Compendium of Abstracts

NYC Watershed Science and Technical Conference

September 9, 2015   Thayer Hotel, West Point

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INTRODUCTION AND ACKNOWLEDGMENTS

Dear Conference Participants,

In 1997, the signatories to the historic New York City Watershed Agreement formed an enduring partnership to protect and enhance the City's Watershed and the scores of communities living within it. Underlying this complex social and political undertaking has been an unprecedented technical initiative among scores of local, State and federal agencies with one common goal: to advance the science of watershed protection.

The Watershed Science and Technical Conference was created as an annual opportunity to bring scientists, professionals, and other experts together with watershed stakeholders and the public, to technically inform, exchange ideas, and unveil new information regarding the protection of the nation's largest unfiltered surface water supply.

As we were assembling the components of this year's program, we were mindful of the fact that this year has been named the "Year of the Operator", in recognition of the very important and technically complex work that water and wastewater operators accomplish for all of us each day.

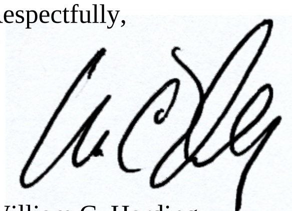
Operators across the country perform extraordinary and important functions around the clock, every day. Through a careful and highly trained approach to the tasks, water and wastewater plant operators perform life sustaining functions: bringing us clean drinking water, and after our use, managing its return safely to the environment.

And so it is appropriate to thank our hard working operators, and to reflect on the incredibly valuable work that they do for us. Thus, in this "Year of the Operator" it is our desire to set aside a major portion of our conference program to highlight their dedication and professionalism, and to say, thank you for your service.

The Conference Call for Abstracts was made to agencies and stakeholders in and beyond the New York City Watershed. The resulting responses were reviewed by the Technical Program Committee for technical merit and interdisciplinary utility, as well as temporal and substantive relevance. Those chosen by the Committee for presentation at this year's Conference are included in this Compendium.

In addition to our esteemed presenters and all those who submitted their scientific endeavors, we wish to thank the many agencies, professional organizations, and individuals who contributed to the success of this conference. It is our hope that all who attend will be edified by the scientific data presented, and inspired by the dedication and hard work of those who, each day, advance our insight into the science of protecting the drinking water for 9 million New Yorkers.

Respectfully,



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Executive Director, Watershed Protection and Partnership Council

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- The Watershed Agricultural Council
- The United States Geological Survey
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Performance Assessment of Stochastic Weather Generators for precipitation over Catskill Mountain Watersheds, New York, USA

Nachiketa Acharya, Ph.D., Allan Frei, City University of New York; Karen Moore, Ph.D., Jim Mayfield, NYC Department of Environmental Protection

The New York City Department of Environmental Protection (DEP) has performed studies to assess the potential impacts of climate change on the availability of high quality water in this water supply system. To better address this, there is a need to develop future climate scenarios that can be used as inputs to the DEP's integrated suite of hydrological models. There are two familiar approaches used to incorporate climate change into vulnerability analyses viz., top-down and bottom-up approaches. Top-down approaches use scenarios from Global Climate Models (GCMs). Bottom-up approaches identify the climate vulnerabilities of a water supply system over a wide range of potential climate changes. Stochastic weather generators are often employed in bottom-up risk assessments to simulate potential shifts in both long-term (decadal) precipitation means and persistence as well as in extreme daily precipitation amounts. The main goal of the current work is to document the performance of two weather generators, the widely used generator WGEN, and the comparatively new and sophisticated WeaGETS, in simulating precipitation over the Catskill Mountain region. The performances of these two weather generators are compared in order to gauge their capabilities of reproducing the observed statistical properties including the probability distributions, means and variances, and the frequencies and magnitudes of extreme events.

