Compendium of Abstracts

Presented at the

2006 New York City Watershed Science and Technical Conference

September 20 & 21, 2006

Advancing the Science of Watershed Protection

George E. Pataki
Governor

Christopher L. Jacobs
Secretary of State

2006 New York City Watershed Science and Technical Conference

Advancing the Science of Watershed Protection

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Due to space and time limitations, the following abstracts were not able to be presented at the 2006 conference:

INTRODUCTION AND ACKNOWLEDGMENTS

Dear Conference Participants,

In 1997, the signatories to the historic New York City Watershed Agreement formed an historic partnership to protect and enhance the City's Watershed and the scores of communities living within it. Integral to this complex and ambitious undertaking has been an unprecedented array of Watershed protection and water quality monitoring measures, coupled with unparalleled efforts and resources devoted to understanding the science of watershed protection.

The New York City 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 present information regarding the protection of the nation's largest unfiltered surface water supply. Through the presentation of new research findings and data, the conference serves to enhance information, technology, and coordination among the array of entities working to advance watershed science.

Earlier this year, a Call for Abstracts was made to agencies and stakeholders in and beyond the New York City Watershed. The resulting overwhelming response, coupled with a conference constrained by space and time, necessitated a process of review and selection by the Watershed Protection and Partnership Council's Technical Program Committee. All submitted abstracts were reviewed for technical merit and interdisciplinary utility, as well as temporal and substantive relevance. Those chosen by the Committee for presentation are included in this compendium.

In addition to all 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,

William C. Harding
Executive Director, Watershed Protection and Partnership Council

For the Conference Organizers and Sponsors:

- The Watershed Protection and Partnership Council
- The New York State Department of State
- The New York Water Environment Association
- The New York State Department of Environmental Conservation
- The New York State Department of Health
- The New York City Department of Environmental Protection
- The Catskill Watershed Corporation
- The Watershed Agricultural Council
- The United States Geological Survey

Automated Storm Sampling of Giardia cysts and Cryptosporidium oocysts to Optimize Recovery

Kerri A. Alderisio, James Alair and Christian Pace

Many factors surround the accurate assessment of public heath risk with relation to protozoa in water. Samples must first be filtered during collection, eluted, centrifuged, concentrated, and analyzed by immuno-fluorescent microscopy to obtain enumerated results. Other than numbers of organisms, another factor to be considered when discussing health risk, is the actual loading of these organisms into the water supply. If the watershed load of protozoa can be calculated, a more accurate assessment of whether those protozoa may affect the drinking water may be determined. In the case of New York City's water supply, fixed frequency, routine sampling over 16 years has not indicated an issue with Giardia cysts or Cryptosporidium oocysts at key locations.

In order to characterize the times of potential increased loading of protozoa into the reservoir, a two year study was designed to evaluate the protozoan contribution with a focus on storm water at the eight perennial streams in the Kensico Reservoir watershed. Phase 1 of this work was to optimize all aspects of automated storm water collection on a pilot scale at three stream locations in the Kensico watershed through the use of individual discrete samples. All three sites were set up with two autosamplers, batteries, solar panels and Campbell equipment, and were designed to collect 48 discrete one liter samples at each site. Two of the three locations were on the same stream, but spatially distributed above and below a retention basin. The goal of this Phase 1 work was to characterize the phases of the hydrograph when cysts and oocysts were at their highest levels.

Five storm events were captured at three sites between September and November 2005. The initial flow trigger, as well as the time intervals between samples, was adjusted for different storms. Approximately 84 one liter samples were sent to the laboratory during each event. The number of Giardia cysts recovered ranged from 2 to 26 cysts per liter, and Cryptosporidium oocysts ranged from 3 to 14 per liter. Preliminary analysis of the data supports the hypothesis that all streams cannot be treated equally with respect to storm response. Streams with differing characteristics (detention basins, steep slopes, land use) can respond differently to the same storms, and these factors need to be considered when designing programs for the automated equipment. The site upstream of the retention basin, along with the site with no retention basin, yielded higher numbers for both cysts and oocysts along the rising limb and the peak of the hydrograph compared to the site at the outflow of the retention basin. The peak concentrations of protozoa for upstream of the retention basin and the site with no retention basin occurred during high storm flows. Conversely, peak protozoan values at the effluent of the retention basin occurred during lower flow events.

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Effects of Recreational Flow Releases on Natural Resources of the Indian and Hudson Rivers

Barry Baldigo, Beth Boisvert, Anne G. Ernst and Christiane I. Mulvihill

A commercial rafting industry near the village of Indian Lake currently relies on regular releases of water from Lake Abanakee to increase depths throughout a 25 km section of the lower Indian River and the Hudson River Gorge. Anglers are concerned that these recreational releases decrease the abundance of stocked brown trout (Salmo trutta) and rainbow trout (Oncorhynchus mykiss) through loss of thermal refuges that decrease survival during summer. In 2005, the U.S. Geological Survey, in cooperation with the New York State Department of Environmental Conservation and Cornell University, began a four-year study to assemble baseline data on natural resources and to assess the effects of recreational flow releases on trout survival and other resources. Preliminary findings from eight sites on both rivers indicate that flows on the Indian River immediately below the dam typically increased from an average of 180 ft3 s-1 to almost 1,400 ft3 s-1, during releases and river stages increased from 1.24 to 2.60 feet, depending on channel widths. Changes in river temperatures during releases at all sites were either not significant or small (less than 0.5 C), when significant. Slow-water habitat in the 5-km-long Indian River study area decreased from 28 to 4% of the total during releases, and fast-water habitat increased from 69 to 93%. Richness and equitablity of fish communities at the Indian River site nearest the dam was similar to other sites, but total density and biomass were 50 to 90% lower than at other downstream sites and at a control reach on the Cedar River. Species composition at the three Indian River sites differed from that at most sites on the Hudson River and in the control site in the Cedar River. Fish-temperature data logged during a pilot fish-tracking (ratio-telemetry) study in late July and August 2005, indicate that about 8% of brown trout observations were from thermal refugia (fish temperatures were more than 1 C colder than the surrounding river), and nearly half of those fish (42%) were displaced from these refuges during recreational releases. Continued surveys of natural resources are scheduled for 2006 to replicate sampling efforts and ensure that gathered data supports preliminary findings.

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In-Reservoir Applications of Alum and Its Potential Public Health Implications

Irina Birman and Jamal Kamalov

Since the efficacy of the disinfection process can be compromised during high turbidity events, it therefore creates a particular concern for the unfiltered systems. In order to control turbidity, the water suppliers are compelled to a series of regulatory, monitoring and operational actions. These actions may include in-reservoir applications of turbidity reducing agents, typically Alum, which is an aluminum-based coagulant. Due to such applications, levels of aluminum in water become elevated. In addition, since aluminum is a very prevalent element in the environment, it can be also transported during storm events via suspended particles. Known as neurotoxicant, aluminum has for years been associated with Alzheimer disease and other encephalopathies. In our study we attempted to estimate the aluminum intake associated with drinking water, as well as the cumulative brain uptake via water and other environmental sources of exposure. The neuronal and thymocytal effects of aluminum were measured in mice via the flow cytometry method. Aluminum-induced oxidative stress, intracellular calcium accumulation, cell death, and membrane integrity were the investigated parameters. Our results clearly demonstrate the presence of neurotoxic and thymotoxic effects of aluminum in laboratory animals. The mechanism of aluminum toxicity has also been investigated and some potentially-related morphological and biochemical changes in neurons and thymocytes have been documented. Our findings will be presented and the potential public health consequences discussed. These data could provide additional information that would urge the scientific and medical communities to further assess the potential and actual health risks associated with the currently recommended levels of aluminum in drinking water.

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UV Disinfection Considerations for the Regulatory Upgrade Program

Randall Booker

The New York City Watershed Regulatory Upgrade Program provides funding for the upgrade of over 100 municipal and privately-owned wastewater treatment plants (WWTPS) located within the New York City drinking water supply watershed in accordance with the 1997 Watershed Rules and Regulations. Among the upgrade requirements for existing and new WWTPs with SPDES-permitted surface water discharges are: 1) 99.9 percent removal and/or inactivation of Giardia lamblia cysts and 99.99 percent removal and/or inactivation of enteric viruses; and 2) treatment to include sand filtration, microfiltration and disinfection. The assumption is that a properly operated and maintained WWTP that includes sand filtration, microfiltration and disinfection, as provided for under the Rules and Regulations, will provide the required 3-log Giardia and 4-log enteric virus removal/inactivation. With respect to sand filtration and microfiltration performance, the post-Upgrade SPDES permit will also have a new turbidity standard that must be met. The turbidity standard will provide both a direct and continuous measurement of filtration system performance as well as a reasonable surrogate indicator for removal of relatively larger-sized particles such as Giardia cysts. 4-log enteric virus removal/inactivation, however, is not achievable through a typically-operated sand filter followed by microfiltration. Therefore, virus removal/inactivation is largely achieved through the disinfection process and a significant number of WWTPs are specifying ultraviolet (UV) disinfection to meet these requirements. While UV is often a favored disinfection process for WWTP Operators due to its simplicity and minimal chemical storage and handling requirements, there are factors to consider when specifying a UV disinfection system as part of a watershed upgrade project. Unlike disinfection with chlorine, UV disinfection does not provide a directly monitored indicator of disinfection performance. With chlorine disinfection, residuals may be directly monitored, and residuals, contact times and temperatures have been correlated with enteric virus inactivation performance. With UV disinfection, however, there is currently no measurable indicator that can independently confirm that the design dose has been delivered due to the fact that the actual UV dose delivered at any location within the UV reactor or channel is a complex function of hydraulics, influent conditions and UV system intensity/output. Consequently, the performance of a UV system under a given set of conditions must be validated using theoretical dose calculations and/or a direct bioassay. In addition, while UV disinfection is effective against viruses, the design UV dose required for inactivation may differ significantly depending on the target virus. The significance of UV design dose will be discussed in the context of current UV design standards (88 DEC and Ten States) as well as evolving national standards for UV design (NWRI/AWWARF Water Reuse Standards). Current Regulatory Upgrade Program policy requires that all new and modified UV systems be validated. The presentation will include the following:

Overview of Regulatory Upgrade Program Treatment requirements
Relationship between Filtration and Disinfection Processes
UV Disinfection Process Review
Use of UV Disinfection to meet Regulatory Upgrade Program requirements
UV Design Dose and Standards
UV System Validation

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Designing a Rapid Environmental Virus Test for NYC

Susan Boutros

The EPA ICR method for viable enteric viruses is the only validated virus method for source water. The method is an MPN assay of the enteric viruses that will grow on BGM cells during repeated two-week incubation periods. The method calls for the testing of 100 liters of source water or 1000 liters of finished water. The time required for the assay is a minimum of 30-35 days. The assay costs about $500 and uses a $175 filter for sample collection. In other words, the test is expensive, slow and limited.

