COMPENDIUM OF ABSTRACTS

September 15–16

2010 Watershed Science and Technical Conference

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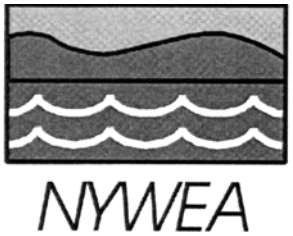

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INTRODUCTION AND ACKNOWLEDGMENTS

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 nations largest unfiltered surface water supply.

Each year, this conference showcases the most current trends, technologies and scientific developments in the arena of watershed protection and management. Usually, in response to our Call for Abstracts a dominant theme appears, reflecting the newest concern, a technological breakthrough, or the latest shifts regulatory tone and reach. Last year for example, Climate Change was the topic thread woven throughout our two day discussions.

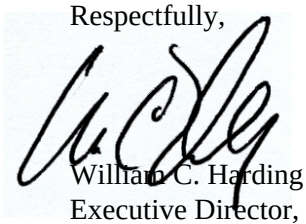
This year, while the traditional offering of cutting edge information continues, a primary theme is decidedly absent. Instead, the conference punctuates the multiple longstanding themes that remain central to the business of caring for a watershed:

- Stormwater control,
- Wastewater treatment,
- Stream health,
- Emerging contaminants and microconstituents,
- Monitoring and modeling,
- Pathogens, nutrients, and turbidity,
- Recreational use, forestry, agriculture,
- and more.

We work together on these issues every day, and we've talked about them at conferences past, so we thought it opportune to 'circle back' and update our attendees on the newest findings and accomplishments in areas that are the 'ways and means' of watershed stewardship.

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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Are Coliform Bacteria Good Indicators of Pathogen Occurrence in NYC Source Water?

Kerri Ann Alderisio, NYC Department of Environmental Protection

Indicators should have certain characteristics that allow them to be able to predict the occurrence of the target organism - in this case, pathogens. Ideally, pathogenic indicators should: be easily and rapidly identified and enumerated, be relatively inexpensive to test, have a survival rate relatively similar to the target pathogen, be present in higher concentrations than the pathogen, and show a reasonably strong correlation of presence and absence relative to the pathogen in question.

Source water for the New York City Environmental Protection is tested daily for total and fecal coliform indicator bacteria at the effluents of Kensico Reservoir as per the Filtration Avoidance Determination (FAD) and Surface Water Treatment Rule (SWTR). Additionally, the recent Long Term 2 Enhanced Surface Water Treatment Rule (LT2) requires large systems to monitor for Cryptosporidium and for filtered systems to also monitor for Escherichia coli (and turbidity). Moreover, small systems are required to monitor for E. coli as an indicator to trigger Cryptosporidium monitoring. E. coli triggers for initiating Cryptosporidium sampling on small systems were set at 10/100ml for reservoirs and 50/100ml for streams.

Protozoan samples are collected weekly form the source water effluent sites on the same day that total and fecal coliform bacteria are sampled. Data from these weekly protozoan surveys were examined with the same day bacteriological results to determine if the characteristics for a good indicator applied. Many of the guidelines did apply; however, while coliform bacteria often occurred at times the pathogens were present, unfortunately the indicators also occurred at approximately the same rate when the pathogens were not present. While perhaps not the best indicator of background levels of pathogens, coliform bacteria, particularly E. coli, remain one of the more practical indicators of fecal pollution, especially if there is an acute and recent insult to the water supply.

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Comparison of Two Change Factor Methodologies over West of Hudson (WOH) Catskill Mountain Watersheds

Anandhi Aavudai, Ph.D. and Allan Frei, CUNY Institute for Sustainable Cities and Donald Pierson, Ph.D. and David Lounsbury, NYC Department of Environmental Protection

Meteorological time series derived from Global Climate Model (GCM) simulations are used to evaluate the effects of climate change on the NYC water supply. The use of GCM simulated data is limited by the mismatch of spatial scales between GCMs on the one hand, and local observations and local impact assessments on the other hand. A number of techniques have been employed to overcome this problem of mismatched spatial scales. Future climate scenarios have been derived (i) based on analogies with different climatic zones or (ii) from GCMs using simple manipulation of current climate observations (e.g. Change Factor Methodology, or CFM) and (iii) more sophisticated statistical and dynamical downscaling methodologies.
For this study daily GCM simulations are obtained from the World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project phase 3 (CMIP3) multi-model dataset. Two variants of CFM are used to downscale precipitation, air temperature, and wind: data that are used to drive watershed and reservoir models. The first variant calculates average monthly change factors that are subsequently added to local meteorological data on a monthly basis (i.e. a CF of +1.0 C is added to all January air temp data). The second variant rather than calculating a single CF, calculates 25 CFs across the frequency distribution of all January data in the GCM scenario, and then adds the derived 25 monthly change factors to local meteorological data based on each days frequency ranking. This method should allow CFM to more adequately represent future changes in event frequency. The objective of this study is to compare the future climate scenarios of meteorological variables derived using these two variants of CFM.

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Ecosystem Disturbance in Catskill Mountain Streams: Indicators of Climate Change or Coincidence?

Barry Baldigo, M. McHale, D.A. Burns and P.S. Murdoch, US Geological Survey and A.J. Smith, NYS Department of Environmental Conservation

Pristine streams of the Catskill Mountains provide millions of people with high quality drinking water and outstanding recreational opportunities. Aquatic and terrestrial ecosystems within a small number of watersheds in this region have been disturbed to varying degrees, yet most are now faced with multiple threats due to increasing temperatures, changing rates of precipitation, altered timing and magnitude of storm-runoff events, and newly introduced or invasive species. Data from past and current research and monitoring programs suggest that recent trends in water quality, shifts in species assemblages, and the recent blooms of an invasive diatom species, Didymosphenia geminata (didymo), could be indirect responses to declines in forest health. Decreases in pH and increases in nitrate concentration by several magnitudes in soils and surface waters within a Neversink sub-basin following forest harvest demonstrate the nitrogen cycle is strongly disrupted when vegetation is removed (forest production is reduced). Increasing trends in nitrate concentrations and acidity in stream waters of the region correspond with shifts in water quality and in macroinvertebrate communities (from oligotrophic assemblages to eutrophic assemblages) in parts of Upper Esopus Creek. The

didymo bloom, first observed in Upper Esopus Creek during 2009, may also be related to changes in nitrate and phosphorus concentrations in surface waters of the watershed. These water quality and ecosystem changes can theoretically be linked to altered nitrogen cycling, increased tree mortality, and (or) reduced forest heath. It is uncertain whether recent changes in temperatures and precipitation (and the severity and duration of insect defoliations) are primary reasons for changes in forest production (and health) and stream communities; however, it appears that some changes in climatic conditions could be starting to affect ecosystems across the Catskill Mountain Region.

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Is Wastewater Reuse Coming to the "Water Rich" Northeast? The University of Connecticut Evaluates MF / RO / and UV to Solve Its Water Supply Problems

Kristen Barrett, Richard Cisterna and Joyeeta Banerjee, Hazen and Sawyer, P.C.

Wastewater reuse can be an important component of a comprehensive watershed management program and water supply plan. Removing wastewater streams from surface water bodies can reduce pollutant loads to these receiving waters including nutrients, heavy metals, pharmaceuticals and endocrine disrupting compounds. Instead of discharging wastewater to surface water bodies, the wastewater can be treated to a higher level and reused for beneficial purposes. Another important advantage is that wastewater reuse also reduces water demands that potable supplies would otherwise have to satisfy. These benefits of reclaimed water are being strongly considered by a growing number of utilities in the "traditionally water rich" northeast, as water supplies are becoming more stressed. In particular, the University of Connecticut is embarking on a first of its kind water reclamation project for the region.

Due to limited groundwater supply, the University is considering wastewater reuse. Most utilities in the region are not familiar with the concept and are typically steered away due to the lack of: drivers, public education/acceptance, and established regulatory framework. But the University has decided to place wastewater reuse at the forefront of their alternative water supply strategy, as the severity of their water supply limitations becomes clearer.

Three primary reuse applications were identified; low pressure boiler feed, cooling tower makeup water and irrigation for a maximum day demand of 1mgd. Microfiltration was selected based on several criteria, including the need for proper pretreatment for the boiler feed's reverse osmosis system. Ultraviolet light disinfection was evaluated against sodium hypochlorite. UV disinfection was selected using a low pressure / high output in-vessel system.

This presentation will describe the water supply issues and institutional challenges that the University faces and will present the details of the technical evaluation and design of the microfiltration, reverse osmosis, UV disinfection and ancillary systems.

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Occurrence of Cyanobacteria Toxins in New York State - The Facts Behind the Headlines

Gregory Boyer, SUNY College of Environmental Science and Forestry

In addition to taste and odor issues, cyanobacteria produce a number of bioactive compounds including hepatotoxins such as microcystins, neurotoxins such as anatoxin-a, and dermatoxins such as lyngbyatoxins. When these toxins occur in a public water body, the public outcry is often swift and vocal, especially when animal fatalities are involved. However not all species of cyanobacteria are toxic, and even toxic species have both toxic and non-toxic variants. Here we describe the results from several major projects on the occurrence and distribution of cyanobacterial toxins in both large and small water bodies in and near New York State. Emphasis is on the water bodies such as the great Lakes that serve as drinking water sources. These studies have shown that hepatotoxic microcystins are the most common in NYS, with detectable levels of toxin being found in more than 50% of the samples tested. However much fewer of these samples (ca 14%) exceeded the WHO guidelines for drinking water exposure. Other toxins, while significant when they occur, are extremely rare in most waterbodies. There are a large number of different techniques available to measure for cyanobacterial toxins, however not all are appropriate for routine monitoring. A simple tier-based monitoring strategy will be presented as well as critical discussion of what a positive sample means from a public health standpoint. Both chemical and modern molecular techniques will be integrated in an effort to put the risk from exposure to cyanobacteria toxins in proper context.

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How is Forest Harvesting Intensity Related to Water Quality in the Catskill Mountains?