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Overview of Hillview Reservoir Protozoan Data and Update on Related Research Studies – New York City Water Supply

Kerri Alderisio, NYC Department of Environmental Protection

As the pre-finished water reservoir for New York City's water supply, Hillview Reservoir is a critical component to the drinking water system. All of the Catskill water delivered to Hillview flows through the reservoir while, under normal operations, most of the Delaware water flows past the reservoir through a bypass tunnel. As such, approximately 40-45% of New York City's drinking water flows through Hillview Reservoir before it is delivered to consumers. Protozoan samples were collected at Hillview Reservoir from 2006 through most of 2008 for a specific targeted study. Weekly sampling resumed in 2011 under an Administrative Order related to covering the reservoir, as made necessary through the Long Term 2 Surface Water Drinking Rule (LT2). Different sample collection volumes and methods have been tested to optimize recovery. Moreover, testing performed by DEP or contract laboratories has included the counting of Giardia cysts and Cryptosporidium oocysts by conventional microscopy (USEPA Method 1623), genotyping by Polymerase Chain Reaction (PCR) of oocysts (small-subunit rRNA-based nested-PCR), and pilot testing of a cell culture - immunofluorescent assay (CC-IFA) method to determine potential recovery of infective oocysts in that particular matrix. Additionally, there have been a few related events that have occurred since sampling began, including a study examining the occurrence and types of oocysts in wildlife feces collected around the reservoir, wildlife management enhancements, and the start-up of the Catskill/ Delaware Water Ultraviolet Disinfection facility.

An overview of the data will be presented as well as up-to-date results related to any pathogen research studies associated with Hillview Reservoir.

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UV-Oxidation for Recalcitrant Chemical Contaminants

Scott Binder, Trojan Technologies

Increasing demand for drinking water has led to a reduction in water sources that provide suitable high quality raw water. As a result, many drinking water providers utilize raw water resources which can be considered impaired and contain increased concentrations of biological and chemical contaminants. Commonly detected contaminants in impaired water resources include taste and odor (T&O) causing compounds, pesticides, volatile organic compounds (VOC) as well as other contaminants. Standard drinking water treatment methods often include a combination of chemical coagulation, filtration and disinfection. However, due to various physical and chemical properties inherent to emerging contaminants found in impaired water resources, many are resistant to standard treatment and are considered "recalcitrant". Quantification of recalcitrant compounds in U.S raw water sources continues to increase with initiatives such as the USEPA Unregulated Contaminant Monitoring Rules (UCMR) and it can be concluded regulations aimed at reducing the concentrations of recalcitrant compounds in drinking water are on the horizon. As a result, water providers will need to adopt more advanced treatment measures to remove emerging recalcitrant contaminants of concern.

UV-oxidation is an advanced oxidation process (AOP) that utilizes UV-light in combination with hydrogen peroxide (H_2O_2) to generate highly reactive hydroxyl radicals. These radicals react indiscriminately with many chemical contaminants. This presentation profiles three water providers and the rationale used when selecting the use of UV-oxidation to degrade recalcitrant chemical contaminants. Specifically, the contaminants addressed by the water treatment sites profiled in this report include: T&O compounds 2-methylisoborneol (MIB) and geosmin, metaldehyde (pesticide), and 1,4-dioxane. Highlighted advantages of incorporating UV-oxidation included either year-round or intermittent operation of UV-oxidation systems depending on the contaminant being treated and the frequency of its detection, improved safety and reduced risk of unwanted by-product formation.

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Environmental Concerns for Temporary Pumping and Dewatering Applications

Ryan Booth, Seth Morris, Godwin Pumps, a Xylem Brand

In most temporary pumping and dewatering applications, there are many risks for the environment ranging from air and noise pollution to erosion concerns and potential damages to endangered species in the area. In many cases the solutions are simple enough to be addressed during the planning and execution phases of these projects with a minimal cost and impact on the total project. Specific examples include spill proofing for petroleum products, calculating the highest diesel efficiency in a temporary pumping application, automation for diesel pumps to reduce fuel consumption, sound attenuation, using electric pumps (when possible) to reduce emissions, and siphon applications for temporary solutions (when potential energy is available). As always, the ability to identify where to employ these solutions is critical. We intend to show applications where we have successfully employed many of these solution to reduce environmental impact, and show some cost savings for the project and some of the risk/reward criteria that went into making the decision making process.

