Source Separated Organics Management for NYC DEP

The Energy Office is developing a GHG emissions assessment of options for managing source-separated organics (SSO), including food waste, fats oils and grease, and a small amount of yard waste. The comparison of GHG emissions from three different SSO management scenarios will provide DEP with necessary data to inform their decision-making with regard to SSO management. The goal of this study is lowering the City's overall carbon footprint. The results of this study will be paired with an earlier study looking at the GHG emissions associated with different end-uses of biosolids. Combined, they will provide DEP with a holistic understanding of best practices for organic material from a GHG emission perspective.

Energy > ElectraTherm Demonstration at Port Richmond WRRF

BWT is working with ElectraTherm, the manufacturer of an Organic Rankine Cycle system that uses low-grade heat from boilers to produce electricity. This one-year demonstration project started up in 2022 and will allow the Port Richmond WRRF to beneficially utilize its biogas during the summer, when the plant typically flares much of its biogas. Specifically, the Organic Rankine Cycle utilizes the thermal energy generated from biogas in boilers to provide power to the facility. At the end of this one-year demonstration, DEP has the option of retaining the Organic Rankine Cycle system and will also be able to assess the feasibility of this technology at additional facilities. This pilot project was fully funded by DEP's partner agency, the Department of Citywide Administrative Services.

Climate Change > Fugitive Methane Monitoring and Reduction Plan

BWT is in the process of reviewing and improving its approach to methane emissions due to leaks. There are two approaches: (1) inspecting and upgrading meters that measure biogas to ensure that all measurements are correct; and (2) detecting leaks to identify areas for maintenance, repair and/or upgrade. Working with Office of Energy, BWT is in a planning phase to establish how best to measure the reduction of methane emissions as a result of inspections, repairs, and upgrades. In 2021, a cost assessment was intiated to understand economic, environmental, and social benefits of this work. Work is ongoing and reductions monitoring will be integrated into ongoing carbon inventory reporting by the Office of Energy.

ElectraTherm heat to power conversion system, Port Richmond Wastewater Resource Recovery Facility, Port Richmond, NY

Treatment > Nitrous Oxide Production and Mitigation Project

Nitrous oxide is one of the most significant GHGs with a global warming potential about 300 times that of carbon dioxide. To achieve DEP's carbon neutrality goals, this project will inform process-specific monitoring and mitigation strategy planning for biological nutrient removal processes to control nitrous oxide production and emissions. The project builds on research supported by the Energy Office, The Water Research Foundation, and National Science Foundation. In collaboration with City College of New York, Columbia University, and The Water Research Foundation, it will inform process-specific monitoring and mitigation strategy planning for biological nutrient removal processes to control nitrous oxide production and emissions.

Climate Change > Citywide Stormwater Resiliency Planning

In 2018, BOS initiated a stormwater resiliency study with the Mayor's Office of Resiliency to model flood-prone areas under different storm scenarios and with current and future climate projections. Local Law 127 of 2018 requires the City to provide maps of areas most vulnerable to flooding, and to develop a mitigation plan that reflects existing and potential future approaches through green and green-gray hybrid stormwater management solutions. In 2021, the Mayor's Office of Resiliency released the City's first "Stormwater Resiliency Plan," along with maps developed by DEP based on models of flood-prone areas under different storm scenarios and with current and future climate projections.

Aftermath of Hurricane Ida, Staten Island, NY

Following Tropical Storm Ida, the City accelerated and expanded upon the commitments in the Stormwater Resiliency Plan in "The New Normal" report, and subsequently in DEP's "Increasing Stormwater Resilience in the Face of Climate Change: Our Long Term Vision." As part of the commitments identified in these plans, DEP has been developing cloudburst projects to mitigate extreme rain events, utilizing the flood maps and building upon the City's existing efforts and projects incorporating operational and structural approaches.