Douglas Burns, Ph.D., Jason Siemion and Peter Murdoch, US Geological Survey and Rene Germain, SUNY College of Environmental Science and Forestry

Stream and rivers draining forested land cover generally have better water quality than those within human-disturbed land

cover such as that of urban/suburban and agricultural land uses, yet previous research in the Catskills has shown that forest clearcutting can greatly degrade water quality for a period of two to three years after harvesting. Given the observed water quality effects of clearcutting, we studied the effects of more modest forest harvests that removed 22%, 28%, and 68% of basal area in harvest blocks within the Frost Valley Model Forest. These forests were cut during 2005-06, and stream water, soil water, and soils were sampled during pre- and post-harvest periods to evaluate the effects of these harvests. Increases in nitrate concentrations in streams, soil water, and soils were evident within a few months after completion of all three harvests. Additionally, increases in calcium and aluminum concentrations were observed in stream water and soil water in the harvest blocks. Two general conclusions can be drawn from this study: (1) recovery of water quality to background levels was more rapid as the harvesting removal rate decreased, and (2) the relation between harvesting intensity and the extent of alteration of water and soil quality changed with harvesting intensity. These results suggest a threshold of harvesting below which changes in the water quality indicators measured here are more gradual, and above which the relation steepens. The harvesting intensity at which this threshold occurred in the current study varied with the water quality constituent considered, and was less than 68% for nitrate, but greater than 68% for calcium and aluminum. The applicability of these results beyond the forest blocks we studied is uncertain, but changes in water quality that resulted from forest harvesting did not vary linearly with the intensity of tree removal in this Catskill forest.

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Silver Nanotechnology Unregulated Emerging Contaminants: Bioaccumulation, Toxicity and Genotoxicity Effect in Exposed Aquatic Organisms

Allen Clayton, Rachel Serafin, Chau Quach and Zofia Gagnon, Marist College

The use of nanotechnology has become widespread in commercial, industrial, and medical applications. However, the very property that makes nanoparticles desirable, their high level of reactivity, raises concerns that they may also pose risks to the environment and human health. Silver nanoparticles are proven to be very effective bacterial filters; however, the qualities that make them such effective filtering agents could also cause them to negatively affect waterways and living organisms. Presently, there are no laws regulating the use of nanoparticles. We hope that with our results, steps can be taken to implement regulations on these particles until more research can be done to show their health and environmental effects. Therefore, the purpose of this project is to consider the effect of silver nanoparticles (AgNPs) on an animal model. Crayfish (Orconectes virilis) were purchased from Northeastern Aquatics in Rhinebeck, NY. The organisms were exposed to different concentrations of AgNP: 0.0, 5.0, 10.0, 15.0 and 20.0 ppm. At the end of the exposure period, the crayfish were harvested and examined for pathological changes and Ag accumulation levels using atomic absrption spectrometry. DNA and oxidative damage were also investigated. The exposure to AgNPs had multiple effects on the crayfish. Our results demonstrate that there was significant bioaccumulation of Ag in the crayfish tissue. An effect on DNA was also documented. In our controlled experimental environment, bioaccumulation of AgNPs in tissues and repeatable results suggest that the DNA damage was the effect of the exposure to AgNPs. The results raise concern about the impact of AgNPs on the environment and human health.

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Microconstituents-Why All the Concern and How They Can Be Controlled and Treated?

Joseph Cleary, HydroQual, Inc.

Microconstituents are a group of compounds being evaluated by the Water Environment Federation's (WEF) Community of Practice and other organizations and researchers. Endocrine Disruptor Compounds (EDCs) are a sub-group of Microconstituents that include groups of compounds such as human and veterinary drugs, pesticides and industrial chemicals. Only some of the compounds in these groups are EDCs. EDCs include naturally occurring and synthetic steroid hormones, organohalides, metals, alkylphenols, polynuclear aromatic hydrocarbons, crude oil and plasticizers. These compounds may interfere with hormone processes in both humans and wildlife. EDCs are being detected more in the environment in water, wastewater and biosolids as more studies are done and analytical techniques have progressed. The WEF Microconstituents Community of Practice has developed "Technical Practice Updates" on various topics of Microconstituents including one on wastewater treatment and another in development on water treatment.

Microconstituents are a concern and have gotten more attention in recent years based on the following:

- Better analytical methods are finding Microconstituents in numerous receiving waters
- Feminized fish discovered in Europe in mid 1990s
- Steroids are implicated in Europe in late 1990s
- Treatment studies on POTWs (2002-2003) show POTWs are a collection point and one source to receiving waters
- USGS study of 139 streams in 2002 detected pharmaceuticals in 80% of samples
- Trend towards water conservation and reuse in both private and public sectors resulting in higher concentrations and potential for Microconstituents in reuse water.
- More media coverage & public awareness and concerns.

A review by the World Health Organization has concluded that low-level environmental exposure to Endocrine Disruptors has not yet been demonstrated to cause harm to human health (Damstra et al., 2002). Uptake of Endocrine Disruptors by humans from treated drinking water is relatively low in comparison to other sources such as food (GWRC, 2003).

This presentation will discuss Microconstituents and what is included. The physical and chemical properties and structures of these Microconstituents and EDC compounds that determine the treatment removal mechanisms and applicable treatment technologies are presented. An approach for evaluating and developing wastewater treatment solutions will be discussed. The approach includes a combination of bench-scale and pilot-scale treatability studies which are used to test treatment processes prior to design and the use of process modeling tools which are used to predict removals through treatment processes. Treatability testing case studies are presented along with actual data on removal through municipal and industrial treatment plants.

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Converting a Bowling Alley to Wetlands: Wetland and Stream Restoration in New York City's Water Supply Watershed

Laura Csoboth and John Roebig, HDR, Inc. and Jose Nieves and Maria G. Mandarino, P.E., NYC Department of Environmental Protection

The New York City Department of Environmental Protection (DEP) is responsible for operating, maintaining, and protecting the City's water supply. This is in part provided through land acquisitions that ensure continued protection and re-naturalization of land within the City's water supply watershed.

The DEP recently purchased a former bowling alley located on almost 7 acres of land within the Kensico Reservoir watershed in Westchester County, New York. Historically, the property was undeveloped agricultural land that was constructed into a bowling alley in the 1960s. Prior to this development, a major tributary of the Kensico Reservoir flowed through the site and nearby wetlands are depicted on historic maps. However, over time, the stream was channelized and re-routed several times and is currently conveyed through a ditch that makes three 90-degree turns around a three-acre parking lot.

To create additional wetland habitat in the watershed, DEP will remove the condemned bowling alley building and parking lot. The stream would be restored to its historic location by meandering through almost three acres of created floodplain forest and tussock-sedge wetland habitat. Upland areas surrounding the wetland would be planted with meadow grasses and wildflowers. The design is based on reference data gathered from an upstream reach of the tributary, located within the Betsy Sluder Nature Preserve. The morphological reference data was extrapolated to restore the relocated stream to its historic location and create a natural, stable stream configuration. Designs based on reference stream and wetland morphological data typically provide sustainable and self-maintaining ecosystems.

This project will be constructed along-side other created wetlands in the watershed, creating a large, hydrologically connected wetland complex. These combined wetland sites will create and restore wetland habitats and provide significant water quality benefits within the Kensico watershed and increase local vegetative and wildlife diversity.

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Identifying High Septic Density Areas in the Wappinger Creek Watershed

Neil Curri, Cornell Cooperative Extension Dutchess County and Russell Urban-Mead, Chazen Companies and Celine Teo Ying Zhen, Vassar College

Aquifer recharge supports groundwater supplies critical to the reliability of public water system and individual domestic wells, the adequate dilution of wastewater discharges from septic systems, and aquifer base flow contributions to streams. In Dutchess County, New York, aquifer recharge rates were correlated with hydrologic soil groups by The Chazen Companies, consultants to Dutchess County. These rates can be readily mapped using the Natural Resource Conservation Services' Soil Survey Geographic (SSURGO) database. To ensure that private septic systems do not exceed the aquifer recharge capacity required to dilute wastewater discharges, minimum average parcel sizes were recommended for each hydrologic soil group, varying across the county with average annual rainfall. Geographic Information Systems can be used to identify parcels whose areas fall below the recommended minimum average parcel sizes. The purpose of this study was to identify parcel clusters in the Wappinger Creek watershed in Dutchess County, New York with private septic systems below recommended minimum average sizes. Such clusters may be areas or neighborhoods where the density of septic systems servicing those parcels could be impacting local wells and the local aquifer. We used the Wappinger Creek watershed as our study area for two reasons. First, surface water areas downgradient from clusters of undersized parcels could potentially be sampled during low-flow periods to identify whether aquifer base flow entering streams near undersized parcel clusters contains measurable nutrients and other pollutants associated with septic discharges. Second, we want to encourage local leaders to approach water resource management issues from the perspective of the natural boundaries (e.g. watershed scale) in addition to considering political boundaries. Our goal is to provide recommendations to the municipalities in the Wappinger Creek watershed and members of the Wappinger Creek watershed Intermunicipal Council about where to target education on maintaining and limiting septic systems densities

as well as targeting possible sampling and contaminant mitigation efforts.

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Geologic Investigations Supporting Stream Management Strategies in the Ashokan Reservoir Watershed: A Status Report

Dan Davis, NYC Department of Environmental Protection and Andrew Kozlowski, Ph.D., US Geological Survey and John Rayburn, Ph.D., SUNY New Paltz and Cory Ritz, Ulster County Soil and Water Conservation District

The Ashokan Watershed Stream Management Program (AWSMP) is developing targeted stream management strategies to address hazards from flooding and stream erosion, improve stream corridor ecologic integrity and, to the extent possible, reduce turbidity. The highest priority water quality concern in the Ashokan Watershed is turbidity caused by suspended sediment. The suspended sediment sources are heterogeneously distributed across the watershed from the reach to sub-basin scale. Available water quality data shows that the Stony Clove Creek watershed, and in particular its lower half, is the current predominant source of chronic turbidity in the Ashokan Watershed stream network. The AWSMP Action Plan includes plans to remediate the dominant loading stream reaches in the Stony Clove Creek watershed that contribute to sustained turbidity levels. Understanding the distribution of geologic sources in the watershed will be vital to successful management in this watershed.