Approximately two years ago EPA held a workshop to develop a consensus method for a PCR-based rapid environmental virus method to overcome the limitations of the ICR method. While a number of promising alternatives were presented, participants could not reach a consensus. EPA subsequently produced recommendations for quality assurance in PCR laboratories based on discussions from the meeting, but no protocol was advanced for validation. It is difficult for one protocol to meet the needs of all projects, and the analytical method probably should be tailored to projects objectives. Method design takes into consideration project priorities and limitations relating to factors such as analysis time, diversity of virus type, host origin, method costs, etc.

This presentation will review the components of an environmental virus method as well as some of the alternatives for each of these components. The components will include sampling, extraction, and primary and secondary concentrations. Considering that there are about six steps and probably at least four alternatives for each step it is easy to see why it has been difficult to develop a consensus method. While each alternative has strengths and weaknesses there are probably many ways to produce an acceptable end result. In addition, a number of new products for virus identification and culture have become available for medical laboratories. These products have potential crossover application to environmental virus analysis.

The objective of this presentation is to suggest a method tailored to the needs of the watershed, present some of the alternatives available within the proposed method, and to present the results to date in the validation of method components.

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Use of Partial Harvests and Wood-Chip Application to Minimize Logging-Associated Water-Quality Changes in the Catskill Mountains

Douglas A. Burns, Peter S. Murdoch and Peter Homyak

The U.S. Geological Survey (USGS), in cooperation with the New York City Department of Environmental Protection and the New York State Department of Environmental Conservation, has been studying the effects of forest harvesting on water quality in the Catskills/Delaware (Cat/Del) Watershed since the 1990s. A timber-stand improvement harvest in 1995-96 caused little change in water quality, whereas a clearcut in 1997 resulted in pronounced changes that included increased stream nitrate concentrations to values >10 mg NL-1, decreased pH, sharply increased base-cation concentrations, and increased aluminum concentrations to levels toxic to brook trout. Current USGS work is attempting to define a harvesting-intensity threshold below which changes in water quality are minimal, and to test whether decomposition of wood chips derived from slash and applied to the soil surface can minimize these changes in water quality. Results from four partial harvests indicated that where less than 50% of forest basal area was removed, water-quality changes were small and less than proportional to the removed basal area. This finding suggests that canopy and root-network expansion after tree removal combined with microbial uptake of nitrogen can partly compensate for the loss of nutrient uptake after tree removal. Application of wood chips to the soil surface after the clearcutting of 0.4 hectare patches diminished the amount of nitrate available in the soil relative to untreated areas during some, but not all sampling periods; immobilization of nitrogen by microorganisms during the decomposition of chips was the process believed to be primarily responsible for the observed decreases in nitrate availability. The results of these studies indicate that changes in water quality associated with forest harvesting in the Cat/Del Watershed can be minimized through below-threshold partial harvests and application of wood chips in areas of intensive harvests.

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The Changing Face of a Forested Watershed: Links Between Parcelization, Land Use and Land Cover in the New York City Watershed

Jennifer Caron, Rene Germain and Nate Anderson

Parcelization occurs when large land holdings are divided into smaller parcels under different ownerships. Recent studies have documented the parcelization of non-industrial private forest land (NIFF) within the New York City Watershed, with average parcel size dropping from 19 acres to 16 acres in the Watershed from 1984 to 2000. This average parcel size is below the national average of 24 acres (Lapierre and Germain, 2005). Land use changes from forest management to the non-forest uses that are associated with parcelization have the potential to negatively impact water quality. This study combines social and biophysical methods to determine the relationship between parcelization, land use change and land cover. We hypothesize that landowners of parcelized properties are more likely to report land uses that are less compatible with maintaining water quality and more likely to engage in practices that result in increased impermeable surface area and a decline in forest cover at the landscape level.

To test these hypotheses we combined mail surveys of landowners with field visits and a detailed analysis of orthophoto imagery for 138 NIFF properties in the NYC Watershed. Half of the sampled properties have been parcelized since 1984, while the balance have not. In addition to forest inventory data, information was collected on road and stream density, area covered by impervious surfaces, including structures and paved driveways, and vegetative cover types. These data were digitized on aerial photographs to determine the ratio of impervious surface per property. Aerial photographs, ground-truthed by systematic plot sampling in the field, were also used to characterize the extent of different cover types on each property. Each landowner was surveyed to confirm current land use and land use change since the time of acquisition of the sampled property. The survey also assessed NIFF owner awareness, knowledge and implementation of forest management practices.

This rigorous combination of field measurement, survey results and remote sensing have provided understanding of the links between parcelization of NIFF, land use and land cover change in the NYC Watershed. Results indicate that, if current trends continue, parcelization in the NYC watershed will result in higher density of impermeable surface area and a larger proportion of developed land, both of which may negatively impact water quality. These results provide watershed managers with a better understanding of the impacts of parcelization on the forested character of the watershed.

Citations:

Lapierre, S., and R.H. Germain. 2005. Forest land parcelization in the New York City Watershed. Journal of Forestry 103:139-145.

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Managing Watershed Nutrient Accumulations on Dairy Farms in the Cannonsville Basin Through Precision Feed Management

Paul Cerosaletti, D.R. Dewing, A.W. Lucas and M. Kiraly

Nutrient accumulations on dairy farms have been identified as a major non point source of nutrient pollution in many US water bodies, including the Cannonsville Reservoir in the New York City Watershed. Research has shown that the largest source of nutrients coming onto dairy farms is purchased feed. A team of Cornell University Cooperative Extension specialists in Delaware County, under the auspices of the Delaware County Action Plan for watershed protection and economic viability (DCAP) are developing and implementing a unique program to manage nutrients (nitrogen and phosphorus) and improve profitability on dairy farms in the Cannonsville Basin through precision feed management (PFM). In this program, extension specialists are working with farmers and their feed advisors to improve forage production, increase utilization of homegrown forages in cattle diets, and more precisely balance cattle diets to reduce phosphorus and nitrogen feed imports and manure excretions. Monitoring of cattle diets, whole farm mass nutrient balance, and farm financial performance is performed to quantify and document changes in manure nutrient excretions, purchased feed nutrient imports, farm nutrient accumulations, and profitability on the farms as a result of program efforts. On farm feed planning efforts are supported by field research and education that provides farmers and the local feed industry with skills and technology to implement precision feed management. The program includes collaboration with faculty from Cornell University and USDA Agricultural Research Service Northeast Pasture Lab in areas of program development, research and education. Results in this ongoing program include an average 40% reduction in farm phosphorus accumulations and reductions in manure phosphorus and nitrogen excretions of 14 and 52 lbs/cow/yr respectively. Other impacts include increased milk production, reduced feed costs, improved animal health, and adoption of advanced precision feeding cattle nutrition software by the local feed industry. Future directions for the PFM program include incorporating animal health objectives into feed management of both lactating animals and calves in an effort to reduce risk of pathogen shedding as well as managing forage crop production to reduce soil erosion.

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Highway Management Planning in Delaware County, New York

Michael Clugston, Spencer Devaul, Nicole Franzese and Wayne Reynolds

Road design, condition and maintenance have a direct effect on the potential pollutant load originating from the roads of Delaware County. Road maintenance practices, such as the application of sand, cinders and salt for public safety and the cleaning of ditches to ensure proper drainage, create opportunities for accumulation and transport of sediment and pollutant loads to adjacent watercourses. Roads and their associated stormwater structures also serve as conduits for pollution originating from contiguous land uses like farms or commercial developments.

The issue of roads and stormwater must be viewed from two different viewpoints: a County/watershed perspective and a town perspective. Because most of Delaware County is within the New York City watershed, broader aspects of roads' influence on water quality come into play - pollutant loads to the reservoirs, etc. Yet, most of the roads in Delaware County are town roads; that is, roads maintained by individual municipalities. While water quality locally is a concern, towns are often more concerned with the bottom line of the high cost of road construction and maintenance. As a result, the goal of this project - to inventory and assess the roads and stormwater infrastructure in the towns of Delaware County and to create Highway Management Plans (HMPs) for each - presents a 'win-win' situation for all involved parties. Regional water quality will be enhanced by mitigating pollutant delivery from road and stormwater infrastructure systems and localities will see cost savings by improved management of their individual infrastructure systems.

Staff from the Delaware County Department of Public Works (DPW) and the Planning Department will inventory and assess the roads and stormwater infrastructure of the towns and create a GIS database for each. Using these data and assessments, the Departments will create individualized HMPs for each town.

All roads and stormwater conveyance structures will be inventoried and mapped making note of their location, surrounding land uses, and adjacent watercourses. Assessment and evaluation will occur simultaneously and will consider: the condition of the driving surface and stormwater structures, signage and guiderails. In consultation with town representatives, the data will be analyzed and compiled into individualized Highway Management Plans.

The following goals will be achieved through the completion of this project:

- The high quality of New York City's drinking water supplies will be ensured by minimizing pollutant delivery to the Cannonsville, Pepacton and Schoharie Reservoirs by initiating appropriate Best Management Practices (BMPs) for roads and stormwater infrastructure.
- The County and Towns will be develop appropriate cost-effective strategies to minimize local expenditures on road and stormwater infrastructure systems.
- Each town will be able to achieve GASB34 compliance for municipal accounting.

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Monitoring the Potential for Subsurface Delivery of Phosphorous to Streams in the Cannonsville Reservoir Watershed

Larry Day, Stephen Pacenka and Jery R. Stedinger

Upland soils in the Cannonsville Reservoir basin tend to have shallow, permeable horizons that overly fragipan subsoils. Modeling calculations combined with limited field evidence suggest the potential for phosphorus to be conveyed by sub-surface drainage to streams, and thence to the reservoir. Calibration of terrestrial non-point source water quality models has yielded coefficients that indicate that up to one third of dissolved phosphorus arriving at the reservoir might be attributed to groundwater. This project evaluated different land uses to determine if groundwater P-loadings to streams can be substantiated. Five study sites were chosen in the Cannonsville basin based on representative land use (forested, agricultural and residential), soil parent material and landscape position (upland or lowland). Groundwater was sampled ~monthly from relatively shallow wells (~1 to 5 meters deep) in unconsolidated deposits across a number of seasons. A long-term forested upland site was used to represent background levels of total dissolved phosphorus (TDP), which ranged from about 1 to 15 µg/L. Preliminary results indicate that total dissolved P levels in groundwater at some sites are significantly above these levels. Samples downgradient from actively farmed fields in upland glacial till soils had TDP levels only slightly greater than background, while greater values tended to occur from shallow wells in more porous, gravelly soils in lowland settings.