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Innovative Stormwater Management Applied under Environmental Site Design at a Trash Transfer Station in Baltimore County, MD

Hans de Bruijn, Fresh Creek Technologies Inc.

Run-off collects impurities. Obvious methods to capture these solids with flat screens, settling tanks and sand filters work, but how efficient are these methods? Managing the water in run-off goes hand in hand with managing the removed impurities. Innovative designs reduce maintenance cost with infrequent and efficient cleaning methods. Purifying water is an old art, but purifying stormwater run-off is an old art applied in a new application. In the 20th century great strides were mate to improve efficiency in potable water treatment. Those lessons and stormwater flow regimes led to post construction stormwater management treatment device adaptations applied in Baltimore County. Trash nets can increase flow through surface area by 1700%, capture volume by 1600% and reduce maintenance attendance. Placing parallel plates in a settling tank can reduce settling tank footprint and match conventional settling tank performance by reducing the required tank area up to 90%. The single surface area of a sand filter can be increased with pleated surface areas of cartridge filters and do the work of 190 square feet of sand filter in one square foot cartridge assembly.

We discuss the application of MDE Appendix D10 for ESD (Environmental Site Design) and above technologies for the Central Acceptance Site. We discuss the treatment train capture- and maintenance experience after filter installation in august 2013 and how in one year we discovered the substantial filter cake build-up on the filter surfaces. We report the Particle size distribution and concentration of TP in the cake. We highlight the particle behavior in run-off and how it enters the water column. We show what controls must be in place to allow a particle to stratify in the water column and how new patent applied for settling technology reduces turbulence in a settling cell to further efficiency of particle and water separation by gravity.

Currently this Con-Current settling technology is tested according to the January 2013 NJDEP laboratory protocol at Alden Laboratory in Holden Massachusetts.

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Monitoring Turbidity Under Ice Cover at Ashokan Reservoir

Allison Dewan, NYC Department of Environmental Protection

The New York City Department of Environmental Protection (DEP) has been expanding its water quality monitoring network to allow for near real time data to be collected for turbidity, temperature and specific conductivity within specific reservoirs and at selected stream sites. These data are critical for making operational decisions with respect to water quality. The network primarily consists of profiling and fixed depth buoys, and water quality monitoring huts at stream sites. One limitation of the in-reservoir monitoring buoy platforms is that they must be removed for winter during ice cover conditions. This resulting data gap, lasting for several months, has led to operational decision support challenges. To resolve this issue, DEP deployed an under ice turbidity monitoring system which when deployed during open water conditions, has the capability to provide near real time water quality data throughout the ice cover period. Two of the main challenges with an under ice system are power and communications. This system was designed to use a cellular modern, stick buoy and antennae, along with a submerged battery pack that would power the whole system for the entire deployment period. Two units were deployed on Ashokan Reservoir, one on the east basin and one on the west basin in the vicinity of the Catskill Aqueduct intake on each basin. The units monitored turbidity, temperature and specific conductivity at two fixed depth positions on an hourly basis. To conserve battery power, the cell modem is programmed for a 10 minute data transmission window per day. Data collected during this initial deployment will be presented as well as lessons learned during deployment and retrieval.

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Distribution, Density and Movements of Non-Breeding Golden Eagles in the Catskills

Margaret DiBenedetto, Thomas Salo, Delaware-Otsego Audubon Society; Todd Katzner, Division of Forestry & Natural Resources, West Virginia University

Golden eagles, which once bred in upstate New York, are now exclusively winter visitors to the region. These birds breed in Quebec and Labrador and migrate through and winter in New York, including the Catskills. However, little is known about their winter distribution, density and movements. To address this lack of knowledge, we (a) evaluated hawk count data to characterize the number that pass through New York; (b) established a camera trapping program of 17 sites to gain insight to their regional distribution and density; and (c) used GPS telemetry to track their local movements (n = 3).