Modeling > Water Demand and Wastewater Flow Projections

The Integrated Water Management group in BEPA is developing updated short- and long-term water demand projections in consultation with BWS to statistically characterize trends in water use patterns by user class, sectors, and geographic regions. The Integrated Water Management group will also consider the influence of climatic and socio-demographic factors that shape short- and long-term demand trends when updating the projections. Additionally, BEPA is developing updated dry weather wastewater flow projections by sewershed to empirically connect water demand and wastewater flow projections and translate water demand forecasts to projected wastewater flows. BEPA developed a forecasting framework, which will be used for the development of the water demand forecast model. The forecasting framework centers around the disaggregation of water-use data, as well as the socioeconomic and other variables that can be used to explain variability in water use. Initial projections are available through 2055.

Climate Change > Climate Data and Analysis

Global Climate Models (GCMs) tend to underestimate the multi-year variability of precipitation over some regions, including NYC's watershed, resulting in an underestimation of the magnitudes and/or intensities of prolonged droughts as well as prolonged wet periods. Two methods – an analog method and a change-factor-method are being proposed to correct for this bias. BWS is testing these methods for Ashokan Reservoir basin.

Energy > Exploring Advanced Wood Heating Options at Cat/Del Facilities

Agency decarbonization goals include the expanded use of renewable energy across all DEP facilities. Using the BWS Continuous Improvement program as a springboard, DEP Forestry collaborated with the US Forest Service's Wood Energy Support Team to test assumptions on the feasibility of utilizing regionally sourced wood chips and/or wood pellets to meet space-heating demands of facilities in the Catskill and Delaware watersheds.

The team reviewed heating bills from 2017-2019 (#2 Oil/5% bio oil/LP Gas/Electric) across all of DEP's relevant facilities and considered preliminary studies underway for the expanded use of ground/air source heat pumps. Following this initial review, sites were chosen based on the potential benefits identified in the first phase of study and those deemed representative of other Cat/Del facilities suitable for advanced wood heating systems.

A feasibility report for each of the facilities and summary of the project findings was issued in autumn 2021 and was accompanied by touring a wood-chip heated school in the Hudson Valley. Ultimately, the study illustrated that the benefits provided by using advanced wood heating include:

- Net reduction of greenhouse gas emissions
- Support of the local economy through the purchase of locally sourced wood chip and pellet fuel
- Diversification of heating fuels can avoid possible effects of regional fossil fuel and electric cost fluctuations.
- Avoidance of electric grid load-growth can ensure that the increasing but limited supply of renewable electricity on the grid is available for other projects.

Diverting Reservoir

List of Acronyms

AVID	Assessing Vegetation Impacts from Deer
AvN	Ammonia vs NOx
BEC	Bureau of Environmental Compliance
BEPA	Bureau of Environmental Planning and Analysis
BOS	Bureau of Sustainability
BWSO	Bureau of Water and Sewer Operations
BWS	Bureau of Water Supply
BWT	Bureau of Wastewater Treatment
CCFRPMP	Centrifugally Cast Fiberglass Reinforced Polymer Mortar Pipe
CFS	Carbon Fiber System
CSO	Combined Sewer Overflow
CUSP	New York University Center for Urban Science+ Progress
CDUV	Catskill-Delaware Ultraviolet Treatment Facility
DBP	Disinfection Byproduct
DDC	New York City Department of Design and Construction
DEP	New York City Department of Environmental Protection
DOC	Dissolved Organic Carbon
eDNA	Environmental DNA
EPA	United States Environmental Protection Agency
GI	Green Infrastructure
GAC	Granular Activated Carbon
GHG	Greenhouse Gas
LSL	Lead Service Line
LiDAR	Light Detection and Ranging
MgBalance	Magnesium Hydroxide Slurry
MS4	Municipal Separate Stormwater Sewer System
MIB	2-methylisoborneol
NAPL	Non-Aqueous Phase Liquids
NYC	New York City
NYCHA	New York City Housing Authority
NYPD	New York Police Department
NWI	National Wetland Inventory
PO4	Orthophosphate
R&D	Research and Development
SSO	source-separated organics
SWAT	Soil and Water Assessment Tool
UV	Ultraviolet
USGS	United States Geological Survey
WQI	Water Quality and Innovation
WRRF	Wastewater Resource Recovery Facility

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