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Catskill Watershed Corporation Septic Monitoring Program: Phase I Completion and Phase II Preliminary Results

Thomas De John and James Hassett

The Catskill Watershed Corporation (CWC) is a not-for-profit corporation that implements and administers various environmental protection, economic development, and community improvement programs throughout the portion of the New York City (NYC) watershed located west of the Hudson River (WOH watershed). This watershed and its six reservoirs are the primary source of drinking water for NYC as well as numerous other municipalities that adjoin the NYC aqueducts.

The goal of this research project is to provide information about the effectiveness of alternative onsite wastewater treatment technologies under local conditions to help designers and regulators select appropriate, cost-effective systems in the WOH watershed. CWC staff works with many septic systems that are on lots insufficient for NYS Department of Health 75-A conventional onsite systems standards due to poor soils, small size, proximity to watercourses, high groundwater, or steep slopes. The CWC Septic Monitoring Program will help promote use of the best available technology for long term control of sewage from on-site systems. This research project is designed to provide information to help answer the following questions:

Can alternative technologies remediate substandard absorption areas to an acceptable level (i.e., to dispose of wastewater to the subsurface)?

What is the performance (i.e., carbon, nutrient and pathogen removal) of such systems in real world conditions?

What is the cost of installation, operation and maintenance of various technologies?

Can these systems be provided proper maintenance, through septic maintenance districts or other mechanisms?

The National Research Council confirmed the need for such research in a draft report released in 1999 entitled Watershed Management for Potable Water Supply: Assessing New York City's Approach. The report recommended greater use in the watershed of aerobic systems. The report stated that other alternative technology such as peat filters, re-circulating sand filters, constructed wetlands and waterless systems may be as effective as aerobic units, but research is needed to verify this. The report further states that performance monitoring of septic systems can be difficult and has not been done in the NYC watershed on a regular basis.

For this research project, CWC and their consultant Project Team will monitor alternative technologies to or repair existing septic systems in difficult sites typical to the WOH area. In Phase I of this project the CWC will oversee installation of several alternative technologies including aerobic treatment, peat filters, sand filters, raised systems as well as conventional 75-A systems at up to 38 sites. In Phase II the Project Team will sample subsurface soil water and pretreated effluent at twenty select sites over a one year period to observe the level of treatment provided. This presentation will summarize Phase I including aspects of equipment design and system installation as well as site selection criteria as well as provide preliminary results and analysis of Phase II. The importance of this research lay not only in the system types and sites tested but also the significant number of systems of each type in a single coordinated research project.

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Risk Management by Adapting to Climate Change: New York City's Water Supply, Sewer, and Wastewater Treatment Systems

Kate Demong, David Major and Cynthia Rosenzweig

The New York City Department of Environmental Protection (NYCDEP) recognizes that New York City's water supply, sewer, and wastewater treatment systems are at risk due to climate change, and the agency must proactively plan for future climate conditions in order to reduce the vulnerability of the City's water systems. In 2004, NYCDEP established an agency-wide Climate Change Task Force, with representatives from all operating and planning Bureaus, to develop a plan for identifying and addressing the potential impacts of global climate change, in particular sea-level rise, higher temperature, increases in extreme events, and changing precipitation patterns, on the City's water systems. In addition to proactive adaptation to climate changes, the Task Force recognized the importance of greenhouse gas mitigation, and NYCDEP's Bureau of Environmental Planning and Assessment is now working to develop a greenhouse gas management program for the agency.

The NYCDEP Climate Change Task Force, in partnership with Columbia University's Center for Climate Systems Research (CCSR), evaluates climate change forecasts, impacts, indicators, and adaptation and mitigation strategies to support agency decision-making. CCSR is developing downscaled regional climate change scenarios for use by NYCDEP, based on recent global climate model simulations for the Intergovernmental Panel on Climate Change Fourth Assessment Report. CCSR also coordinates scientific projects to yield maximum benefit from research and development. For instance, as a next step to NYCDEP Bureau of Water Supply involvement with CLIME, a European Union project to develop integrated regional climate and water quality models to study climate change impacts on watersheds, CCSR is coordinating the integration of climate forecasts for the NYC watershed region with NYCDEP's reservoir management models.

The Task Force has created a comprehensive climate change Adaptation Assessment framework to identify system impacts and potential strategies for reducing risk. Potential adaptations are categorized as management, infrastructure, and/or policy, and assessed by relevance in terms of when changes in climate will exceed thresholds of concern, the capital cycle of infrastructure at risk, fiduciary, and other impacts. Potential impacts to the water supply system include decreased dependability due to more prolonged droughts, increased turbidity due to more extreme storm events, and reduced cold water pools for fisheries releases due to atmospheric temperature rise. A wide range of potential adaptations has been identified, such as changing operations to further integrate NYCDEP's system with systems of other jurisdictions, diversifying the City's predominately surface water supply by building a desalination facility, increasing storage capacity of reservoirs, and modifying infrastructure design criteria to reflect changing hydrology. The Task Force is identifying potential indicators which could be tracked to help guide decision makers on the timing of adaptations, such as drought and flood frequency and severity levels, and fish populations in streams within the watershed. In addition to assessing potential impacts of climate change on the City's water supply, the Task Force is identifying potential impacts of sea level rise, changing precipitation patterns, and storm surge on NYCDEP's vulnerable coastal infrastructure, including its storm, sanitary, and combined sewer systems, and wastewater conveyance, treatment, and discharge systems.

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Evaluation of Heavy Metal Concentrations in a Created Wetland Detention Pond BMP

Candie Ferrazzoli, William Wallace and Alfred Levine

Urban stormwater runoff is a major non-point source of pollutants to receiving waters and recent investigations have evaluated the usefulness of engineered catch basins, i.e., best management practices (BMPs) to minimize pollutants to receiving waters. BMPs are special drainage facilities, such as created wetlands, that lessen the impacts of urban stormwater discharges into natural areas by reducing high velocity run-off and capturing sediment and pollutants. Because of their particle-reactivity, heavy metals can be removed from sediments in BMPs as they are mostly found associated with the particulate solids in stormwater runoff.

In Staten Island, NY there is currently a Bluebelt project that takes the natural land and transforms it into a best management practice (BMP). This is done to alleviate flooding without the cost of expensive infrastructure and disruption of the natural land. The focus of this investigation was to determine the extent of heavy metal contamination in sediments collected from a more established extended detention wetland BMP on Staten Island, NY (Richmond Creek watershed area; BMPRC-5), but prior to release to receiving waters. This project focused on copper and lead because of their toxicity in the environment. Results showed that concentrations of copper and lead lessened from the inlet to the outlet area prior to discharge to receiving waters. Also found was that the amount of coarse material was significantly less than fine material in the outlet, micro pool area.

Results showed that copper and lead were indeed associated with fine particulates in stormwater runoff during the 2005 winter storm season. The average total copper inlet concentrations ranged from 1,704 to 2,412 ug/g, and outlet ranged from 682 to 1,238 ug/g. The resultant concentrations decreased from 27% to 61%. The average total lead inlet concentrations ranged from 904 to 925 ug/g, and outlet ranged from 519 to 615 ug/g. The resultant concentrations decreased from 33% to 44%. The lowest average percent decrease that was measured occurred during a wet rain event. The BMP, in particular, appears to effectively attenuate copper and lead in stormwater runoff and the results of this study provide some evidence that BMPs are meeting their projected goals.

Keywords: urban stormwater runoff, heavy metals, extended detention wetland, BMPs.

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Contributions of Local Initiative Programs to Watershed Protection

Dean Frazier, Rick Fritschler and Rene Van Schaack

Implementation of New York City's watershed rules and regulations presents an ongoing challenge to local units of government. While the response of each county to meet these challenges has taken various forms, the implementation of the Filtration Avoidance Determination (FAD) requirements and related City programs have advanced local expertise and fostered a new perspective of land stewardship in West of Hudson counties.

Local Initiatives Programs (LIPs) refer to specific watershed management programs conceived at the local level that are 1) in keeping with the anti-degradation principles outlined in the City's Long Term Watershed Protection Program, and 2) have the potential to substantially enhance the effectiveness of existing programs within the City's watershed. These initiatives include practices or programs that reduce pollutants of concern from entering surface waters, and eventually entering the City's reservoirs.

LIPs offer an opportunity to strengthen the City's Long Term Watershed Protection Program, the FAD, watershed partnerships and local stewardship. They integrate water quality protection measures through existing legal, political and technical institutional mechanisms.

LIPs provide:

The delivery mechanism for local comprehensive watershed management;

The local institutional link between existing state and federal programs and regulations that can empower communities to take an active role in the stewardship of important resources at critical points of protection;

A pathway to extend and integrate existing technical expertise through long standing institutional arrangements that link communities and landowners.

LIPs are active in the watershed at the regional, county and municipal levels. This paper will focus on the latter two. They utilize existing local expertise, which has developed a planned approach at the local municipal level, and provides an extensive organized service that enhances and complements regional programs. LIPs foster enhanced integration and improved cost benefit for the implementation of watershed projects based on priorities that consider the overall basin in question. Local knowledge addresses needs from a basin perspective and can help guide communities towards addressing the issues in their jurisdiction. This planned approach has existed, but has not been well understood or utilized West of Hudson. Each county's level of integration with municipalities varies, as the needs of each town and county vary across the West of Hudson watershed. This paper describes how partnerships can be enhanced for the benefit of water quality, economic objectives and better working relationships between New York City and local municipalities.

Non Point Source (NPS) pollution varies widely both temporally and spatially therefore requiring a comprehensive, integrated and strategic management approach. This approach includes building and enhancing local expertise, education, building a local ethic of resource protection, and incorporation of water quality protection principles such as EPA's multiple barrier approach. Municipalities using this management approach in their land use tool box empower local stewardship at points on the landscape contributing to long-term watershed protection that regulations cannot possibly achieve. LIPs provide an opportunity to build trust between stakeholders and a means to provide long-term benefits to all watershed stakeholders by balancing water quality protection with communities, individuals and businesses.