On average, ~203 golden eagles are counted each autumn at New York hawk counts. We therefore estimate that at least 800-1000 golden eagles migrate through New York each spring and fall. Over a 3-year period, golden eagles were detected at 11 of 17 camera trap sites in four New York counties (Delaware, Madison, Orange and Otsego). The sites with the most frequent detections were in Delaware and Otsego Counties. One of the three golden eagles we tracked in 2014 was likely killed by lead poisoning from consuming a lead-contaminated (lead-shot) carcass. The two others moved as far as 30 km from the trap site and used predominantly forested habitats over the period before they began northbound migration.

Our ongoing work highlights several key points about golden eagles in upstate New York and the Catskills region. First, there are more birds moving through and wintering in this region than was previously recognized, and their distribution is broader than expected. Second, many of the habitats they use have the potential to be impacted by renewable and extractive energy development. Finally, more information is needed to successfully manage these birds and to ensure that their New York wintering populations persist.

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Implementing Stormwater Green Infrastructure for Regulatory Compliance in the New York City Water Supply Watershed

John Drake, NYC Department of Environmental Protection

A significant part of the New York City Department of Environmental Protection (DEP)'s water supply protection efforts is achieved through a regulatory program that focuses on managing stormwater runoff from land disturbance activities undertaken in its watershed. Management of stormwater runoff generated by such activities is achieved through the review, approval, and implementation of a Stormwater Pollution Prevention Plan (SWPPP), as required by the Rules and Regulations for the Protection from Contamination, Degradation and Pollution of the New York City Water Supply and its Sources (Watershed Regulations). In April, 2010, DEP adopted newer stormwater runoff volume reduction requirements and green infrastructure design standards into the Watershed Regulations. Runoff volume reduction is achieved through implementation of green infrastructure practices that are based on these design standards. The green infrastructure design standards include a wide array of distributed controls that utilize infiltration, canopy interception, evaporation, transpiration, rainwater harvesting and reuse, and extended filtration that are intended to reduce or eliminate the need for traditional collection, conveyance, and detention structures.

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Intended and Unintended Consequences of Collection System Rehabilitation: One Experience

James Fitzsimmons, Matthew Burd, NYC Department of Environmental Protection

Unintended consequences are a challenge to planners in wastewater operations as elsewhere; this presentation will provide a real-life example. We will review needs that drove the project: severe inflow and infiltration in a sewer collection system over 80 years old, threatening compliance with permitted limits. We will present the reader a brief overview of the system, then escort the reader through the project timeline to the consultant's recommendations, re-visit how the recommendations were re-written by operational staff for a very different final design, walk through construction of Phase 1 via an accelerated "Job Order" contract process, and review the intended and unintended consequences noted at the end of Phase 1. Our presentation will then update the report with the end of Phase 2, quantifying the unit costs and total cost, quantifying the intended consequence- the flow reductions achieved, and the surprise unintended consequences - wastewater treatment plant effluent warming. We will then describe effluent temperature compliance issues, in-plant temperature mitigations made and considered, and the current outlook for regulatory relief/consequences due to the effluent warming.

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Examining Land-Use Changes and Associated Stormwater Management Design in a Sub-Watershed within the NYC Water Supply East of Hudson Watershed - 1997 to Present

Mary Galasso, P.E., NYC Department of Environmental Protection

The drivers behind development or urbanization are diverse and are dependent not only on the physical characteristics of a particular sub-watershed but also on the economic needs of a community and/or zoning that may vary across political boundaries. This presentation will examine land-use changes within a single sub-watershed in the New York City Water Supply's East of Hudson watershed over the course of 18 years beginning in 1997 at which time DEP's stormwater regulations were initially promulgated. A discussion of the topographic, hydrologic, geologic and land cover characteristics of the sub-watershed will be provided. Stormwater management concepts that preceded the subject time period will be discussed as well as the transformation of stormwater design philosophy and regulatory requirements through the time period and their associated impact on development trends. The presentation will include an overview of the nature and density of development, increases in impervious cover, changes in types of pervious cover, and the stormwater management practices that have been implemented to control water quantity and protect water quality in the sub-watershed throughout the time period.