The AWSMP, NYS Geological Survey and the SUNY New Paltz Research Experience for Undergraduates program are coordinating on investigations in the Ashokan Watershed into stream channel and landscape geomorphic and geologic conditions that influence stream flow turbidity from suspended sediment. At the last glacial maximum the Catskill Mountains were completely covered by the Laurentide Ice Sheet. The basal till deposited under the ice sheet is typically very clay and silt rich since its source is mostly Paleozoic shales and sandstones. During deglaciation, ice contact lakes in the ice-free valleys received sediment laden meltwater that yielded variably thick laminated silt and clay deposits (varves). These deposits are the primary in situ source of suspended sediment in Catskill Mountain streams. Geologists are coordinating on a mapping effort led by NYSGS to improve the state of knowledge on the glacial and post-glacial surficial geology of the Esopus Creek watershed. Ongoing geomorphic stream and landscape assessments, drilling, GPR surveys, and interpretation of varved lake sediments and other glacial geomorphic features are being used to develop a conceptual model of geologic conditions that can inform management strategies targeted to reduce turbidity in the Esopus Creek watershed. An improved, three-dimensional conceptual model of the suspended sediment sources distribution can be used to inform sediment entrainment and transport modeling assumptions, target water quality monitoring, and identify and prioritize future stream remediation projects.

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Addressing Invasive Species in the NYC Watersheds: The Invasive Species Working Group

Barbara Dibeler, NYC Department of Environmental Protection

The aquatic and terrestrial ecosystems of the New York City watersheds are vulnerable to to a number of invasive species that have the potential to cause costly ecological and economic impacts on water supply lands, infrastructure and water quality. DEP currently does not have a comprehensive, coordinated program in place to address these threats. DEP has formed an Invasive Species Working Group (ISWG) to develop a proactive and comprehensive plan that emphasizes early detection/rapid response, prevention of introductions to water supply lands and reservoirs, control of existing invasives and outreach and education, The ISWG is charged with developing and making recommendations for an invasive species plan and policy.

By leveraging the knowledge and experience from groups throughout the Bureau of Water Supply and coordinating and building upon work being done by our watershed partners, the ISWG is working on developing set of recommendations to minimize the threat and impact of invasive species. The ISWG is generating a list of priority species by developing risk assessments based on water quality impacts and ecological characteristics and analyzing species based on the assessments. An early detection and rapid response plan will be drafted by the group to include comprehensive monitoring for aquatic invasives. The outcome of the priority list and the early detection/rapid response plan will serve as a basis for recommendations regarding the need for targeted actions, internal policies and procedures that lessen the likelihood of introduction and spread of invasive species; set up a monitoring program to detect invasive species; provide for response capabilities to manage incipient populations and the allocation of resources required to implement the management plan.

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Hormones, Pharmaceutical Compounds, and Estrogenicity of Wastewater Effluents from Different Treatment-Plant Types in New York State

Anne Ernst, Patrick J. Phillips and Barry P. Baldigo, US Geological Survey

Almost 1,900 public, private, and commercial wastewater treatment plants (WWTPs) are permitted to release their effluents into surface- and ground-waters across New York State. Many natural and synthetic hormones as well as other common organic and inorganic compounds in WWTP effluents can act as estrogenic hormone mimics and alter the endocrine systems of affected fish and wildlife. We characterized estrogenic activity (estrogenicity) as well as the levels of selected hormones, estrogenic compounds (ECs), and pharmaceuticals and personal-care products (PPCPs) seasonally at 7 WWTPs and once at 25 WWTPs in the New York City water-supply watersheds. We assessed relations between estrogenicity and levels of hormones, ECs, and PPCPs, and evaluated the effectiveness of five different treatment-plant types to reduce or remove estrogenicity. Estrogenicity was high at two sites with no or low EC detection, suggesting that hormone analysis alone is not detecting all of the ECs in the water. Treatment type had a large effect on estrogenicity in effluents; trickling filter and aerated lagoon had poor removal, whereas rotating biological contactors, activated sludge, and sequential batch reactors had better removal.

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NYCDEP Forest Management Plan

Fred Gliesing, NYC Department of Environmental Protection and Bruce D. Higgins, USDA Forestry Service

Large forest landowners, including water suppliers, manage their lands through comprehensive forest management plans based on the goals of the landowner and periodic forest inventories. Forest management plans commonly have a 10-20 year planning horizon based on a 10 year inventory cycle. NYCDEP has managed the forest resources on City properties since prior to the construction of the dams and reservoirs. Forest management has been based on site specific inventories, forest stand delineations and foresters' professional knowledge to meet the goals of the Agency. To date, there has not been a comprehensive forest inventory and watershed forest management plan for the New York City water supply. In 2009, NYCDEP initiated a comprehensive forest inventory and planning process in partnership with the USDA Forest Service with completion scheduled for November 2011. The proposed plan will set a comprehensive direction for how DEP will manage its forest on water supply lands for the long term protection of water quality. The presentation will cover an overview of the initial findings from the inventory, the components of the plan and how it will be used as a planning and management tool.

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Manursing Lake Tidal Gate Replacement and Aquatic Habitat Restoration

Hugh Greechan and Thomas Shay, Woodard & Curran and Sven Hoeger, Creative Habitat Corp.

Manursing Lake is located within Westchester County's Playland Park and adjacent to Edith G. Read Wildlife Sanctuary in Rye, NY. The Tidal Gate Replacement included replacing manually operated tide gates beneath an existing bridge. The bridge structure controls the flow between the Long Island Sound and Manursing Lake. The purpose of the automated system was to improve the tidal exchange while controlling the lake levels to elevations conducive for aquatic habitat restoration and establishment of tidal wetlands and estuarine functions.

The new tidal gate system, which is comprised of motorized, stainless steel slide gates is controlled automatically by a Supervisory Control and Data Acquisition (SCADA) system. The SCADA system receives signals from ultrasonic level transmitters that monitor the water level on either side the gates. The SCADA system is programmed to operate the gates based on specified minimum and maximum water levels within the lake and the actual water level within the Long Island Sound. These levels can be monitored remotely as the water level data is transmitted to a website. The new gate system allows for safer, more efficient operation, and more control of the flows in and out of the lake. Preliminary studies have shown that the new system has potential for significant ecological improvements within the lake.

As a result of increased tidal fluctuation, control of the minimum and maximum water levels, and reshaping of the shoreline, the Aquatic Habitat Restoration included the creation of 4 acres of tidal wetland, grassland, and upland planting areas along 1,200 linear feet of lake shoreline. This new system will create a semi-diurnal cycling of nutrients and oxygen, control and reduce stands of invasive plant species, create colonization for native low and high marsh vegetation, improve areas for fish inhabitance, and maintain and enhance feeding habitat for diving and migratory fowl.

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Assessment of Regional Forest Health and Stream and Soil Chemistry Using a Multi-Scale Approach and New Methods of Remote Sensing Interpretation in the Catskill Mountains of New York

Richard Hallett, Ph.D., USDA Forest Service and Jason Siemion, US Geological Survey and Mary Martin and Lucie Lepine, University of New Hampshire and Jen Pontius, University of Vermont

We have developed a GIS tool that brings together forest canopy chemistry, species, and tree health data layers with soil and stream water chemistry data layers which allows us to create "1st-generation" maps of potential sensitivity to disturbance covering 700,000 acres of lands within watersheds of the NYC water supply in the Catskill Mountains. The methodologies and data layers created in this effort can now be used to aid management decisions and help determine the extent and magnitude of terrestrial and aquatic responses to acidic deposition. The data products derived from this effort have been produced and documented in a way that stakeholders can now use these products for site evaluation as well as to perform more extensive analysis on the suite of readily available GIS and image-based data products. To demonstrate the utility and flexibility of this GIS tool three case studies will be discussed. These case studies focus on questions ranging from the highly practical "Where is sugar maple most susceptible to decline?"; to "Can we predict and map a key streamwater acidification index without sampling a stream?"; and finally can we create and map a theoretical index of "cosystem sensitivity". Ultimately we hope to see this tool deployed on the web allowing land managers and scientists to design their own queries based upon criteria and thresholds that are important to them.

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Pharmaceutical Compounds in the West Point Wastewater Treatment System - Modeling and Analysis

Richard Hoff, United States Military Academy and Shawn Gee, US Army Medical Service Corps and Lynn N. Jones, US Army Infantry

The catchment area of the USMA wastewater system and the potential sewage inputs are well defined. The resident population is nearly 100% military, and their medical care is provided by an on-post medical facility. The management of this facility is also responsible for the issue of over the counter and prescription drugs to all of the resident occupants. By compilation of a year's worth of pharmacological records, a very accurate picture can be drawn of the inventory of drugs that are being introduced into the system and the total mass of each drug. An empirical model was developed that takes into account many factors which influence the proportion of each issued drug that survives the human journey and ends up in the wastewater stream. Human subject surveys were employed to provide estimates of selected model factors. Using ibuprofen as a single model drug, the empirical model was tested by experimental analysis of the wastewater. The predicted concentration in the wastewater was found to be within the same order of magnitude as the experimental value 6 ppb and 12 ppb respectively. This suggests further utility of the model in predicting concentrations of other drugs in the wastewater system. In further work, selected drugs were tracked through the wastewater treatment plant and enumerated in the discharge flow. The treated water empties directly into the Hudson River. The percentages of these drugs which were removed by the treatment process were evaluated.

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Phased Activated Sludge Concept Retrofitted for Compliance with Chesapeake Bay Nutrient Reduction Initiative

Dave Holland, Aqua-Aerobic Systems, Inc.

The AquaPASS® process is a phased approach to the conventional flow through activated sludge process. It is a flow-through, constant-level process with independent basins dedicated to particular tasks.

The first reactor employs anaerobic conditioning of the sludge in order to generate volatile fatty acids to facilitate solublization of bound phosphorus. The anaerobic reactions are stimulated by prior conditioning of the return activated sludge by subsequent phase separator and pre-anoxic reactors.

Flow exits the anaerobic reactor and is equally distributed to staged aeration reactors. In addition to recapturing soluble phosphorous, these basins are also responsible for the bulk of carbon and nitrogen removal. During aeration ammonia will be converted to nitrates. Subsequent periods of anoxic mixing facilitate conversion of nitrates to nitrogen gas. The time-managed environmental control simulates SBR treatment, but in a continuous-flow regime. The flow is then conveyed to final clarifiers for solids liquid separation. The return activated sludge is directed to a Phase Separator

Flow into the phase separator enters an influent trough that directs flow into a baffled compartment towards a compaction region in the lower portion of the basin. A portion of the flow, representing the concentrated sludge, exits to a pre-anoxic reactor. The remainder of the flow, low in solids, exits to the aeration basins. The split is adjustable, but would generally convey 70% to aeration basins, 30% to anoxic basin.