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Onsite Wastewater Treatment Innovations

Steven Gamelsky

Design of Onsite Wastewater systems in the NYC watershed for residential, institutional and commercial properties represents major challenges in order to comply with NYCDEP and County DOH regulations - while achieving cost -effective constructed products.

New emerging and developed technologies offer significant opportunities to achieve high levels of treatment performance. Current regulations and regulatory policies restrict or hinder the application of these newer technologies while burdening the end-user(wastewater generators) with costly less effective designs.

There have been newer systems that have been installed that have been able to buck the traditional regulatory requirements due to site specific conditions and reasons - and these systems are demonstrating their effectiveness - and the potential for long-term applications in the watershed.

A review of critical regulatory regulations will be presented to indicated restraints and parameters that should be investigated.

A review of recent installations will be presented along with their design data, unique site characteristics and constraints and performance data - to date. A review of available technologies including NSF rated systems including: aerobic STU's, Trickling textile filters, and other systems will be presented along with dispersal field options including bottomless sand filters, ELjen, and other dispersal units.

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Economic and Phosphorus-related Environmental Impacts of Precision Feeding and Forage Management on Cannonsville Dairy Farms

Lula T. Ghebremichael, W.J. Gburek, P. E. Cerosaletti, C.A. Rotz, J. M. Hamlett, and T. L. Veith

Excess phosphorus (P) from dairy dominated agriculture within the Cannonsville Reservoir Watershed (CRW) has been identified as the main cause of the eutrophication-related water quality impairment of the Cannonsville Reservoir. Dairy farms in the region have been importing large quantities nutrients due to insufficient on-farm land for producing feed. Continuous P soil build-up is caused by the imbalance between farm P imports in purchased feed and fertilizer and P exports in milk or meat. This build-up in soil P exacerbates off-farm losses of sediment-bound and soluble P, which further degrades the reservoir's water quantity.

Best Management Practices (BMPs) that are mainly structural and management-based have been implemented to control off-field P transport to the Cannonsville Reservoir. Such BMPs, however, have limitations when it comes to addressing long-term P imbalances persisting in the dairy farms of the region. Addressing and targeting such P imbalance problems while at the same time maintaining the economic sustainability of the farms requires a holistic system-level strategy of re-designing farming systems (system-level BMP). Obviously, this holistic system-level approach can only be done on farm by farm basis. The emerging Precision Feed Management (PFM) approach is one such system-level BMP which focuses directly on the root cause of the P build-up problem of farms.

This study employed the Integrated Farming System Model (IFSM) on two CRW dairy farms to evaluate and quantify the benefits of PFM farm planning strategies in controlling P imbalance problems and, ultimately the off-farm P losses while maintaining the profitability of farms. The IFSM generally performed well in representing the economic and environmental status of both farms based on verification done with farm planners, as well as data derived from a well-calibrated hydrological and pollutant model. Model simulation of more accurate feeding of P integrated with increasing the productivity of grass-forage and the proportion of forage in the diet resulted in reductions in farm P balance ranging from 64 to 75% and soluble P loss of 17%. Also, feed supplement purchases declined by 20 to 29 kg/cow/year for mineral P, and by 285 to 442 kg/cow/year for grain and concentrates. Moreover, when land use management practice of converting corn to grass was coupled with the accurate feeding of P and forage management, the model predicted that converting a 1 ha of corn to grass could save 100 g of sediment-bound P /ha in erosion each year. The model also predicted slight increase in grain purchases to offset the reduction in corn silage, and there was no significant change in the farm P balance due to land use conversion. Such model-based studies done on farm by farm basis are useful in complementing the farm planners' efforts in exploring innovative farming systems.

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Enhancing Stream Stewardship at the Local Level

Scott Gladstone, Shelly Johnson-Bennett and Nicole Franzese

Many land-use activities that pose threats to water quality are largely concentrated in narrow valleys, and therefore in the vicinity of streams. These activities and practices can pose challenges to regional stream health. Traditional stream corridor management practices typically focus on single objectives such as bank stabilization or flood threat reduction. Additionally, communities rarely manage streams holistically, neglecting to give due consideration to stormwater management and floodplain development.

In the New York City watershed efforts are focused on empowering local stakeholders (property owners, municipalities, interested organizations and cooperating agencies) to set goals, objectives, and strategies to foster long-term riparian stewardship. An informed constituency of watershed residents and stakeholders can develop a long-term management framework for watershed streams through the development and implementation of local Stream Corridor Management Plans (SCMPs).

SCMPs document issues, concerns and current conditions, summarize known information, and provide a strategy for coordination of stewardship and management activities among the various stakeholders. SCMPs also document partnerships with other water quality initiatives and serve to ensure that no one goal is achieved at the expense of another.

This presentation will explore the integration of highway management, stormwater management and land-use practices in combination with technical and educational outreach. It will describe the progress of the Delaware County Action Plan and West of Hudson Technical Advisory Group; identify how new and existing initiatives, including funding mechanisms, can be expanded and/or enhanced; introduce Local Initiatives Programs and explain how each will continue to enhance and strengthen the effectiveness of SCMPs. Through these mechanisms a holistic approach to stream corridor stewardship and management is being promoted by empowering local communities to enhance riparian stewardship while working in conjunction with city, state and federal programs and initiatives.

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Predicting Future Water Quality from Land Use Change Projections in the Catskill-Delaware Watersheds

Myrna H. P. Hall, Prajjwal K. Panday and Charles A. S. Hall

Understanding the impacts of land use and land cover (LULC) on water quality can contribute important information to understanding and predicting water quality and quantity, especially when linked to hydrological, land use change projection, and/or non-point source pollution models. The objective of this study was to project future expected concentrations of seven chemical analytes (TP, SRP, NO3NO2, TKN, NH4, and TSS) as a function of our empirically-based land use change projections in the Catskill-Delaware water supply region for New York City. We compared the average 2001-2002 concentrations from the New York City Department of Environmental Protection (DEP) 75-site water quality monitoring data set to 2002 satellite-derived LULC, DEP-provided percent impervious surface, road, population, and parcel density, distance from waste water treatment plants, soil, and topographic factors. Although our study indicates that one-third of the region's 1975 agricultural areas reverted to forest cover by 2002, there is also a significant "urbanization" trend revealed both by analysis of time-series imagery and "on- site" visits to land that has been parcelized (divided into smaller ownerships) since 1984. In the Catskill basins where the average 2002 percent forested equals 85.65, most of the variation in TP, TDP, TN and NO3NO2 is explained individually by the variance in percent forest cover and percent agriculture (which co-vary), mean basin slope, and soil erodibility (the NARCS soil "K" factor). In the less forested Delaware basins (average 2002 percent forested equals 71.28%), percent forest cover and percent agricultural land explain most of the variance in TDP, TN and NO3NO2 variances but "urbanization" factors such as the percent impervious surface, parcel density and population density (all three of which co-vary to some degree) play a role. Most of the variance in TP is explained by "urbanization" factors alone. Collinearity diagnostics indicate that in order to build a multi-variable model, principle components analysis (PCA) must be applied prior to stepwise linear regression analysis to ensure independence of potentially explanatory variables. Of our analyses completed at the time of abstract submission, PCA yields for TDP in the Delaware watersheds a five principle component model with an R2 of 0.94. Stepwise multi-linear regression using the PCA-derived coefficients will allow us to derive loading coefficients for all analytes. For each species we will present the model, model validation statistics, and future expected concentrations, based on our land use change projections to 2016.

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Watershed Protection-An Integrated Approach

Jeffrey Heath

As the challenges and cost for watershed protection and waste management have grown over the years, an interesting development has occurred. The identification, separation, and management of individual waste streams has lead to significantly more challenges with respect to environmental stewardship, waste disposal, and cost control strategies. In the wastewater treatment area, options for the disposal of biosolids are continually being assessed, offered and challenged. This assessment generally focuses on the direct cost associated with post-processing prior to disposal in a landfill or reuse through landspreading or composting. However; municipal officials must now also balance public acceptance for biosolids disposal under the growing regulatory influence of watershed management strategies.

In a parallel fashion, federal and state solid waste regulations call for the continued efforts to Reduce, Reuse, and Recycle, particularly as it applies to public entities. Similarly, solid waste managers are also required to look at post-processing cost (recyclables), transportation cost (separate collection for waste and recyclables), and disposal cost (landfills, incineration, compost application).

Through co-composting of municipal solid waste and biosolids, Delaware County NY has integrated post-processing, transportation, and disposal cost through an Integrated Waste Management Strategy - including acceptance of all biosolids generated within the County as a result of wastewater treatment plant upgrades in the NY City Watershed. The purpose of this paper is to share the results of Delaware County's integrated planning strategies as it applies to watershed protection, and to present the process features and results of their new state-of-the-art MSW Co-composting Facility.

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Suburban Hydrogeology - Observations from Rockland County, New York

Paul Heisig

Infrastructure that accompanies suburban development affects local ground-water flow and the distribution of water within the aquifer and streams of Rockland County, N.Y. Large numbers of wells completed in the bedrock aquifer alter ground-water flowpaths by interconnecting shallow and deep fractures, water-supply-distribution and sanitary-sewer systems convey water within and outside of the aquifer area, and impervious surfaces (roads, parking lots, roofs) divert stormwater to streams and thereby decrease the amount of ground-water recharge. These disturbances result in accelerated ground-water flow and a loss of water stored in the aquifer.

Rockland County has a high degree of suburban development (nearly 300,000 people) and derives about 50 percent of its public water supply from a sedimentary bedrock aquifer that underlies the most developed parts of the County. The primary water-bearing zones are fracture planes parallel or subparallel to gently dipping bedding; these zones become increasingly isolated (confined) with depth. Ground-water movement under predevelopment conditions probably occurred mainly within these fracture planes and primarily along strike toward points of discharge (streams, lakes, springs, wetlands). The presence of an estimated 6,000 to 8,000 wells in the County, mostly finished in the bedrock aquifer, has decreased the confinement of deep water-bearing fractures. Wellbores can provide highly permeable interconnections between shallow and deep fractures. Withdrawals from the aquifer typically induce downward flow within wellbores, moving shallow ground water deeper into the aquifer; the maximum flow rate exceeds 16 gallons per minute in one well. These interconnections, or short circuits, provide increased ground-water flow to production wells but also allow contaminants in shallow ground water to quickly migrate to deeper parts of the aquifer.