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Trends of Chlorophyll and Phytoplankton for New York City's West of Hudson Reservoirs (1988-2014)

Ray Homolac, Lorraine Janus, Ph.D., Kerri Alderisio, NYC Department of Environmental Protection

The New York City Department of Environmental Protection (DEP) performs limnology surveys on most of the water supply reservoirs on a monthly basis, weather permitting, and many water quality monitoring parameters are analyzed. The historical record of DEP data will be examined for long term trends of chlorophyll a and total phytoplankton in the Catskill/Delaware System reservoirs. The reservoirs examined include Neversink, Cannonsville, Pepacton, Rondout, Schoharie, and Ashokan. An overview will be provided for the time period covering 1988 through 2014, including a more in depth focus for the period of 2004 through 2014 when analytical testing methods remained unchanged. Various plots will be presented including the temporal levels of chlorophyll and phytoplankton, boxplots by month and year, ratios of aerial standard units (ASU) to chlorophyll, and correlations between ASU and chlorophyll. The trophic state for each reservoir will also be included. Additionally, a description of the types of phytoplankton that occur at peak chlorophyll levels in the reservoirs will be discussed.

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Recent Advancements in Ground Penetrating Radar Technology Offer Possibilities for Affordable Non-Contact SWE Measurements

Glenn Horton, Francis Huber, NYC Department of Environmental Protection; Robert S. Horton, Independent Contractor, Allan Frei, Ph.D., City University of New York

The New York City Bureau of Water Supply has been monitoring snow pack in its 2000+ sq. mi. reservoir watershed for decades manually. These snow surveys are conducted biweekly due to the amount of labor involved, but the regular accumulation-melt cycles common in New York often require more frequent data for maximum usefulness. NYC has begun investigating remote monitoring through non-contact instrumentation to establish Snow-Water Equivelant (SWE) data for winter reservoir management. Recent developments in Ground Penetrating Radar (GPR) technology may provide a cost effective method of measuring SWE.

The 2014-15 winter season has offered a chance to field test the Novelda NVA6100 Series radar instrument in NYC's drinking watershed. The complexity of this year's eastern winter has allowed the instrument to be tested in a variety of environmental conditions. Preliminary results suggest using this new technology in GPR, accurate SWE measurements can be obtained through economical non-contact methods

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Extreme Hydrological Event Forecasting and NYC Operations Support Tool

Adao Matonse, Ph.D., James Porter, Ph.D., NYC Department of Environmental Protection; Allan Frei, Ph.D., City University of New York

A number of reports have addressed the frequency and intensities of extreme hydrological events across the continental US (e.g. NECIA, 2006; Melillo et al. 2014). In the northeastern US studies have indicated an increase in the frequency of extremely large precipitation and streamflow events during the most recent decades (Kunkel et al., 2013; Walsh et al., 2014; Matonse and Frei, 2013).

For the NYC water supply, operating under changing patterns of extreme events represents an elevated challenge because of the impact on water quality and other risks associated with flood damage. To address the situation and support water supply decision process NYC has developed the Operations Support Toll (OST). OST combines a water supply systems model with a number of reservoir water quality models, data base management and an ensemble hydrological forecast.

During this presentation we show results of extreme events study over the NYC water supply region and illustrate how the availability of an ensemble forecast in OST is impacting system operations and helping to reduce risks associated with floods and droughts.