This split reduces the effects of dilution that impairs the efficiency of the anaerobic process. By recycling the biological solids in a concentrated state, the background substrate level in the anaerobic reactor is optimized. The portion of return flow

entering the anoxic basin is void of dissolved oxygen and will possess relatively low concentrations of oxidized nitrogen The supernatant component is effectively processed in the staged aeration basins rather than affecting the anaerobic step.

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A Historical Analysis of Water Quality Data in the NYC Watershed Streams Using the Protocols of the DEC/DEP Memorandum of Understanding

Ray Homolac, NYC Department of Environmental Protection

In September 1997, the New York State Department of Environmental Conservation (NYSDEC) and New York City Environmental Protection (NYCDEP) finalized a Memorandum of Understanding (MOU) governing aspects of enforcement protocols in the NYC water supply watersheds. Addendum E of the MOU describes a series of methods to examine routine stream sampling data collected by NYCDEP to evaluate water quality in the form of an annual report. Examples of analysis done are exceedances of TMDLs, results of non-routine special sampling efforts, and biomonitoring information. The analytes routinely examined by these protocols are fecal and total coliform bacteria, pH, total phosphorus, dissolved oxygen, total ammonia, and nitrate-nitrite. Most water treatment plants in the NYC watershed have been gradually upgraded since the beginning of this monitoring. As a result some marked improvements in water quality have been noted. The number of sites with a mean total phosphorous greater than 50 µg l-1 has decreased from a high of 9 in 1997 to 2 in 2008. This indicates progress in the goal of reducing eutrophication in drinking water supplies. In particular, the Cannonsville Reservoir has improved significantly and is no longer considered impaired. Correspondingly, there has been a reduction in reported algal blooms in the Cannonsville Reservoir. Stream benthic biomonitoring throughout the NYC watershed has shown improvement in that there are no sites with severe or moderate impairment in 2009, which has never been the case since the beginning of monitoring. The number of sites with more than two water quality standard contraventions has been decreasing steadily since 1997. Fecal coliform and total phosphorus have shown a notable improvement in the number of contraventions. However, the number of contraventions increased significantly for pH and slightly for total ammonia and nitrate-nitrite. The number of contraventions remained roughly the same for other analytes.

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Optimization of Anaerobically Digested Dairy Manure Parameters for Phosphorus Recovery

Matt Huchzermeier and Wendong Tao, Ph.D., SUNY College of Environmental Science and Forestry

Recovering phosphorus from wastewater is increasingly used as a treatment technology for removing nutrients from waste streams which are known to cause environmental impacts such as eutrophication. Phosphorus can be recovered from wastewater in the form of a precipitate: magnesium ammonium phosphate hexahydrate (MAP). Also referred to as struvite, precipitated MAP is crystallized and applied as a solid fertilizer for agricultural, residential, and recreational land-use applications due to its slow-release properties. To enhance struvite precipitation and crystallization from wastewater, it usually requires pH-adjustment and supplementation of magnesium ions. Anaerobically digested dairy manure samples were collected from the SUNY Morrisville Dairy Complex and solids were separated through stage filtration. The manure filtrate was found to be rich in ammonium (370-1800 mg/L NH4+-N) and phosphates (93-332 mg/L PO43--P). Several bench-scale tests were conducted to determine optimal pH-adjustment and magnesium amendment parameters specific to anaerobically digested liquid dairy manure. Preliminary results indicate optimum struvite precipitation when ranging pH between 8.50-9.25 and increasing Mg:P molar ratio >4, consistent with literature on struvite precipitation using other waste types. Precipitates were separated by filtration through 1.0µm pore size glass fiber filters and observed under stereoscopic microscope for crystal structure and scanning electron microscope equipped with x-ray for elemental composition. An air-lift pump driven reactor will be used to test the efficacy of struvite crystallization under the optimum pH adjustment and magnesium amendment parameters. By recycling nutrients, recovering phosphorus by struvite precipitation and crystallization offers farmers a more sustainable approach to manure management.

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The History of Algal and Bacterial Blooms and Their Management in NYC Reservoirs

Lorraine Janus, Ph.D., NYC Department of Environmental Protection

The 19 reservoirs that hold NYC's drinking water are surface waters that undergo the same seasonal and weather-related changes as natural lakes. Variations in nutrients, light, temperature, and precipitation through the seasons affect the conditions that lead to occasional increases in bacterial populations and algal blooms. Although these events are relatively rare, it is important for water quality managers to evaluate the causes, extent, and duration of impairment and how these organisms affect water quality. The response must be rapid

and appropriate to mitigate any water quality impairment due to various organisms. This paper will review the history of blooms experienced in the NYC reservoirs, how these blooms were managed and sometimes treated. The importance of watershed protection programs in reducing blooms will be discussed and the changes in past and future treatment capabilities will be reviewed.

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Long-Term Survival of Fecal Bacteria in Hudson River Sediment

Timothy Kenna, Lamont Doherty Earth Observatory and Andrew S. Ferguson, Columbia University and Alice Layton, University of Tennessee and Brian J. Mailloux, Barnard College

Fecal bacterial pollution can negatively impact water quality, leading to contaminated drinking water as well as the closure of beaches and recreational waters. Whereas fecal bacteria are known to partition to sediments, many aspects regarding transport, fate and long-term survival are not well understood. We evaluate sediments as a reservoir for viable fecal bacteria, by examining dated sediments from the lower Hudson River estuary for Escherichia coli, enterococcus, and Bacteroides. Sediment grabs and cores were collected from in the vicinity of the George Washington (GWB) and Tappan Zee (TZB) Bridges. Sediment deposition ages were constrained using gamma emitting radionuclides and pollution chronology. Growth methods were used to detect Escherichia coli, and enterococcus, and molecular based methods were used to detect E. coli and Bacteroides. Beryllium-7 was detected in 18 of 20 grabs, indicating deposition in the last ~1 yr. Culturable enterococcus or E. coli were detected in all grab samples with a maximum concentration of 394 and 1927 cells/g, respectively. In the GWB core, enterococcus or E. coli were consistently detected in sediment younger than the 1960s with maximum concentrations of 39 and 171 cells/g, respectively. In the TZB core, only enterococcus was sporadically detected in sediment younger than 1950 with a maximum concentration of 79 cells/g. In surface grabs, molecular Bacteroides and E. coli were detected in all samples with a geometric mean of 1.1x106 and 3.0x106 copies/g, respectively. In cores, Bacteroides and E. coli were detected in all samples with a geometric mean of 4.2x104 and 1.2x105 copies/g, respectively. Culturable ($p<0.05$) and molecular ($p<0.01$) counts were lower in the core samples than in the grabs, indicating initial die-off but then long-term survival and persistence. Results indicate that fecal bacteria can survive within sediments for decades, suggesting that sediments could be a significant and persistent source of bacterial pollution.

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Post Regulatory Upgrade Effluent Water Quality Improvements at the Delhi, NY Wastewater Treatment Plant

Paul LaFiandra, NYC Department of Environmental Protection

The Village of Delhi, New York Wastewater Treatment Plant discharges into the West Branch Delaware River which is the primary water source for the Cannonsville Reservoir, an integral component of the New York City water supply system. A requirement of wastewater treatment plants discharging in the New York City water supply watershed is to be upgraded to tertiary treatment consisting of micro-filtration or an approved equivalent. The Village of Delhi wastewater treatment plant was upgraded in 2003 to include a new activated sludge secondary treatment process followed by a previously approved two stage tertiary sand media filtration system designed to eliminate the discharge of pathogenic protozoans while also reducing solids and phosphorus concentrations. Pre and post upgrade data collected by the New York City Department of Environmental Protection from 1995 to 2010 were analyzed to compare pre and post upgrade effluent water quality and determine the long term effectiveness of the upgrade. Seven years of uninterrupted tertiary system operation have shown that the system is robust, reliable and capable of meeting design objectives. Following the upgrade, significant and consistent reductions in total phosphorus, fecal coliform, total suspended solids, biological oxygen demand and pathogens were realized with a concomitant increase in residuals production due to enhanced solids processing and removal.

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Final Results of the Catskill Forest Nutrient Imbalance Experiment

Gregory Lawrence, Ph.D. and Douglas A. Burns, US Geological Survey

Atmospheric deposition has altered Catskill soils by decreasing the availability of calcium and increasing the availability of nitrogen. In other parts of the Northeast, this type of nutrient imbalance has been shown to slow growth and lower the resistance of trees to stresses such as climate and pest infestations. With over 95% of the NYC watersheds forested, changes in the growth and health of the Catskill forest could have significant effects on the quality of the NYC water supply.

To evaluate a possible imbalance in the availability of nitrogen and calcium (and possibly magnesium), a long-term study was initiated in the fall of 2003, in which forest plots in the Neversink River valley were fertilized with limestone that contains both calcium and magnesium and/or nitrogen. Fertilization effects on soil and soil water chemistry are being monitored in conjunction with the response of canopy trees and understory. The goal of this experiment is to determine the degree to which soil conditions are controlling forest health and water quality.

The experimental treatments have caused measurable changes in soil chemistry that are reflected by the vegetation. Decreases in nitrate concentrations in soil water are consistent with the vegetation effects. Concentrations of calcium have increased by a factor of 3 in the rooting zone of the treatment plots, but remain low relative to those found in healthy sugar maple stands. Tree diameter growth of all trees in the plots also showed responses to treatment effects. Data to date suggest that increased calcium and magnesium availability improved water quality at this site by increasing retention of nitrogen in the forest ecosystem through better tree growth. The experiment is scheduled to end in September 2010, providing a total of 7 years of treatment data.

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From Drinking Water Taste Complaints to a Source Water Algae Bloom - NYC DEP's Experience with and Management of Chrysosphaerella in Kensico Reservoir

Tracy Lawrence, NYC Department of Environmental Protection

New York City drinking water is recognized as being one of the best tasting municipal drinking water supplies in the nation. Therefore, in the beginning of October 2009 when the City's 311 system began to log only a few calls from water consumers complaining of "metallic" tasting water, - it was cause for concern. New York City Environmental Protection (NYCDEP) immediately began an investigation into the cause of the metallic taste and increased in-City water monitoring to confirm that the water was safe to drink.