Water-supply mains transport water from the aquifer to users, and sanitary-sewers then convey wastewater to treatment plants and ultimately to the Hudson River. This constitutes a net loss of water from the aquifer system. Leakage out of water mains and infiltration into sewer mains also occurs. Water mains, which are under pressure, tend to lose water (16 to 18% of pumpage is unaccounted for), whereas sewer mains (with the exception of force mains) are not under pressure and tend to gain water during high water-table conditions. The pattern of daily sewer flow to a treatment plant is remarkably similar to the streamflow hydrograph from a local stream, an indication that the sewers act in a manner that is hydrologically similar to streams, but without topographic constraints.

Impervious surfaces limit or prevent ground-water recharge from precipitation and route the storm water to nearby streams. Ground-water-level responses to rainfall in an area dominated by impervious surface are about an order of magnitude smaller than at a well about 1 mile away where impervious surface is limited. Preliminary comparison of stormflows from two gaged stream basins whose surfaces are 12 and 17 percent impervious with that in a third basin with low impervious surface area (3.6 percent) indicates 1.6-fold and 2.4-fold increases in peak stormflow, respectively (per square mile of drainage area).

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Decision Support System Technologies for Water Resources Management

Benjamin Houston, Emily Constantine-Mecurio and David Carr

IAGT has been funded through a grant from NASA to investigate the integration of USGS ground monitoring technologies and water resources data with NASA's Earth Observing System data and systems to enhance and/or develop decision support tools. Driving the requirements of this project will be the specific needs of state and local governments in the Northeastern United States, with particular attention paid to federal regulations necessitating the extension of workflows across various levels of government.

IAGT proceeded by selecting a group of stakeholders across the Northeast, including NYSDEC Division of Water and the Ulster County Water Quality Management Agency in NYS, to assist in application development and to participate in benchmark testing and evaluation. IAGT will work with stakeholders on this project to develop decision support tools that are useful for flooding and water quality applications. These decision support tools may draw upon existing enabling technologies, such as currently maintained civil GIS databases, the USGS Stream Stats program, and other environmental models housed at academic or state institutions. Other stakeholders include research programs at Purdue University, the University of Minnesota, the University of Connecticut and the University of Wisconsin.

Phase 1 of the project, due to be completed in June 2006, will result in an inventory of currently available technologies and tools designed to support decision makers and managers in the priority application areas described above, namely flooding and water quality. Phase 1 will also result in a stakeholder driven design requirements for advancing the technologies forward for future use and implementation across the region.

Phase 2 of the project, due to be completed in March 2007, will result in an application prototype advancing selected technologies reviewed during Phase 1.

This discussion will present the results of Phase 1 and provide specific information regarding several available tools and technologies. The presentation will guide the audience through the lessons learned from the design requirements effort for advancing a selected set of those technologies for implementation. The discussion will also provide an update on the prototype efforts in Phase 2.

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ENR, BNR and MBR Design Approaches You Should Know

Mike Hribljan and Neil Hu

Membrane Bioreactors (MBR's) are quite likely one of the fastest growing technology segments in the wastewater industry. Although the installations are numerous in North America, approaching 400, relatively few have been designed, started and commissioned to achieve Enhanced Nutrient Removal (ENR) limits. The objective of this paper will be to discuss ENR design approaches for small, medium, and large scale treatment plants utilizing Membrane Bioreactors (MBR) for nitrification, denitrification, and biological phosphorus removal to ultimately achieve ENR effluent quality.

The same fundamentals that are applied to conventional activated sludge systems can be applied to MBR with a few key differences, this presentation will compare the similarities and differences. Various process configurations of anaerobic, anoxic and aerobic zones can be used in conjunction with MBR's, the presentation will discuss when certain configurations are most suitable. The high mixed liquor suspended solids (MLSS) in MBRs, and high dissolved oxygen concentration in the mixed liquor return stream are important design considerations. The impact of high MLSS on bioreactor aeration design will be covered and its relationship to the aeration system alpha factor, and the subsequent effect on long term operating costs. Also, several options will be presented to mitigate the impact of high DO concentrations in returned mixed liquor streams on anaerobic or anoxic zones. Simulations from BioWin, a commercially available process wastewater simulator will be used to illustrate the impact of various process design strategies, on ENR performance.

In closing the presentation will discuss a few case studies where membranes are being used effectively with biological phosphorus removal and total nitrogen removal.

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New York State Enhanced Treatment Standards for Phosphorous Removal from Stormwater Discharges

Shohreh Karimipour and Marcus Quigley

In an effort initiated by the NYSDEC, a team of experts is developing criteria to achieve effective phosphorus treatment of stormwater discharges resulting from development activities. These criteria are intended to enhance the performance of systems above existing standards as defined in the New York State Stormwater Management Design Manual. The results of the latest research on stormwater management practice (SMP) effectiveness, modeling of the hydrologic responses of treatment systems, and simulation of phosphorus removal mechanisms are utilized in developing the enhanced criteria. The developed criteria are intended to assist designers in selecting and sizing stormwater management treatment systems to reduce phosphorus loading to receiving waters from urban runoff in the east of Hudson NYC water supply watersheds.

The principle approach in defining the enhanced criteria is based on achieving effective SMP performance. A three part definition of effective SMP performance is used: 1) how much stormwater runoff is prevented, 2) how much of the runoff is captured by the SMP or by-pass the treatment system, and 3) what effluent quality can be expected to be achieved. The enhanced criteria for phosphorus removal are multi faceted. They include criteria for sizing of storage and flow through systems, performance specifications, groundwater recharge, maintenance, and effective source control by practice selection and siting.

Although all the above factors are integral to the performance of the treatment systems, at the most basic level the effective hydraulic function of SMP systems is essential to achieve effective performance. This new set of criteria is intended to provide a point of convergence for the requirements applied in the phosphorus-limited watersheds while maintaining consistency with the existing state stormwater standards.

Hydrologic source controls primarily rely on evapotranspiration and/or infiltration. Due to the use of standard hydrologic calculations that included both impervious and pervious areas in establishing water quality sizing of SMPs, the approach encourages runoff reduction and the utilization of mechanisms that rely on infiltration and evaporation capacity of the soil where possible. This approach results in sizing of the practices to achieve effective capture, the sufficient detention times, and reduced bypass of the runoff in treatment systems.

To define the new criteria, two models are utilized to simulate the hydrologic and hydraulic function as well as the water quality performance of the treatment systems. Long-term continuous simulations are used for both hydraulic and water quality performance evaluations. Additionally, sizing performance was evaluated using standard design storm methodologies. The analytical work also examines effluent concentrations of particulate phosphorous as a function of SMP performance. Modeled performance is supported by empirical analysis of the latest studies of performance in stormwater treatment practices.

The overall system design approach encourages the use of a unit process based methodology for selecting design elements to achieve effective phosphorus performance. Design factors that influence phosphorous removal processes such as settling velocity as a function of particle size distribution of the particulate phosphorus, biological uptake of the dissolved phosphorous, and media contact time for adsorption and or sorption of dissolved phosphorous, are used as the basis for recommending unit processes that will be effective.

The research conducted to support the technical basis for the selected criteria as well as the overall design methodology far exceed the tools used in current statewide standards.

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Experimental Manipulation of Nutrients in a Catskill Forest: Responses Two Growing Seasons After Treatment

Gregory Lawrence, Anthony Eallonardo, Doug Burns and Scott Bailey

Nitrogen, long considered a growth-limiting nutrient for northern temperate forests, may now be available in excess of that needed by the Catskill forest ecosystem. Elevated concentrations of nitrate in Catskill streams suggest that decades of atmospheric deposition has added more nitrogen than can be retained by plant uptake and microbial cycling processes in the soil. Coincident with increased nitrate availability is a decrease in the availability of calcium and magnesium. Also, important nutrients, calcium and magnesium have been leached out of soils at increased rates by the acidity in atmospheric deposition. Related research in Pennsylvania showed that deficiency of calcium and magnesium resulted in greater susceptibility of sugar maple trees (Acer saccharum) to defoliating insects, which caused high levels of mortality.

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 dolomite (limestone that contains both calcium and magnesium) and/or nitrogen. This experiment is a component of the USGS Nutrient Controls Study that is evaluating the effects of forest harvest intensity on water quality. 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 tree growth and health. This information on nutrient status will enable forest managers to develop strategies that will promote healthy regrowth and avoid impairment of water quality.

Analysis of data from two complete growing seasons is insufficient to fully evaluate the response of overstory trees, however, the response of sugar maple seedlings provides preliminary indications of how nutrient relations are linked to growth of this species. Relative growth rate (biomass in the pre-treatment year/biomass in 2004 or 2005) in the plots that received only nitrogen was virtually the same as in the control plots in both 2004 and 2005. Relative growth rate in the plots that received only dolomite was higher than in control plots and in plots that received only nitrogen, but the differences were not statistically significant. Relative growth rate in plots that received dolomite plus nitrogen was substantially higher ($p < 0.01$) than in any of the treated or control plots. Concentrations of calcium and magnesium, and pH, in the uppermost soil horizon (Oe), were positively correlated with the relative growth rate of the sugar maple seedlings. Concentrations of nitrogen in the leaves of sugar maple seedlings did not vary between the control and any of the treatments. This result, plus the lack of a growth response to nitrogen addition provide a clear indication that nitrogen availability is not the primary growth control of sugar maple seedlings. Increased growth from additions of dolomite and dolomite plus nitrogen, do suggest, however, that calcium and magnesium are limiting growth of sugar maple seedlings. This study will need to be continued to determine if these relationships also occur in overstory trees.

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Forest Management for Long-term Watershed Protection

Deborah Layton

A study was established in several East-of-Hudson watershed areas to determine effectiveness of silvicultural treatments for increasing quantity of understory native tree seedlings and saplings and reducing numbers of undesirable exotic invasive species. Simply having larger numbers of seedlings will not assure forest cover over the next 100 years if the seedlings do not survive to grow into larger size classes in adequate numbers. Native species are generally considered most desirable as they have co-evolved with native wildlife, landforms, hydrological systems, etc. to create balanced ecosystems that are diverse and resistant to disturbances. Exotic species can form monocultures in forest understories if left unchecked. Intact multi-layer forest ecosystems have been shown in many studies to produce the highest quality water.