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Best Management Practices and their Impact on Turbidity in Stony Clove Creek

James Mayfield, Karen Moore, Ph.D., Danyelle Davis, NYC Department of Environmental Protection

Stony Clove Creek is the largest tributary to the upper Esopus Creek, and has been identified in previous studies as the predominant source for turbidity and suspended sediment loading in the New York City Department or Environmental Protection (DEP) Ashokan Reservoir basin. The Stony Clove Creek Management Plan (2004) identified the segment of Stony Clove Creek in Chichester as a priority reach of stream for remediation to address significant instabilities and chronic suspended sediment loading. Four best management practices (BMPs) were designed and installed on this reach in an effort to reduce the sediment and turbidity originating from here. A water quality monitoring program in conjunction with a channel morphology monitoring program has also been conducted in an effort to assess the effectiveness of these practices. The purpose of the water quality sampling is to estimate the suspended sediment and turbidity loading from areas upstream and downstream of the BMPs, before and after BMP implementation. Sampling consisted of monthly grab samples supplemented with storm event sampling. In addition, in situ turbidity probes were installed to help gather additional data. Sampling began prior to the installation of the BMPs. The data collected to date by DEP will be examined along with data collected by USGS to quantify the effects of BMPs on turbidity

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Exploration and Evaluation of Long-Term Water Quality Data

Karen Moore, Ph.D., James Mayfield, Richard Van Dreason, NYC Department of Environmental Protection

An important goal in watershed protection is to document changes in water quality and look for linkages to what is occurring on the landscape. New York City Environmental

Protection has monitored water quality in its water supply watersheds for more than 25 years to ensure that water quality is of the highest quality. Considerable investment in watershed protection programs has been made to protect this valuable resource that provides drinking water to over 9 million consumers. Assessment of the wealth of long-term data is ongoing as the record builds over time. We applied statistical methods including Weighted Regressions for Time, Discharge, and Season (WRTDS) to the major inflows of West of Hudson reservoirs to look at water quality changes and corresponding explanatory variables related to land management, climatic and hydrological conditions. Examples of trends and patterns in nutrients and other inputs, as well as flows, from the watershed to the reservoir system will be discussed.

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Denitrifying Bioreactors Reduction of Agricultural Nitrogen Pollution at the Watershed Scale

Chelsea Morris, Will Pluer, Larry Geohring, Cornell University

Denitrifying bioreactors (DNBRs) have the potential to reduce nitrogen (N) loading to streams in agricultural watersheds. By passing the nitrate-rich waters of tile-drained fields through a system engineered for denitrification, the total loading of N is reduced before entering sensitive aquatic ecosystems. This project characterizes the biophysical and farm management impacts on N removal in these reactors using high frequency sampling over a growing season. N removal rates from the experimental data are applied in a scenario analysis of a New York State watershed with multiple DNBRs to project aggregate N reduction potential. Results may assist management efforts in heavily agricultural areas where increased nitrogen mitigation is expected.

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Giardia Concentrations in New York City's West of Hudson Streams and Reservoirs: Catskill Watershed Case Study

Christian Pace, Kerri A. Alderisio, NYC Department of Environmental Protection

The New York City Environmental Protection (DEP) has monitored Giardia concentrations throughout the New York City watershed for the better part of the last two decades and has been consistent with the sampling and analytical procedure, Method 1623HV, since 2002. During this period, DEP has shown a reduction of Giardia concentrations as water flows from sites upstream in the watershed to the outlets of the six West-of-Hudson (WOH) reservoirs. Additionally, since approximately 2005, the four Delaware System reservoir outlets have shown a downward trend (year-to-year) in Giardia concentrations, despite an increase in the Giardia concentrations found at some upstream sites.