This presentation will discuss the experience with the taste and odor causing algae Chrysosphaerella. It will begin with NYCDEP's initial response after receiving consumer taste complaints in October of 2009, and describe the investigation that followed. The clues that lead the BWS to Kensico Reservoir and the identification of the algae Chrysosphaerella as the source of the problem will be presented. Once the origin of the metallic taste was identified, the BWS acted quickly to isolate the problem. BWS's operational response to control the problem along with the enhanced water quality monitoring program and tracking of consumer complaints to manage the issue will be discussed. Finally, as concentrations of Chrysosphaerella in Kensico Reservoir began to decline in December of 2009, BWS implemented a de-escalation plan to bring Kensico Reservoir back online.

Although drinking water taste and odor issues related to algal blooms are frequently observed by many water utilities throughout the country, such taste issues are rare to the NYC Water Supply. This incident was the first recorded occurrence of the algae Chrysosphaerella in the Water Supply. Because of its extensive complaint monitoring system, NYCDEP was able to detect this issue immediately and through operational flexibility, NYCDEP was able to manage the problem successfully. This resulted in little to no impact to drinking water consumers.

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FAD Related Stormwater Control - Drewville Road

Eric Lochner and Jesse Horsford, P.E., Gannett Fleming and Maria Mandarino, P.E. and Zaidoun Ereifej, NYC Department of Environmental Protection

Maple Avenue is an unpaved road located in the Town of Bedford, Westchester County, New York. Two unpaved roadside ditches convey stormwater to Cross River Reservoir. The road segment is approximately one mile long and the drainage area is approximately nine acres. The project objective is to reduce the amount of sediment and dissolved pollutants, primarily phosphorus, discharging to the reservoir. A stormwater treatment system consisting of a hydrodynamic separator, detention system and a cartridge filter system is being provided to meet the project objectives. The system is designed to capture and treat the water quality volume for the drainage area. Flows that exceed water quality volume peak flow rate bypass the treatment system. The bypass system is designed to convey the 100 year storm event. HydroCAD stormwater modeling software was used to determine peak flows for the water quality volume and various 24-hour storm events. The hydrohynamic separator is designed to remove 80% of total suspended solids and free oil and grease at the units hydraulic capacity. The detention system which consists of buried 8 foot diameter corrugated metal pipe is designed to store at least 75% of the water quality volume. This system acts as an equalization tank upstream of the cartridge filter system. Flow to the filter system is controlled by an orifice between the detention system and filter. The filter system is designed to remove suspended solids and dissolved pollutants. The filter consists of multiple cartridges that contain a media mix of zeolite, pearlite and granular activated carbon.

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Tertiary Treatment Upgrades Before/After Impact Study: Effluent and Lake Phosphorus Results

Jose Lozano, Ph.D. and Lynn Smith, City of Ithaca

The IAWTF upgrade has had a significant and positive effect on both the performance of the plant and on the water quality of southern Cayuga Lake. The effluent total phosphorus concentration decreased 58.7% after the upgrade, from an

average of 0.424 mg/L to 0.175 mg/L. The effluent phosphorus load also decreased significantly, from 23.8 Lb/day to 9.83 Lb/day after the upgrade. In 2005, the average total phosphorus concentration in the south portion of Cayuga Lake was 40.0 micrograms per liter (g/L). After the upgrade, the average was 29.0 g/L, a decrease of 40%. The effluent and lake sampling data was statistically robust to detect a 58.7% and 40.0% difference, respectively, at 2 =0.05 and a power goal of 0.95 (Error type II = 0.05).

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Pharmaceutical and Personal Care Products in NYC's Watersheds-Results from DEP's 2009 Study

Timothy Martin, David Lipsky, Ph.D., Ian Hurley, Ph.D. and Carla Glaser, NYC Department of Environmental Protection

National reconnaissance studies, as well as studies within the NYC Watershed conducted by the U.S. Geological Survey (USGS) and the New York State Department of Health (NYSDOH) have detected the presence of ng/L (part per trillion) levels of certain pharmaceutical and personal care products (PPCPs) in the nation's waterbodies including groundwater. In response to concerns about the prevalence and potential impacts of these and other emerging contaminants, DEP initiated a pilot program of quarterly monitoring of its source waters for the potential presence of these compounds. Samples were collected by DEP staff at locations representative of Delaware, Catskill and Croton source waters (Del 18, CatLeff, and Cro1T) during 2009. Because of the very low detection limits utilized for the study, the sampling program involved the collection of a number of QC samples as well as the use of "clean hands" sampling techniques. Samples were analyzed by two separate contract laboratories using different analytical methods. 16 PPCP compounds (and one industrial chemical) were detected from among the more than 78 compounds that were looked for during the year. The results of the pilot sampling program will be presented.

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A Comparison of Field and Lab Filtration of Samples to Meet the Methods Update Rule

Gerard Marzec and Karen E. B. Moore, NYC Department of Environmental Protection

This study was conducted to assess the impact of field preservation and filtration as required by the USEPA Methods Update Rule (40CFR 141 et al. 3/12/07). Prior to implementation of this rule, NYCDEP collected samples in the field and filtered them in their laboratories. Since this change of method could potentially cause difficulty with comparisons to long term data, a study was devised to enable statistical analysis of the paired data from the two methods. Sample size statistics were used to determine an appropriate number of comparisons for each of the 13 analytes. Samples were collected from streams and reservoirs in the West and East of Hudson districts and aliquots were filtered in the field and in the laboratory, and then analyzed. Between 2008 and 2009, 3362 analyses were performed. The results show that there was little to no difference for eight analytes: nitrate, chloride, sulfate, silica, calcium, potassium, magnesium and sodium. Two of the remaining analytes - total dissolved nitrogen and dissolved organic carbon showed more of a difference. Total dissolved phosphorus, soluble reactive phosphorus and ammonium had complicating factors that made it difficult to establish the relationship between the methods. These issues included too many non-detects, method bias, poor correlation, and applicability of correlations only to specific sample types or conditions. The results and limitations will be discussed as well as some of the potential causative factors, such as hypoxic conditions during reservoir collection.

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Water Quality Trends in NYC Watershed East of Hudson Streams (1993-2009)

James Mayfield, NYC Department of Environmental Protection

Although much emphasis has been placed on watershed programs in the West of Hudson region of NYC's water supply, a great deal of work has also been done in the Croton System of the East of Hudson watershed, including wastewater treatment plant upgrades and non-point source pollution control programs. One of the goals of DEP's Watershed Water Quality Monitoring Program is to use water quality data to evaluate the effectiveness of watershed protection efforts at controlling pollutants. In this presentation, water quality data collected as fixed frequency grab samples from the Croton watershed from 1993-2009 were analyzed to determine if trends in water quality could be detected. If so, the likely reasons for the trends were explored. The analytes selected for trend analysis were those that would most likely be of practical consequence to the City with an emphasis on nutrients, coliforms, and turbidity. Other analytes, such as chloride and specific conductivity, which may be impacted by watershed activities, were also examined. Statistical techniques were applied to try to minimize the effects of seasonality and flow on the results, in an effort to discern the underlying, long-term water quality trends which may be the result of watershed activities and watershed protection efforts.

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Proven Value of Watershed and Reservoir Modeling for a Remedial Investigation

William McMillin, Jamie Butler, Klaus Albertin and Alam Mohammed, CH2M HILL

Watershed and receiving water modeling was performed by CH2M HILL to support a remedial investigation (RI) of potential contamination of the primary water supply for the City of Williamsburg, VA from a nearby U.S. Navy facility. The RI was completed to determine the nature and extent of PCB releases from the facility potentially migrating offsite to the Waller Mill Reservoir and assess potential current and future human health and ecological risks associated with these PCBs. Following preliminary soil, stream, and reservoir sediment characterizations, modeling was employed to guide field investigations, characterize existing conditions, and guide risk management.

A watershed and a receiving water/sediment transport model were constructed and applied to identify potential contaminant transport pathways in the Waller Mill Reservoir originating from the facility. This effort was intended to estimate flow and sediment loading from the watershed to the Waller Mill Reservoir, transport of the sediment within the reservoir, and identification of areas where this sediment would subsequently settle to the bottom. The HSPF watershed model was applied to estimate flow and sediment loadings to the reservoir. Surface water and sediment transport modeling was performed using a 2-D finite element, depth-averaged flow and sediment transport model FST2DH, also known as FESWMS.

Once constructed and tested, watershed modeling simulated worse case watershed discharge conditions to calculate mobilization and transport of contaminated soils through migration pathways to the reservoir. Reservoir sediment transport modeling simulated transport and fate through the reservoir. Reservoir sedimentation calculations from the model were used to identify primary, secondary and reference investigation locations. Field investigation findings closely matched modeled contaminant fate. Modeling analyses were used to then assess future risk by calculating potential long-term fate and transport. The presentation will describe background, field investigations, model construction and simulations, outcomes, and its application to the Risk Assessment.

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Assessment, Restoration and Management of Watersheds - A Pilot Effort on the Esopus Creek in the Catskill Mountains of New York State

Sarah Miller, J. Craig Fischenich, Ph.D., Michael G. Channell, Ph.D., US Army Engineer Research and Development Center and W. Daniel Davis, NYC Department of Environmental Protection

New York City Department of Environmental Protection (NYCDEP) Bureau of Water Supply manages a surface drinking water supply of approximately 1,900 mi2 of watersheds and 19 reservoirs in New York State (NYCDEP 2006). Esopus Creek is one of two rivers comprising the Catskill water supply sub-system feeding Ashokan Reservoir in the Catskill Mountains west of the Hudson River. The EPA granted the City a Filtration Avoidance Determination provided the City implement a comprehensive Watershed Management Program. The Engineer Research and Development Center, Environmental Laboratory (ERDC-EL) and NYCDEP Stream Management Program (SMP) established a multi-year Cooperative Research and Development Agreement (CRADA) to develop and implement an iterative three-phased pilot approach for watershed assessment, restoration, and management on Esopus Creek. Phase 1 used remotely-sensed data, Phase 2 a rapid ground-truthing, and Phase 3 detailed stream surveys. Following each phase ERDC-EL and NYCDEP analyzed results to adapt subsequent protocols to specific needs in the context of the larger SMP watershed management effort. Issues investigated included:

- Stream system stability (physical, morphological)
- Sources and types of suspended sediment
- Riparian corridor composition and integrity
- Stream corridor geomorphic condition (hillslope and fluvial)
- Areas of excessive erosion, degradation or aggradation
- Areas of long-term (historical) channel stability
- Aquatic habitat condition
- Benefits of implementing various management practices at key locations
- Feasibility and compatibility of projects or programs

Supporting research efforts were developed to provide management tools applicable within and beyond NYCDEP water supply watersheds:

- Stability of Fine-Grained Glaciogenic Sediments in the Upper Esopus Creek Corridor
- Considerations for Best Management Project Implementation for Esopus Creek o Sediment Budget development for Esopus Creek
- Stream Management Practice Evaluation: Gravel Mining to Alleviate Flooding in Phoenicia
- Development of a Flood and Erosion Risk Hazard Assessment Model and Management Protocol

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Catskill Aqueduct Stop Shutter Improvements

Ginger Modafferi, HDR Engineering and Maria Mandarino, P.E. and Zaidoun Ereifej, NYC Department of Environmental Protection

New York City's primary surface water supply, which provides approximately 1.2 billion gallons of water per day, is serviced

via a network of reservoirs, aqueducts, and tunnels extending as far as 125 miles north of the City. This network comprises three systems: the Catskill system, the Delaware system, and the Croton system, which are all operated by NYCDEP. The systems are supplied with water from watershed areas in the Catskill Mountains and Upper Delaware River drainage basins. Water is conveyed from these systems to the local distribution grid via aqueduct tunnels that primarily operate via gravity flow.