The silvicultural treatments used in this study included thinning of overstory trees to create canopy gaps and managing invasive exotic plants by removal and, for certain species, stump treatment with herbicide to prevent re-growth of these undesirable plants. Side-by-side comparisons were made at Amawalk reservoir while before-and-after measurements were taken at West Branch, Bog Brook and East Branch Reservoirs. Measurements to date include only the baseline pre-treatment conditions and first year post-treatment at Bog Brook and East Branch, while the West Branch and Amawalk sites have been measured twice following treatment and can reveal longer-term results.

Treatments, to date, have yielded little advantage in increasing numbers of saplings and shrubs over 4.5 feet tall but did result in a reduction of exotic species in most study sites. Total numbers of native tree and shrub seedlings under 4.5 feet tall increased and exotic seedlings decreased on most areas.

Overall results are promising. Continued measurements of these plots will help determine the longer-term effects of the treatments and guide management decisions regarding forests on watershed lands.

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From MBRs to Disposable Membrane Microfilters: Selecting Innovative and Cost Effective Membrane Technologies for NYC Watershed Upgrade Projects

Silvia Marpicati

Many WWTP upgrade projects are under design, construction or startup in the NYC Watershed. These WWTPs are being built or upgraded under the NYCDEP's Watershed Rules and Regulations, which require all new and existing WWTPs discharging to the New York City Watershed to have sandfiltration, disinfection, phosphorus removal and microfiltration (or Department-approved equivalent technology to microfiltration) in order to achieve 99.9% removal and/or inactivation of Giardia lamblia cysts and 99.99% removal and/or inactivation of enteric viruses.

This presentation will review the evolution of the membrane microfiltration systems and NYCDEP approved equivalent technologies within the New York City Watershed throughout the past decade. Current membrane technologies such as membrane biological reactors (MBRs), pressure microfilters, submerged microfilters and disposable microfilters will be evaluated. The applicability, operability and relative impact on costs for both construction and operation will be discussed.

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Phosphorous Loading Reductions in the West Branch of the Delaware River as a Result of Wastewater Treatment Plant Upgrades

James Mayfield and P. Bryce McCann

Wastewater treatment facilities have become increasingly problematic for the New York City water supply due to the quantity of nutrients they release into the reservoirs that result in problems related to eutrophication (algal blooms, deoxygenation, taste and odor, etc.) They are therefore a significant watershed protection focal point under the City's Watershed Regulations, Filtration Avoidance Determination (FAD), and Memorandum of Agreement (MOA). New York City's 1997 Watershed Regulations require owners of wastewater treatment plants (WWTP) located within the watershed to upgrade their facilities, and the City has funded upgraded treatment technology to significantly eliminate the discharge of pathogens and reduce the discharge of other pollutants. Treatment process upgrades included phosphorus removal, nitrogen reduction, disinfection, micro-filtration and sand filtration, as well as alarms, backup power, and flow metering. The upgrades fell into two distinct programs: Regulatory Upgrades, which helped WWTPs meet the Watershed Regulations standards that are beyond any provision of federal or state law, regulation or enforceable standard, and SPDES (State Pollution Discharge Elimination System) Upgrades, which were designed to assist existing West-of-Hudson WWTPs to meet the conditions of their respective SPDES permits. In 2002, upgrades were completed at the municipal plants of the Villages of Delhi, Stamford, Hobart and Walton.

This report will focus on the reduction in nutrient loads leaving these four WWTPs on the West Branch of the Delaware River, and the improvement in water quality detected in the river below each of these plants. The combined total phosphorus (TP) load from the Delhi, Stamford, Hobart and Walton WWTPs in 1994 was almost 5,500 kg/yr (12,100 lb/yr), and in 2004 the combined total phosphorus load was less than 80 kg/yr (176 lb/yr). At the same time the combined flow from these plants increased from less than 2.65 x 10^6 cu. m/yr (700 MG/yr) to more than 3.10 x10^6 cu. m/yr (820 MG/yr). The annual median TP concentration in the stream below these 4 WWTPs ranged from 51-173 µg/l in 1994, and from 23-32 µg/l in 2004. These drastic reductions in nutrients are a result of DEP's effort to upgrade all surface-discharging plants, and also through the efforts of DEPs Regulatory Compliance and Inspection (RCI) group. These efforts will be discussed in light of the observed improvements to water quality, including the removal of the Cannonsville Reservoir from the TP-restricted list, which was a major accomplishment. Also, the companion paper (Trends in Cannonsville Reservoir) to this presentation will provide further details on improvements in the receiving water body.

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Mercury Concentrations in Streamwater, Sediment, and Fish in the Neversink Watershed, Catskill Mountains, NY

Michael McHale

The U.S. Geological Survey measured total mercury (HgT) and methylmercury (MeHg) concentrations in stream water, sediment, and fish throughout the Neversink River basin during 2002 to (1) quantify mercury concentration and distribution in the basin, (2) identify areas of high mercury methylation, and (3) quantify mercury concentrations in fish tissue. Stream-water samples were collected at 20 sites on July 22, August 27, and October 22; bed sediment samples were collected on October 22. Fish tissue samples of resident brook trout (Salvelinus fontinalis) or brown trout (Salmo trutta) fillets were collected at 8 sites from July 22 to 24, 2002. The highest stream-water HgT and MeHg concentrations on each sampling date were in tributaries closest to and upstream from the Neversink Reservoir, and at those sites the highest HgT concentrations were measured in samples from October 22 (2 to 4.5 ng/L). MeHg concentrations were similar among the three sampling dates and ranged from non-detectable to 2.1 ng/L. The highest HgT concentrations in fish tissue (normalized by length) were in fish collected downstream from the Neversink reservoir outlet (0.038 (ug/g)/cm) and the highest HgT concentrations in sediment (12.2 ng/g) were in the fine sediment of a beaver impoundment adjacent to the reservoir. Discharge and antecedent moisture conditions had little effect on MeHg concentrations, most likely because the basin has few wetlands and therefore few areas with potential for high methylation rates.

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The Removal of Emerging Contaminants in Municipal Wastewater Treatment Plants in New York State, 2003-2005

Patrick Phillips, B. Stinson, K. Esposito and S.D. Zaugg

Across the United States, there is a rapidly growing awareness of the occurrence and the toxicological impacts of natural and synthetic trace compounds, known as emerging Contaminants(ECs) in the environment. Wastewater treatment plants (WWTPs) have been identified as a key collection point for ECs in the water cycle and potentially an ideal location at which to treat to remove them, thereby mitigating their release into the environment. Little is known about the nature, variability, transport and fate of ECs in typical wastewaters and treatment facilities in the United States. Furthermore few studies have been performed to monitor or understand the capability of conventional or innovative wastewater treatment processes to remove or reduce the concentrations of a wide variety of ECs at wastewater facilities. This study was designed to provide baseline information on this topic.

Wastewaters appear to contain a wide range of ECs. Over 55 of the 63 target contaminants were detected in the five different wastewaters examined during the course of this study, 44 of them frequently. The median cumulative concentrations of EC in the wastewaters ranged from between 120 µg/L to just over 500 µg/L. The raw wastewater characteristics were not as variable as anticipated.

Conventional wastewater treatment processes were effective in removing significant amounts of the ECs. Results indicated that the type of technology operated and the mode of operation both had an impact on the removal capability of the plants.

Over half of the frequently detected ECs were reduced by 95 percent or more in samples collected at Plants which operated an activated sludge process. Less than 10 percent of the ECs were reduced by 95 percent or more at Plant D, which uses a trickling filter treatment process

Furthermore, focused pilot studies indicated that increased removals of ECs were closely associated with increased SRTs in the activated sludge process. The most significant impact of SRT appeared to occur as the sludge age increased above 5 days. While removals continued to improve as the SRT increased above 10 days the benefits were less marked.

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Evaluating the Transport of Giardia spp. from Field Monitoring Data within the West of Hudson District New York City Upstate Reservoirs

Gerald Pratt and Allison Bennett

The Pathogen Monitoring Group of the New York City Department of Environmental Protection (DEP) has developed and implemented a water quality monitoring objective to assess its six reservoir basins within the West of Hudson system. Each of the reservoirs, which function as impoundments, varies in storage and shape. These differences in the reservoirs' physical characteristics could affect fate and transport of, among other things, microbial constituents such as Giardia spp. passing through them. A reservoir analysis was conducted to determine if a difference exists in Giardia cysts entering and leaving the reservoirs. Filtration samples were collected for Giardia cysts from each of the reservoir's primary inflow and outflow locations and enumerated for concentration per 50 liters. Over 650 samples used in this study were processed using USEPA Method 1623 from 2002 through 2005. Sampling frequency at each site was monthly except for one which was weekly. This difference in sample frequency did not affect the outcome of the analysis. Annual inflow and outflow Giardia median and flow weighted medians concentrations were calculated and regression analysis performed. Additionally outflow data were compared to residence time and temperature for each of the reservoirs and evaluated for trends and seasonal effects. Research such as this is an essential building block to reservoir removal rates as it relates to risk posed to a public water supply and may provide insight into other more complex reservoir processes and kinetic effects (e.g., sedimentation, dispersion).

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Recharge to Bedrock in an Upland Locality in Eastern New York

Allan Randall

Averill Park is a residential hamlet in an upland area of till-mantled bedrock in east-central New York. Water is pumped from on-lot wells that penetrate shale bedrock; wastewater goes to sanitary sewers. Measurement of static water levels in 2002 in 145 wells allowed delineation of a 0.54-square-mile area within which ground-water discharge is entirely by pumpage from wells and should equal recharge from infiltration of precipitation. That recharge sustains a residential population density of 1.9 persons per acre, and is estimated to average 104 gallons per day per acre (based on per capita consumption in two neighborhoods of similar homes served by metered public water supply in nearby towns). However, the rate of recharge is inferred to be higher in 20 percent of the study area where bedrock is discontinuously mantled by less than 30 feet of till, and lower where bedrock is mantled by thick till in the form of drumlins, as evidenced by the fact that high heads and strong downward gradients within the bedrock, and very hard high-chloride water that results from infiltration of winter highway runoff, are largely restricted to the area of discontinuous thin till.