The Catskill System reservoirs, Schoharie and Ashokan, have not shown a clear trend in protozoan concentrations at the outlets, with Schoharie generally having the highest mean annual Giardia concentrations of the WOH reservoirs. Stream sites upstream of Schoharie Reservoir (S4, S5i and S7i) have been sampled monthly for the last several years and consistently results have shown elevated Giardia levels. Sites were selected upstream of S7i in attempt to identify sources of these pathogens and DEP has made considerable progress with this objective. Sampling sites have been geographically repositioned a number of times as the list of potential sources has been refined. Downstream of Schoharie Reservoir within the Catskill System, Giardia concentrations were markedly lower after leaving Ashokan Reservoir as measured at the influent to Kensico Reservoir.

DEP has built a large dataset of over 2800 protozoan samples, collected from WOH streams (n=1453) and reservoir outlet sites (n=1370) over the past 13 years. This presentation will summarize this data and illustrate the Giardia reduction as water travels down through the watersheds and from reservoir to reservoir. Specific attention will be paid to the Schoharie watershed where additional sites have been selected and sampled over the last few years.

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The Operations Support Tool (OST) with HEFS Forecasts: Recent Use Cases

James H. Porter, Ph.D., NYC Department of Environmental Protection

The New York City Department of Environmental Protection (NYCDEP) operates the City's water supply system, providing more than one billion gallons of high quality water each day to more than nine million residents in the City and in several outside communities. The water is delivered via aqueducts from a 2,000 square mile watershed that extends more than 125 miles from the city. The system is comprised of 19 reservoirs and three controlled lakes with a total capacity of over 580 billion gallons. Managing such a complex system in an increasingly stringent regulatory environment and under a changing climate requires cuttingedge scientific tools. To meet this need, NYC worked with a team of consultants and expanded on its existing partnership with the National Weather Service (NWS) to build a decision support system known as the Operations Support Tool (OST). One of the keys to OST is runoff forecasts derived from the NWS Hydrologic Ensemble Forecast Service (HEFS). HEFS is new system which ingests meteorological forecasts and current snowpack data to produce a set (called an "ensemble") of runoff forecasts. These runoff forecasts are input to OST to predict reservoir conditions in the future, allowing water supply managers to model potential operations a priori and assess the probability of resulting outcomes. This talk will present data from 2015, including the use of OST to balance spring refill, conditional season storage objectives, and potential drought conditions during a spring that had both a large snowpack and an extended period of below normal precipitation.

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The Floristic Composition of the Phytoplankton within New Croton Reservoir, New York: Implications for Water Quality Management

Michael Principe, Ph.D., HDR Engineering

The spatial heterogeneity and temporal variability of phytoplankton floristic composition was studied in New Croton Reservoir, NY, initially from 1984-1987, and more intensively during 1988. The reservoir exhibited the same classic pattern of phytoplankton succession during both the 1984-1987, and the 1988 study periods, as that observed in most northern temperate mesotrophic-eutrophic lakes. Diatoms predominated in the spring and fall, whereas Cyanobacteria occurred in great numbers during the late summer.

Reservoir hydraulic residence time and volume appeared to affect floristic composition. Growing season (July-October) reservoir volume and hydraulic residence time were positively correlated with the abundance of cyanobacteria, as well as the abundance of Chlorophyta. The rapid 1985 summer flushing rate that occurred during a drought period may have inhibited the usual proliferation of slow-growing cyanobacteria within the reservoir. In contrast, the longer 1988 summer hydraulic residence time may have led to the more pronounced presence of Cyanobacteria and overall phytoplankton abundance observed during that period.

Findings from the study suggested that when studying phytoplankton dynamics it was not only important to consider reservoir nutrient dynamics, hydraulic residence time effects, and light and temperature variations, but it was also essential to examine the individual ecological characteristics of the dominant phytoplankton. In addition, study results suggested that in order to achieve optimum quality within the diversion to the Croton Aqueduct, the formulation of an effective water quality management program should consider the selection of an ideal aqueduct intake location, both horizontally and vertically based upon water quality conditions and the regulation of growing season hydraulic residence time.