This project includes the modernization of Stop Shutter installation at three Siphon Chambers and three Downtake Chambers located along the Catskill Aqueduct. These Stop Shutter are used along the Catskill Aqueduct to maintain minimum levels upstream of a shut-down or slow-down for other communities that draw water from the aqueduct. They are also used during periods of high turbidity to regulate the water quality in the reservoir.

The stop shutters are installed by lowering the shutter panels into grooves in the aqueduct wall. Installation of the stop shutters is necessary to supply upstate communities that rely heavily on the City for their water supply. These communities do not have adequate back up sources of water to handle a shutdown for more than a few days. The DEP intends to have the existing wooden stop shutters replaced with new modern aluminum stop shutters. Along with new stop shutters, DEP intends to modernize the means of installation and removal. In order to accurately asses the condition of the aqueduct for the positioning of new shutters, a three day shutdown of the Catskill Aqueduct was required.

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Suspended Sediment Transport Dynamics in the Esopus Creek Watershed

Rajith Mukundan, Ph.D., City University of New York, Donald C. Pierson and Elliot M. Schneiderman, NYC Department of Environmental Protection and David O'Donnal, UFI

Better understanding of temporal changes in water quality is often limited by lack of high frequency monitoring data. This can sometimes result in inaccurate estimates of pollutant loads entering water bodies. Calibration of watershed scale hydrologic water quality models is also dependent on high quality measured data. A case study from the Catskill region of New York is presented. Transport of suspended sediment is of concern in the streams of the Esopus Creek Watershed that drains into the Ashokan reservoir, one of the drinking water reservoirs in the New York City water supply system. During and following high levels of stream discharge increases in reservoir turbidity can impact water quality and potentially affect a portion of the drinking water supply. Therefore it is important to understand the dynamics of sediment loads entering the reservoir. This study describes the use of high frequency time series of monitored turbidity data for estimating suspended sediment loads, calibrating a SWAT sediment model, and for a better overall understanding of suspended sediment dynamics. Our results clearly indicate that sediment load estimates and model calibration can be improved using high frequency data from automated monitoring.

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Suspended Sediment and Turbidity in the Esopus Creek Watershed

Christiane Mulvihill, Jason Siemion and Michael R. McHale, US Geological Survey

Samples for suspended sediment concentration (SSC) and turbidity analysis were collected monthly and during stormflow events at four main stem and nine tributary sites along the upper Esopus Creek to identify sources of water quality impairment to the Ashokan Reservoir. Preliminary analysis of data collected in the watershed shows: 1) a significant relation between SSC and turbidity ($p < 0.001$, $R2 = 0.65$) across all sites, and 2) SSC and turbidity in samples collected during hydrograph rising limbs and peaks were significantly higher than those of samples collected during falling limbs ($p = 0.05$), which in turn were significantly greater than those collected during periods between storms ($p < 0.001$). Similar results were found for individual sampling locations, but the number of samples was too few to test for statistical significance.

Analysis of sediment sources was limited to examination of median SSC and turbidity values because flow data are not yet available to calculate sediment loads. Stony Clove Creek had the highest median SSC (111 mg/L); followed by Birch Creek (79 mg/L), Little Beaver Kill (69 mg/L), Esopus Creek downstream of the Shandaken portal (47 mg/L), and Woodland Valley Creek (40 mg/L). Stony Clove Creek had the highest median turbidity (80 NTU), with lower and similar turbidity observed at Broad Street Hollow (27 NTU), Birch Creek (24 NTU), Woodland Valley Creek (24 NTU), and Esopus Creek downstream of the Shandaken portal (21 NTU). SSC and turbidity increased downstream along Esopus Creek, with both parameters increasing sharply immediately downstream of the Shandaken portal. Preliminary data analysis indicates that: 1) several tributaries and the portal are probably the source of most of the suspended sediment observed in the upper Esopus Creek, and 2) the highest concentrations of suspended sediment and turbidity are observed during storm runoff.

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Ammonia Recovery Process for Municipal and Agricultural Applications

Morton Orentlicher, Ph.D., ThermoEnergy/CASTion and Tim Shephard, Cornell University

This report demonstrates that the Ammonia Recovery Process (ARP) will economically remove ammonia from concentrated wastewaters. The core technology for ARP is a proprietary vacuum distillation system developed by the CASTion Corporation. A series of pilot studies have been completed to demonstrate that the CASTion vacuum distillation system, RCAST, can consistently reduce ammonia from the level of 500-50,000 ppm found in municipal, industrial, and agricultural wastewaters (centrate, filtrate and leachate), to below 100 ppm. The purpose of this paper is to demonstrate this capability and to illustrate the economic benefits for both municipal and agricultural application.

Demonstration of Ammonia Removal with RCAST system

Vacuum distillation using RCAST produces an ammonia vapor stream and an effluent with less than 100 ppm of ammonia, relatively independent of the influent ammonia concentration. Vacuum is maintained by a Venturi using a working fluid containing sulfuric acid and ammonium sulfate. This captures the volatilized ammonia and produces a commercial grade ammonium sulfate solution.

Examples are given for RCAST performance with very-high strength ammonia wastewater (industrial), typical municipal centrate, and agricultural wastewater from the dairy industry. Key variables governing rapidity of ammonia removal are pH and temperature. The industrial and municipal examples utilize caustic to volatilize ammonia and then vacuum distill the ammonia at about 110 F. Caustic use in the dairy application is uneconomic and in the dairy applications, temperatures above 150 F are used to rapidly remove the ammonia with no caustic application. Economic benefits are demonstrated for both municipal and agricultural applications relative to alternative modes of achieving ammonia reduction.

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Evaluation of Perennial Stream Protozoan Data to Establish Means and Percentile Range Guidelines for Potential Re-Sampling

Christian Pace and Kerri Alderisio, NYC Department of Environmental Protection

New York City's Environmental Protection (NYCDEP) has monitored for Giardia cysts and Cryptosporidium oocysts throughout its watershed using Method 1623HV since 2002. The data gathered from this monitoring can be converted to information in order to determine mean conditions and establish guidelines for what would be considered unusual results.

Fixed frequency and special investigation sample results were used to determine mean values and 95th percentiles of sample concentrations for the 18 studied sites. Using mean calculations, sample sites were able to be ranked and refined to the areas with the highest protozoan occurrence. The current Watershed Water Quality Monitoring Plan includes eight of these sites determined to have the highest mean concentrations of Cryptosporidium and Giardia. Subsequently, the location with the highest value is the focus of upstream protozoan monitoring, in order to facilitate the identification of a point or non-point source. The 95th percentiles of the data were calculated and used to establish guidelines for what is considered outside the normal range of results for each stream. Results for the 95th percentile of Cryptosporidium concentrations were low at all sites (less than 0.25 oocysts per L), while those for Giardia were much higher (0.28 to 4.93 oocysts per L). As a guideline, the 95th percentile can be readily used to assist with decision making regarding additional sampling or potential upstream point source monitoring. Other factors, such as on site conditions during sampling and weather events, should also be considered. It is recommended that these guidelines be recalculated annually. These established guidelines are a relatively new tool being used to aid Water Quality managers when determining whether a follow-up investigation should be considered for an elevated count.

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Protecting Ground Water Via Pesticide Registration in New York

Steven Pacenka and Brian K. Richards, Ph.D., Cornell University

Pesticide use in the US is governed by a registration process that takes into account environmental quality impacts as well as the intended benefits of pesticide use. Pesticide use restrictions in New York State are particularly sensitive to ground water concerns after hundreds of Long Island wells were contaminated by routine pesticide use in the 1970's. The State monitors ground water for pesticide residues as part of its ongoing evaluation of how well the registration process is performing. Monitoring of private wells, which often are placed in much more vulnerable settings than public wells, has found that contamination above drinking water standards is very rare outside of Long Island. Low level residues - far below current standards - are commonly found for high use herbicides in both stream baseflow and shallow wells in many areas. However evidence is accumulating that the registration process, which was made far more protective as a consequence of the Long Island experience, has been effective at preventing higher groundwater concentrations from occurring as a consequence of routine pesticide use in upstate New York. Over 200 wells selected for relative vulnerability were sampled in five upstate counties (Cayuga, Cortland, Genesee, Orange and Schenectady) in cooperation with local Soil & Water Conservation districts. Samples were analyzed for over

90 pesticides and herbicides. Analysis by the NYS DEC laboratory found only one detection in excess of the 1 µg/L detection limit. More sensitive immunoassay testing for selected compounds (such as atrazine, metolachlor, alachlor) detected lower levels (between 0.05 and 1.0 µg/L) in a minority of samples, typically occurring in the most vulnerable shallow wells that often had elevated nitrate concentrations as well. All detections were substantially below relevant water quality standards or guidance levels.