The average recharge rate of 104 gallons per day per acre computed in this study is substantially smaller than average recharge rates that have been computed from streamflow hydrographs by base-flow separation methods for upland areas elsewhere in and near New York. Results of base-flow separation include recharge to till and any other unconsolidated deposits in upland areas as well as recharge to the bedrock aquifer that is tapped by most wells. If several other residential hamlets or clustered housing developments in upland localities were studied in much the same manner as Averill Park, and if these clusters incorporated a range of bedrock types, till thicknesses, precipitation, and topographic settings, it should be possible to come up with a reliable estimate of sustainable housing density at any location in the uplands of New York.

Water-quality data from Averill Park and a few nearby localities suggest that substantial degradation of ground-water quality in bedrock by highway de-icing chemicals is much more likely in upland localities of negligible overburden thickness than where bedrock is overlain by 30-100 feet or more of glacial till.

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Mercury Cycling and Bioaccumulation in the Upper Neversink and Upper Hudson Rivers, New York

Karen Riva-Murray, Douglas Burns, Michael McHale and Mark D. Brigham

Investigations of mercury cycling and bioaccumulation in riverine systems were initiated at five watersheds in 2005 as part of the National Water Quality Assessment Program of the U.S. Geological Survey. Objectives are (1) assessment of the relative importance of selected ecosystem components in net production, transport, and bioaccumulation of methylmercury in streams and rivers, and (2) evaluation of the effect of natural and manmade factors on these processes. Two of the study areas are in New York State: the upper Hudson River (Newcomb, NY), and the Neversink River (Claryville, NY). The three other study areas are the Edisto River (Givhans, SC), the Raritan River (Bound Brook, NJ), and the Clinton River (Sterling Heights, MI). These five watersheds encompass a broad range of land use and environmental settings. Their simultaneous investigation will facilitate comparison of methylation, demethylation, transport, bioaccumulation, and other processes in relation to factors such as urban, forest, and wetland land uses, point and nonpoint chemical inputs, and watershed hydrology. Components of the mercury cycle to be assessed include wet-depositional flux of total mercury and methylmercury (determined via Mercury Deposition Network collectors); methylation and demethylation in various media (through rate experiments); biogeochemistry of stream sediments and upland soils; and determination of methylmercury concentrations in aquatic organisms representing various trophic levels, from primary producers to top predator fishes.

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Sewage Treatment - Small System in A Watershed

Andric Rodriguez and Lowell A. Kachalsky

Water purveyors, in examining their watersheds, have raised concerns over small community pollution sources, particularly over phosphorus, nitrogen, pathogens and suspended solids. As our population has increasingly moved further upstream in watersheds, the application of classic sewage treatment plants (STPs) have been pushed to their limit of design, especially in light of the need by water purveyors to gain control of pollutant sources and emerging issues. Needs for upgraded and/or new STPs are readily evident. Typical downsized big system designs are being applied. However, many of the existing STPs that need upgrading or replacement are located on sites that have residents screaming in anger and the costs of treatment are causing some to be concerned about their family budgets and the sellability of their homes.

O'Brien & Gere Engineers, Inc. (OBG) was retained by the Town of Beekman, New York to design a STP to replace the existing plant at the Dover Ridge residential community. The Town was required to take over the facility following default of the former owner.

The existing STP, which was not meeting several of the requirements of its NYSDEC SPDES permit, discharged to a waterbody tributary to the water supply of a correctional facility. The existing STP consisted of intermittent sand filter beds and sodium hypochlorite disinfection. Such designs are common for small communities, schools, and camps. These systems are typically unable to handle increasingly more stringent effluent requirements that are being imposed by regulating agencies, especially for those STPs that discharge to drinking water supplies.

Under pressure of an order on consent, an initial solution consisting of an MBR was proposed. However, the community demanded a lower cost facility to keep sewer fees at affordable levels. In addition, the project site was in the backyards of homes and a zero profile facility was important to residents. To meet these requirements, OBG proposed a recirculating sand filter (RSF) based STP. Advantages of RSFs over conventional STPs (e.g., activated sludge, fixed film) are as follows:

-Simpler operation and lower O&M costs

-Less visual impacts

-Improved solids removal and enhanced nutrient removal

Other improvements at Dover Ridge included additional septic tankage, UV disinfection, and cascade aeration.

RSFs offer superior performance and have lower footprint requirements than traditional intermittent sand beds. Their improved suspended solids removal allows for the use of UV disinfection, which does not form disinfection by products, as does chlorine.

To date, the construction of the new Dover Ridge STP is complete. Actual operating data will be discussed at the presentation.

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Climate Change Scenarios for the New York City Watershed and Metropolitan Region

Cynthia Rosenzweig, Radley Horton and Asher Siebert

Columbia University' Center for Climate Systems Research (CCSR) evaluates climate change forecasts, impacts, indicators, and adaptation and mitigation strategies to support decision-making throughout the New York City Metropolitan Region. One of the principal ways the Center approaches its science work is through the development of regional climate scenarios for the current century. These scenarios are based on recent GCM simulations for the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. CCSR has chosen three scenarios from the IPCC' Special Report on Emission Scenarios: A2, A1B, and B2, and five GCMs to provide a suite of future scenarios to guide adaptation planning. This approach provides a range of outcomes suitable for risk management planning that incorporates both emissions scenario and climate model variability.

Daily and monthly temperature and precipitation results from the GCM simulations chosen for the regional scenarios are statistically downscaled for the New York City watershed and urban region using interpolation techniques, applied to the appropriate grids for the different models. Sea-level rise estimates are taken from the applicable GCM model grid and adjusted as needed for local subsidence, thermal expansion, and freshwater influx. Other GCM outputs, such as specific humidity, solar radiation, and windspeed that are relevant to the New York City water supply, sewer, and wastewater treatment systems as well as to City infrastructure, are also downscaled from the grids. The GCMs are validated and calibrated where necessary to appropriate temporal scales, through comparison of hindcast runs based on historical greenhouse gas concentrations with observed historical climate. These scenarios can then be used to guide the identification and development of appropriate adaptations for the New York City Metropolitan Region.

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Divided Forests: Landowner Parcelization Decisions in the NYC Watershed

Rebecca Sanborn and Mary Tyrrell

The fragmentation and loss of forestland in the northeastern United States is a well-established trend (Alig et al. 2000, Peterson 2000), correlating with rising development rates in rural areas. Tyrrell et al. (2004) found that conversion of forest to non-forest in the Catskill region of New York State is occurring at about 1% per year, and will result in the loss of approximately 162,000 acres of forestland by 2011. There are many possible explanations for the increasing sale and subdivision of large forest tracks, including a decline in working lands, an aging base of private forest owners, an increased demand for second home sites, and the excessive burdens of estate and property taxes (Greene et al. 2000, Birch 1996). No studies have surveyed landowners about their objectives and reasons for subdividing, however. This data on landowner decisions can help to inform sound tax and land use policy in the future.

In the New York City Watershed of the Catskill region, New York, we surveyed forest landowners in a study area comprising 1,198,400 acres of land in Ulster, Delaware, Schoharie, Sullivan, and Greene counties. Using GIS parcel data available from the New York State Office of Real Property, we identified 4426 individual parcels in the study area over 80 acres in 1996, 904 of which were subdivided by 2001 and another 409 subdivided by 2004. The average parcel size for the study area declined from 27.32 to 20.18 acres during this time period.

We sent mail surveys (Dillman 1978) to all individuals who were owners in 1996 of a parcel that has since been subdivided. Survey questions focused on motivations for owning and purchasing land; circumstances of acquisition; land use and timber harvests during ownership; reasons for subdividing; and demographic characteristics. In addition, we surveyed 600 landowners who did not subdivide large (greater than 80-acre) parcels in the study region during the same time period. We asked the control group a series of similar questions, focusing instead on reasons the landowners did not choose to subdivide property.

While complete results are not yet available, several trends have already emerged from the data. The mean age of subdividing landowners in the study area is 68 years, which is significantly older than the mean age for landowners overall. Anecdotal evidence has suggested that landowners are forced to subdivide to cover medical costs and retirement, especially when no younger family members are interested in taking over forest management; the trends in age distribution seem to support that theory. In addition, the largest parcels seem primarily to be owned by government entities; 41 of 53 (77%) of parcels larger than 1000 acres were owned either by New York State or New York City. Very few of these parcels were subdivided between 1996 and 2004, and several were actually expanded. The size category at greatest risk appears to be parcels between 80 and 250 acres in size, which are primarily owned by individuals or families.

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Using Data and Modeling to Estimate Impacts of Phosphorous Reduction Programs and Land Use Change on Nutrient Loads to Cannonsville Reservoir

Elliot M. Schneiderman and Mark S. Zion

Fourteen years of water quality monitoring of the West Branch Delaware River at Beerston (WBDR), at the inlet to the Cannonsville Reservoir, and an application of GWLF, a watershed water quality model, were used to investigate the relative impacts of watershed management programs and land use change on phosphorus loads. The GWLF model was calibrated and validated against streamflow and nutrient loading data for 1992-1999. Future predicted nutrient load reductions due to watershed management of non-point sources (agricultural and urban best management practices) and point sources (upgrading of treatment plants to tertiary treatment of phosphorus) were estimated and tested against monitoring data at WDBR for 2000-2004.

Substantial reductions in nutrient loads were predicted due to watershed management, but these predicted reductions for dissolved nutrients were much less than the observed reductions. We attribute the additional observed reductions to substantial losses in agricultural land use and livestock that occurred independently of watershed management from 1997 to 2003. When nutrient concentrations in runoff in GWLF are further reduced by the decrease in livestock, predicted dissolved nutrient loads approach observed loads for the test period. The combined data and model results indicate that runoff concentrations of dissolved nutrients are rapidly sensitive to both changes in the watershed nutrient mass balance and by improvements associated with implementation of watershed management programs.

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Use of Advanced Surface and Borehole Geophysical Methods in Environmental and Engineering Studies

Frederick Stumm and Anthony Chu

The U.S. Geological Survey has used advanced borehole and surface geophysical techniques in a wide range of environmental and engineering studies in the New York City area and on Long Island in an effort to study the region's hydrogeology. The case studies described below present new and innovative applications of surface and borehole geophysical techniques in urban environments.

Surface-geophysical methods such as a new 2-D capacitive resistivity system and 100-MHZ ground-penetrating radar have been used in Brooklyn to delineate local variations in unconsolidated deposits, locations of buried cables, and presence of boulders below pavement. These techniques, coupled with hydrologic data and borehole geophysical logs such as gamma, electromagnetic induction, optical televiewer, and borehole radar were used to delineate the extent and local variation in subsurface hydrogeologic units, presence of subsurface boulders, locations of locally elevated and regional water tables, and the general direction of ground-water flow.