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Development of a Watershed Timeline to Chronicle Historical Events for Potential Contribution to Changes in Water Quality

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There are many natural events that can affect a watershed, and the quality of the water, that may require a change in the operation of a water supply. With this in mind, a New York City Watershed Event Timeline ("Timeline") was developed to ascertain "cause and effect" relationships by linking significant environmental events (e.g. droughts and hurricanes) within the New York City Department of Environmental Protection (DEP) watersheds to water quality variations. Moreover, the effects these events have on DEP operations and infrastructure (*e.g.* alum treatment, wastewater treatment plant operations, intensified monitoring) can be related for planning purposes. This timeline portrays information from 1985 to the present, and will continue to be a "living document" that can be updated as needed with more information, and new parameter headings that directly relate to other aspects of water supply operation. Criteria for determining what would be considered significant events in the watershed had to be defined and that process will be discussed. Current events within the timeline include, as examples, system-wide droughts, floods, hurricanes, turbidity events, and chemical treatments.

The information included in the timeline can be used by DEP Bureau of Water Supply employees as "history at a glance" to which their own operations work or water quality observations can be linked. The potential of future work on the timeline will be discussed.

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Hydrilla, an Invasive Aquatic Plant with Potential to Disrupt Water Supply Activities

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In the fall of 2014, an infestation of the invasive aquatic plant Hydrilla verticillata, or hydrilla, was discovered in the New Croton Reservoir by a multi-agency group of experts reviewing the plant's extent in the Croton River below the dam. It had been detected downstream the previous year near the Hudson River and survey efforts were underway to determine how far it had spread. With the detection of the plant in the reservoir, the infested area now included a drinking water supply, bald eagle habitat, rare plant habitat and estuarine conditions, all of which pose unique challenges to management.

While aquatic plants are generally beneficial to aquatic ecosystems, providing habitat for fish, helping to oxygenate the water and providing substrate for the settling out of sediments, hydrilla, is not your average aquatic plant. It crowds out other native plants and breaks apart easily, allowing the plant to spread and clogging water intakes with fragments. It can change water chemistry and in advanced infestations it can even make waterways impassable to boats. In the last seven years it has been detected in a handful of New York's waterways, including the New Croton Reservoir.

New York State Department of Environmental Conservation and New York City Department of Environmental Protection are working together to respond appropriately to this infestation. Short-term and long-term strategies have been established to efficiently manage the threat posed by hydrilla. This effort presents an excellent case study for future response efforts to hydrilla in other systems or new introductions of other harmful invasive species.

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A Transition to Resource Recovery Facility through the installation of Enhanced Primary Treatment

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It is now clear that the path forward for the wastewater industry to achieve its ambitions of energy independence, resiliency and resource recovery is to capture the majority of the organics in the primary treatment stage thus producing a number of benefits, the two most significant being a decrease in energy consumption and an increase in energy production. By removing the organics in the primary stage, it reduces the aeration energy required in secondary treatment while also yielding a primary sludge with greater biogas potential when fed to an anaerobic digester.

Conventional primary treatment consists of screening, grit removal, primary clarification and flow equalization, all performed in separate pieces of equipment and infrastructure, in the end only removing approximately 33% of the organics entering the plant. The ClearCove Harvester technology is an innovative solution that combines all of the aforementioned capabilities into one tank while delivering superior organic and inorganic solids removal and separation. The sludge captured in the Harvester is sent to another propriety technology known as the Classifier. The Classifier "cleans" and conditions the sludge to provide a trash-free, highly organic fuel to the anaerobic digester.

A facility in upstate New York will be installing the Clear Cove Harvester and Classifier technologies with the goal of transforming into a resource recovery facility and renewable energy hub. The facility will also be importing waste from food processors, smaller wastewater treatment facilities, and other generators of organic waste nearby. This presentation will cover an overview of the Harvester and Classifier technologies, the full-scale design of the system, and the plant wide implications of its installation. Pilot data from a NYSERDA-funded demonstration project in Ithaca. NY will be presented to communicate the performance of the technology in terms of its removal capabilities and its impacts on the energy balance of the facility.

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