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Pharmaceutical Formulation Facilities as Sources of Pharmaceuticals to the Environment

Patrick Phillips, US Geological Survey

Facilities involved in the manufacture of pharmaceutical products are an under-investigated source of pharmaceuticals to the environment. Between 2004 and 2009, 35-38 effluent samples were collected from each of three wastewater treatment plants (WWTPs) in New York and analyzed for seven pharmaceuticals including opioids and muscle relaxants. Two WWTPs (NY2 and NY3) receive substantial flows (>20% of plant flow) from pharmaceutical formulation facilities (PFF) and one (NY1) receives no PFF flow. Samples of effluents from 23 WWTP across the United States were analyzed once for these pharmaceuticals as part of a national survey. Maximum pharmaceutical effluent concentrations for the national survey and NY1 effluent samples were generally<1µg/ L. Four pharmaceuticals (methadone, oxycodone, butalbital, and metaxalone) in samples of NY3 effluent had median concentrations ranging from 3.4 to >400 µg/L. Maximum concentrations of oxycodone (1700 µg/L) and metaxalone (3800 µg/L) in samples from NY3 effluent exceeded 1000 µg/L. Four pharmaceuticals (butalbital, carisoprodol, and oxycodone) in samples of NY2 effluent had median concentrations ranging from 2 to 11 µg/L. These findings suggest that current manufacturing practices at these PFFs can result in pharmaceuticals concentrations from 10 to 1000 times higher than those typically found in WWTP effluents.

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The Importance of Snow and Snowmelt in Present and Future Simulations of NYC Reservoir Water Quality

Donald Pierson, Ph.D. and Mark Zion, NYC Department of Environmental Protection and Adao Matonse, CUNY Institute for Sustainable Cities

The largest portion to the New York City (NYC) water supply is located in a 4100 km2 watershed approximately 160 km North of New York City. In this area, snow accounts for approximately 15-20% of the annual precipitation, and snowmelt significantly contributes to spring streamflow.

As part of an effort to evaluate the effects of future climate change on the NYC water supply we have used a system of linked watershed, reservoir and water supply system models to simulate projected changes in hydrology, nutrient loading and tropic conditions in water supply reservoirs, and reservoir operations, respectively. One consistent outcome of our simulations is a pronounced shift in the timing of streamflow due to increased winter rain, decreased snow, and earlier snowmelt.

In this presentation we summarize the results of future climate projections which focus on changes in snow accumulation, snowmelt and hydrologic processes occurring during winter and spring. Our results suggest that more runoff occurs during winter, that there is reduced storage of water in the snowpack, and reduced spring runoff. At a subsystem level and under current rules and demands reservoir storage levels, water releases and spills are projected to increase during the winter months. Changes in the timing of runoff can have important affects on phytoplankton growth, and reservoir tropic status. A shift to winter in nutrient delivery, when growth conditions are less favorable to phytoplankton, attenuates the growth response to a projected increases in future nutrient loading. We also examine the sensitivity of the above projections to the choice of snow algorithms and parameterization of these algorithms in our watershed models.

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Building New York City's Operations Support Tool: (1) Background and Need

James H. Porter, Ph.D., NYC Department of Environmental Protection and Grantley W. Pyke, P.E., Hazen and Sawyer

The New York City Department of Environmental Protection (DEP) has initiated design of an Operations Support Tool (OST), an innovative, state-of-the-art decision support system to provide computational and predictive support for short-term operations and long-term planning. The purpose of this paper is to describe the history of the water supply and the conditions leading to the decision to develop OST.

Over 90 percent of NYC's water comes from six large reservoirs in the Catskill Mountains of New York State, approximately 100 miles northwest of NYC. This water is of such high quality that NYC currently holds a waiver of the filtration requirement in the federal Surface Water Treatment Rule, part of the Safe Drinking Water Act. However, there are significant challenges both in maintaining the delivery of over one billion gallons of high-quality drinking water to consumers every day and in operating the water supply system. Chief among these is managing turbidity that originates from erosion of glacial lake

clays in two of the reservoir basins. In recent decades, increasing regulation, development within and downstream of the reservoir watersheds, the creation and maintenance of tailwater fisheries and their associated local economies, and aging infrastructure have added significant complexity to the operation of the water supply. Climate change may also have an impact, now or in the future. Failure to properly manage these issues could have significant financial and societal costs. This paper will outline how these factors came together to create the need for OST.

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Community Implementation of the Moodna Creek Watershed Management Plan, Orange County, NY

Michael Principe, Ph.D. and Michael Murphy, HDR Engineering and Kelly Dobbins, Orange County Water Authority and Katy Dunlap and Simon Gruber

The Moodna Creek Watershed consists of 115,600 acres, or 180 square miles. It is located in the northeast section of Orange County, New York. The Moodna Creek is one of the largest rivers in the County and drains 21% of the County's land area into the Hudson River near Cornwall, N.Y. The watershed includes parts of 22 municipalities and its boundaries lie entirely within Orange County. Over the last three years, the Orange County Water Authority (OCWA) has been working with the municipalities and many stakeholders within the basin to create a management plan for the Moodna Creek Watershed. The overall goals of the plan were to first, summarize the existing conditions in the watershed, second, identify issues that were important to local communities, and third, develop a prioritized list of action items and recommendations for addressing identified issues. The final plan was completed and released in early 2010. The plan's recommendations fell into seven categories: planning and cooperation, regulatory change, research, education & outreach, safety/hazard mitigation, the implementation of site specific projects, and conservation. As one of its first implementation initiatives, the OCWA and the Moodna Creek Watershed municipalities and stakeholders focused on the creation of a inter-municipal watershed group that will work cooperatively to address the recommendations delineated in the Watershed Plan. This paper discusses the process that was employed by the Moodna Creek Watershed Plan implementation team in developing a long-term mechanism that would ultimately allow for the inter-municipal coordination on the watershed issues identified in the plan. The implementation team focused on four key tasks: group formulation, research and recommend watershed committee organizational structure, establish committee structure and bylaws, and conduct technical briefing on identified issues of concern. This paper provides useful information to community groups interested in the formulation and implementation of watershed management plans.

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Historical Trends of Permitted Right-of-Way and Aquatic Pesticide Use within the NYC Watershed System and Aqueduct Property; 1993-2009

David Quentin, NYC Department of Environmental Protection

Two different permitting systems exist for terrestrial and aquatic environments regarding the use of pesticides within the NYC Watershed System and Aqueduct Property. One permit type entails the use of pesticides by utilities such as railroads, electric power companies, and vehicular transportation, for the maintenance of their Rights-of-Way (ROW). The ROW permitting system was developed by New York City Environmental Protection (NYCDEP) in the 1980s and became a routine operation in the 1990s.

The second permit type is for control of aquatic vegetation and algae on private and publically-owned ponds and lakes within the NYC Watershed System and was developed by the New York State Department of Environmental Conservation in the 1970s. A Memorandum of Understanding between the NYSDEC and NYDEP in 1993 lead to a formalized arrangement between the two agencies for reviewing aquatic pesticide permit applications.

Herbicides are the primary class of pesticide used for both permit types. ROW herbicides are used for the control of terrestrial vegetation to ensure dependable operation of the utility. Aquatic herbicides are used for the control of vegetation to improve the aesthetic condition and render the water body more desirable for human recreational activities.

Monitoring by the NYCDEP and contract agencies such as the United States Geological Survey (USGS) over the past 15 years, have not detected significant concentrations of pesticides linked to ROW and aquatic use in NYC reservoirs or receiving streams. Furthermore, no violation of water quality standards or threat to NYC drinking water quality has been discovered to date.

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Mercury Cycling and Bioaccumulation in a Central Adirondack Stream Ecosystem

Karen Riva-Murray and Douglas A. Burns, US Geological Survey

Concentrations of mercury (Hg) in fish are elevated in relation to human-health and wildlife-health guidelines across much of the Adirondacks, where atmospheric deposition is the principal source of Hg. The Adirondacks are particularly sensitive to Hg deposition because of environmental characteristics that promote conversion of inorganic Hg to methylmercury (MeHg), the toxic and bioavailable form). Since 2006, the U.S. Geological Survey has been studying the factors that control Hg cycling and bioaccumulation in Fishing Brook, an upper Hudson River tributary that drains an area of about 67 km2. Water, bed sediment, macroinvertebrates (shredder, scraper, and predator taxa), and fish (omnivore and predator taxa) have been sampled seasonally at sites that vary widely in environmental characteristics that are believed to affect MeHg production and bioavailability. Results of analyses to date indicate that Hg concentrations in biota (within particular feeding groups) vary widely across the study area. These spatial patterns are related to stream water concentrations of MeHg and dissolved organic carbon, and to landscape characteristics that include catchment slope, proximity and hydrologic connectivity of wetlands, and the presence of open water. This study highlights the importance of local- and landscape-scale controls on mercury cycling and bioaccumulation in Adirondack streams.

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Stormwater Retrofit Program in the NYC Watershed

Andric Rodriguez and Lowell Kachalsky, O'Brien & Gere Engineers, Inc.

Per Part IX of the NYSDEC MS4 General Permit for Stormwater Discharges, (GP-0-08-002), administered under the State Pollutant Discharge Elimination System (SPDES), municipalities within the New York City EOH Watershed are required to comply with enhanced phosphorus reduction requirements. One of these requirements is the implementation of a Stormwater Retrofit Plan geared towards phosphorus reduction. The stormwater retrofit plan for each municipality must contain a list of retrofit projects and an implementation schedule for meeting its phosphorus reduction target.

The Croton Watershed Phase II Phosphorus TMDL Implementation Plan has set 5-year phosphorous load reduction targets from stormwater retrofits for each EOH municipality. The initial 5-year phosphorus load reduction targets are geared to High Intensity Development (HID) areas, and represent half of the HID phosphorus loading reductions expected over a 10-year period.

Per Part IX A.5.b.v. of GP-0-08-002, municipalities have the option of joining forces with other municipalities to form a Regional Stormwater Entity (RSE) and to develop a joint stormwater retrofit plan.

The municipalities in the RSE are requried to meet the phosphorus reduction targets identified in the Croton Watershed Phase II Phosphorus TMDL Implementation Plan collectively. Compliance would be obtained by achieving a yearly phosphorus reduction equal to the sum of the individual municipal reduction targets. The municipalities collectively would achieve compliance regardless of the location of the individual retrofits (watershed bubble compliance).

The northern Westchester municipalities with land area in the Croton and Kensico Watersheds decided to go this route and on June 12, 2008 entered into an intermunicipal agreement to form the Croton-Kensico Watershed Intermunicipal Coalition (CKWIC).

CKWIC engaged an engineering team led by O'Brien & Gere to develop their Stormwater Retrofit Plan. The plan includes retrofit descriptions, modeled phosphorus reduction estimates, analysis of construction/operational costs, a 5-yr retrofit implementation schedule, and an identification of funding sources.

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Trends in Stream Macroinvertebrate Bioassessments in NYC Water Supply Watershed Streams, 1994-2009

Martin Rosenfeld, NYC Department of Environmental Protection

Since 1994, NYCDEP has been assessing the health of streams in its watershed by sampling benthic macroinvertebrate communities, using protocols established by the New York State Stream Biomonitoring Unit. Routine sites are sampled annually; other "status" sites are sampled on a rotating basis. Routine sites are integrator sites, located on mainstems or important reservoir tributaries, or in streams in whose watersheds there is a significant potential for land use changes. Status sites are chosen to cover a wide geographic area and to represent a broad array of physical and chemical conditions. Trend analysis was conducted on all routine sites and 10 status sites (5- to 16-year sampling record) to detect long-term changes to the benthic community. Of the 31 sites examined, 29 displayed no significant trend (i.e., $p>0.05$), suggesting that habitat and water quality conditions in these indicator streams remained relatively stable during the period of record. No trend was noted for two sites in Hallocks Mill Brook, below the Yorktown Heights WWTP, despite the sharp increase in scores at both sites following the plant's upgrade. The failure to detect a positive trend may be a reflection of the small sample size at these two sites (n = 6 and 9). An

update on the third year of post-upgrade sampling of Hallocks Mill's benthic community will be presented.

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Effects of Altered Hydrologic, Turbidity and Thermal Regimes on Rainbow and Brown Trout Populations in the Upper Esopus Creek

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The Upper Esopus Creek, essential component of the Catskill District Water Supply System for New York City, supports a world renowned rainbow and brown trout fishery. Upper Esopus Creek streamflow is supplemented by water releases from the Shandaken Tunnel, an underground aqueduct originating in the Schoharie Reservoir, which alter the hydrologic, turbidity and thermal regimes of the stream. Waters released through this diversion, though at times turbid and thought to negatively impact trout, are also cold during summertime, and thought to benefit the growth and survival of trout. Actual impacts on resident trout are unknown and are a point of contention between anglers and managers in the watershed. Addressing stakeholder concerns and enacting effective management requires further understanding of interactions between water releases and trout populations. We implanted resident and hatchery trout with radio transmitters and tracked them during the summer of 2009 to determine if rates of movement, thermal refuge use, and apparent survival (persistence) differ in trout located upstream and downstream of the diversion. Preliminary results indicate that summertime stream temperatures were not stressful at either site, and apparent survival and average rates of daily movement were slightly greater downstream of the diversion. Tracking efforts will be continued during the summer of 2010 (and possibly 2011), and additional fish and habitat data will be collected. Condition of resident and hatchery trout will be assessed using bioelectrical impedance analysis, gill histopathology, and blood chemistry. Habitat selection of tagged trout will be determined using stream habitat characterization and GIS mapping. We hypothesize that downstream trout will exhibit higher movement rates, condition, and apparent survival; use less thermal refuges; and have lower habitat selectivity. The implications of preliminary findings will be discussed in relation to trout management in the Upper Esopus Creek.

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Advanced Oxidation Processes and Reverse Osmosis Treatment of Pharmaceutical in a Municipal Wastewater-Treatment-Plant Effluent

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From 2004 through 2008, the United States Geological Survey (USGS) has assessed the performance of several of WWTPs to treat various emerging contaminant compounds, including 11 opiates, muscle relaxants and other pharmaceuticals. During these assessments, it was noted that significant levels of pharmaceutical products are discharged from an extended aeration activated sludge municipal WWTP with tertiary treatment. This WWTP collects wastewater from a pharmaceutical manufacturing facility (PMF), and has pharmaceutical contaminant concentrations ranging from 1 to over 1000 g/L. From this particular WWTP tertiary-treated effluent, the USGS sampling program has detected concentrations of:

- Oxycodone
- Hydrocodone
- Methadone
- Tramadol
- Metaxalone

Recently, USGS and O'Brien & Gere Engineers, Inc. teamed to study the effectiveness of advanced oxidation processes (AOP) and reverse osmosis (RO) for treating the municipal WWTP effluent with high pharmaceutical concentrations. The study assessed the effectiveness of pharmaceutical removal using four treatment technologies:

1. Ozone (O3) and ultraviolet (UV)
2. Ultraviolet (UV) catalyzed hydrogen peroxide (H2O2)
3. Purifics Photocat®: Titanium dioxide (TiO2) photocatalyic AOP
4. Reverse osmosis (RO) membrane

Testing involved the quantitative analysis of the opiates/pain medication and an additional 69 additional microconstituents/emerging contaminants by each treatment technology.

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Acidification Status of Streams and Soils of Forested Lands of the Catskill Mountains, NY

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The Catskill Mountains of New York receive some of the highest acid deposition rates in North America, and are particularly vulnerable to acidification because of poorly buffered soils that

are naturally acidic. This study investigated the base cation surplus (BCS) and inorganic monomeric aluminum (Alim) concentrations of more than 180 streams in the spring and fall for the period 2001 to 2006, and soil base saturation from more than 150 soil pits, in order to determine the acidification status of streams and soils of forested lands within the New York City West of Hudson (WOH) reservoir watersheds. Approximately 18 to 40 percent of the streams sampled in the Neversink and Rondout watersheds were acidified (BCS < 0) during the spring and fall, more than 80 percent were prone to acidification (BCS < 60), and 23 to 40 percent had Alim concentrations that were greater than 2 µmol L-1, a known brook trout mortality threshold. Between 18 and 31 percent of streams sampled in the Ashokan and Schoharie watersheds were prone to acidification in the spring. In general, streams in the Cannonsville and Pepacton watersheds showed minimal effects from acid deposition. Median soil base saturation in the upper 10 cm of the B-horizon in all of the WOH watersheds was lower than 20 percent, a known threshold for Alim mobilization which may cause deleterious effects on tree species such as sugar maple and red spruce as well as result in concentrations toxic to brook trout in many streams. The large percentage of sampled streams that were acidified or prone to acidification during high flow conditions, and the low base saturation and exchangeable calcium levels of soil samples in the Neversink and Rondout watersheds, are evidence that the soils in these watersheds are ineffective at neutralizing acidity.

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Rain Gardens at Vassar College: A Water Quality Assessment

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Rain gardens were recently developed as a stormwater best management practice (BMP) to reduce the impact of stormwater on receiving waterbodies. Rain gardens are vegetation-filled depressions that receive stormwater from impervious surfaces; as the water infiltrates through a soil matrix, several processes reduce concentrations of contaminants. During the summer of 2008, rain gardens were constructed at Vassar College and two were selected to assess their effectiveness in improving stormwater quality. Precipitation, runoff, soil water, and catch basin water samples were taken during and after storm events between November 2008 and April 2009. Samples were analyzed for total suspended solids (TSS), dissolved inorganic nutrients (nitrogen and phosphorus), heavy metals (copper, lead, and zinc), and chloride. While the rain gardens appear to be effective in reducing TSS loads to Vassar Lake (the receiving waterbody), results were much more variable for nutrients and heavy metals. Rain gardens had no impact on chloride levels, though chloride accumulation in the soil may impact rain garden functioning in the future. By reducing TSS and increasing the on-site retention time of stormwater, rain gardens can address aspects of both quantity and quality issues of stormwater in developed areas. Low Impact Design, which includes BMPs like rain gardens, represents a valuable new framework for human development that emphasizes maintaining pre-development hydrology and ecology. Planting rain gardens offers a unique opportunity to link function and aesthetics in developed areas to protect fresh water resources and surface water quality.

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Building New York City's Operations Support Tool: (2) Structure and Functionalities

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NYC DEP has initiated development of an Operations Support Tool (OST), a state-of-the-art decision support system to provide computational and predictive support for water supply operations and planning. The OST represents a major upgrade of DEP's current linked water supply - water quality model, developed to evaluate alternatives for controlling turbidity in NYC's Catskill reservoirs. While the current linked model relies on historical hydrologic and meteorological data, the OST can be driven by forecasted future conditions. It will receive a variety of near-real-time data from DEP (SCADA, keypoint monitoring, in-reservoir robotic monitoring) and outside sources (USGS gauges, NWS forecasts).

The OST will support two major types of simulations: long-term, for evaluating policy or infrastructure changes over an extended period of time; and short-term "position analysis" (PA) simulations, consisting of multiple short simulations, all starting from the same initial storage, hydrologic, and water quality conditions. Typically, the starting conditions for a PA run will represent those for the current day and traces of forecasted hydrology will drive the model for the duration of the simulation period. Results can be post-processed within the OST interface and used to compare, for example, the results of alternative operating decisions.

OST functionalities will support a wide range of DEP uses, including short term operational projections, outage planning and emergency management, operating rule development, and water supply planning. The primary use of OST will be management of turbidity in water diverted from terminal reservoirs via the application of linked water quantity-water quality models coupled to inflow forecasts. This will allow DEP to continue providing an adequate supply of high quality water for the nine million customers it serves. Secondary operational uses of OST include maintaining ecological flows in tailwaters and creating

reservoir voids linked to snowpack to enhance the protective effect the dams provide to downstream communities.

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Effects of Long Term Trends in Solar Radiation on Watershed Evapotranspiration and Implications for Modeling and Long Term Planning in New York City's Water Supply Watersheds

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Recent studies have demonstrated that incoming solar radiation at the Earth's surface has been increasing in recent years due largely to long term reductions in traditional industrial pollution in the developed world allowing greater atmospheric transmission. This phenomenon is occurring in the New York City (NYC) water supply watershed region as illustrated by both data and model results. Incoming solar radiation is a major energy forcing for evapotranspiration rates and as such, these recent increases in incoming solar radiation can lead to increases in potential evapotranspiration. These trends in solar radiation and potential evapotranspiration, in turn, have implications for the watershed models used by water managers to simulate hydrology and water quality as many models are calibrated based on historical relationships between air temperature and solar radiation. These long term trends in solar radiation, however, can change the calibrated relationships underlying the model calculations, and therefore, create biases in model predicted long term water balances. This presentation investigates the sensitivity of watershed model results for NYC water supply watersheds to the long term changes in incoming solar radiation, the model upgrades undertaken to account for the phenomenon and the implications to long term model runs being performed for climate change studies.

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