2-D resistivity surveys were completed in eastern Suffolk County at a public-supply pumping center. High amperage current was injected into the earth and the resulting data was processed to produce a 100 ft. deep resistivity profile. The water-table and a conductive plume of roadsalt from a nearby recharge basin were delineated.

Advanced borehole-geophysical techniques were used to assess the hydrogeology of crystalline bedrock in 26 boreholes on Manhattan Island that were drilled in preparation for construction of a water-supply tunnel. The boreholes provided a unique opportunity to study the fractured-rock ground-water flow system in southern Manhattan Island. The geophysical logs included natural gamma, single-point resistance, short-normal resistivity, mechanical and acoustic caliper, magnetic susceptibility, borehole-fluid temperature, resistivity, and specific conductance, dissolved oxygen, pH, redox, heat-pulse flowmeter, borehole deviation, acoustic and optical televiewer, and borehole radar. Hydraulic-head and specific-capacity-test data were collected from these and other boreholes, all of which penetrated gneiss, schist, and other types of crystalline bedrock. Heat-pulse flowmeter logs were obtained under pumping and nonpumping conditions and, together with other geophysical logs, indicate transmissive fracture zones at every borehole. The 60-MHZ directional borehole-radar logs delineated the locations and orientations of several radar reflectors that did not intersect the projection of the borehole.

Continuous marine seismic-reflection surveys in the East River along Manhattan Island's southeastern coastline and along the north shore of Long Island delineated the northern extent of several hydrogeologic units and variations in the bedrock-surface altitude beneath the sea floor.

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Monitoring the Performance of Stormwater BMP Retrofit Projects

David Van Valkenburg and Tracy Lawrence

The Water Quality Impact Assessment Group (WQIA) of the New York City Department of Environmental Protection (DEP) in partnership with the Catskill Watershed Corporation (CWC) has developed and implemented a water quality monitoring project to measure the efficiency of stormwater best management practice (BMP) retrofits to remove pollutants. As part of the New York City Watershed Agreement, the Stormwater Retrofit Program has implemented more than 20 construction projects since its inception. The objectives of this monitoring program are to quantify the removal of pollutants from stormwater runoff, mainly total suspended solids and total phosphorus, by different BMP types.

This presentation will focus on a discussion of the actual field data collection methods used and the procedures applied to estimate the efficiency of monitored BMPs to remove pollutants from stormwater. This monitoring project utilizes automated sampling equipment to collect flow-weighted composite samples from both the inflow and outflow of the BMP structures during rainfall runoff events. There were three different types of BMP retrofit devices slated for monitoring by this program. These structures are located in Catskill watershed villages and have small drainage areas of less than 50 acres. Each BMP inflow and outflow storm event sample is collected as a composite sample into a single sample container which is then analyzed to determine pollutant concentrations. Composite sample results are used to estimate an Event Mean Concentration (EMC) of pollutants for both the stormwater entering and exiting the BMP system. A comparison of these two EMCs, referred to as the Efficiency Ratio, is used to evaluate the efficiency of a BMP to remove pollutants for individual storm events.

Developing an accurate EMC requires that each aliquot of a composite sample represent an equivalent portion of the total storm event. In practice this can be difficult to accomplish as automated sampling equipment must be programmed to account for predicted runoff and complex field conditions. However, once automated sampler programming has been refined and field conditions have been accounted for representative composite samples can be collected and accurate BMP efficiency ratios for individual events can be determined. BMP efficiency ratings for individual storms can be highly variable and may not be indicative of overall BMP performance. To determine overall BMP efficiency a sufficient number of individual events must be monitored. The Lognormal Statistical Efficiency method can then be used to estimate overall BMP efficiency for a range of runoff events.

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Developing an Integrated and Comprehensive Buffer Initiative for Agricultural Lands in the NYC Watershed

Richard Weidenbach and Scott Gladstone

Policy makers and resource professionals alike are challenged in the development, funding and delivery of a comprehensive, practical and science-based buffer initiative for agricultural land in the New York City watershed. There is a need to integrate existing programs and emerging science with our understanding of how streams function and how pollutants are delivered.

Current programs and farm planning procedures implemented by USDA, SWCDs and the Watershed Agricultural Program have provided opportunities for resource professionals to plan and implement buffers on agricultural lands in the NYC watershed. The most notable effort in the watershed is the Conservation Reserve Enhancement Program (CREP), administered by the USDA/Farm Service Agency. CREP is a voluntary USDA program that establishes buffers between agricultural fields and streams. CREP is the only program in the NYC watershed that attempts to mitigate the financial impacts on farms as a result of removing land from agricultural production for the purpose of establishing buffers. CREP buffers primarily address nutrient and sediment delivery from agricultural lands as well as providing benefits to fish and wildlife.

In addition to establishing buffers for the purpose of reducing pollutant delivery from agricultural land, there remains a strong need to establish buffers from a stream stability and morphology standpoint. The Stream Corridor Management Plan for the West Branch Delaware River has identified 18 streambank miles between Walton and Stamford that are actively eroding. The majority of this eroding agricultural land is not eligible for CREP because federal rules require that stream banks be stable before buffers are established.

Policy makers and resource professionals alike are challenged by this situation, because the cost to stabilize these sites is often prohibitive and in many situations, not technically feasible. As an example, stream program staff in Delaware County have identified a 4.35 mile segment of the West Branch Delaware River that exhibits an unstable geometry. The river is adjusting and will continue to migrate until it reaches a more stable sinuosity. Intervention at this location is estimated at approximately 1 million dollars. However, conventional intervention techniques are ineffective in these situations and are likely to fail.

This challenge to policy makers is profound. If CREP cannot be implemented due to reasons of instability, and the option for intervention is expensive and not technically feasible, it is inevitable that this resource concern will continue indefinitely. As many resource professionals know, the development of a cost-effective streambank stabilization program has eluded policy makers for many years.

This presentation will explore options and facilitate discussions for the development of a comprehensive buffer initiative for agricultural lands in the NYC watershed. Future efforts need to integrate the science of stream morphlogy with the need to establish buffers that address the delivery of nutrients and sediment from surface runoff. The opportunity exists to integrate our emerging understanding of streams with existing buffer programs, forming a comprehensive approach that has the potential to be cost effective and practical. Options to be discussed include a Variable Width Buffer pilot initiative as well as enhancements to the USDA CREP.

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Land Use/Land Cover Classification and Change Detection of the Catskill/Delaware Watersheds From 1975 to 2002 Using Cross Correlation Analysis

Mehmet Yavuz and Myrna H. P. Hall

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Due to space and time limitations, the following abstracts were not able to be presented at the 2006 conference, but are instead printed on the following pages with the gracious permission of the authors:

Seeing the Forest Through the Trees: A Critical Examination of the New York City Watershed Land Acquisition and Easement Program

Damian Cavaleri

One of the many tools employed in protecting the New York City Watershed within the Memorandum of Agreement is land acquisition and management. Land acquisition and management plans are very useful in their ability to organize development and permanently protect open spaces. They have been shown to dramatically decrease the cost of treatment and even, in the case of the New York City Watershed, obviate the requirement that a filtration plant is necessary under the Surface Water Treatment Rule in the Safe Drinking Water Act. The land acquisition plan that is being utilized in the New York City Watershed incorporates both an acquisition plan and an easement plan. While the plan has been successful insofar as creating permanent open space, it has faced animosity because of the structure in which land rights are purchased and its potential impact on the economic development of the regions. The current system that has been set up seems to have great potential, however other groups would like more involvement in the decision-making process so that their perspectives can be understood and incorporated into what transpires. Allowing their involvement will not only provide the benefit of greater support from those areas involved but the involvement will also confront other major issues stemming from the changed land uses. The major issues that will be confronted with the proposed incorporation are those addressing planning on the local level, knowing the potential future uses of the land, and knowing the impact that the acquisition of the land or placing an easement upon it will have. As for the WAC, the easements created do not seem to have a provision if the land is no longer used as a farm. Further, there are various enforcement problems in the agricultural easement itself. Using a comprehensive body to review the land acquisitions and easements prior to their completion the aforementioned issues may be remedied. This body may be newly created or created as a subcommittee under the Watershed Protection and Partnership Council. The land and easements that are purchased have a great impact on the areas in which they are located and those responsible for the future development in those areas need to have the opportunity to describe these impacts to those deciding about their purchase.

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Total Water Management: Managing the Water Cycle

Avinash Patwardhan and Aditya Tyagi

As communities grow, managing water resources becomes increasingly complex. Growing demands for water supply intensify need for new sources, conservation, and reuse. At the same time, from a watershed perspective, environmental needs often are considered to compete for water resources. These dynamics highlight complex inter-relationships among the links in the water management cycle, including source, supply, demands, treatment, reuse, and back to source again. Such inter-relationships create greater complexity for water managers, who are already challenged to contain or reduce system capital and operating costs.

Decision-making priorities often are focused on critical issues at specific points in the water management cycle. These may include, changing reservoir operations to provide flows for environmental purposes, changes in flow management at a treatment facility, or the challenges associated with discharging treated effluent for downstream users. Management decisions made only with respect to a single point or a single component in the water management cycle can have unexpected impacts elsewhere in the cycle. A total water management perspective is critical to ensure that the entire system is managed as a whole, thereby providing for a long-term, sustainable water supply.

This paper presents the concept of Total Water Management and its application two projects. The first project, a water supply project in Salt Lake City, Utah for the Recycled Water Coalition, a consortium of Utah water and wastewater agencies, that is committed to identifying projects that will meet increasing water demands without adversely affecting downstream flows that are needed to support waterfowl and other wildlife. The second project is for Tianjin Economic Development Area (TEDA) in China. TEDA's vision is to become a base for processing and manufacturing center for high-tech products, and commercializing high-tech research work. Among various elements of infrastructure that TEDA is developing, a dependable water infrastructure system is the key component of development.

The objectives of the model for Recycled Water Coalition were to consider the flow impacts to the Jordan River that may result from changes such as increased wastewater recycling and increased importation of water supplies. The model provided the most comprehensive view of water supply, use, and return flows to the river available and will be used for evaluating future water projects.

TEDA's goal was to develop a comprehensive broad-based water supply planning based on expectations for future demand due to economic and population growth and competing needs for water sources while considering both conveyance, treatment costs of their water supplies. The major objectives of this study were to evaluate water supply options for TEDA's future water needs in the most economical manner. In brief the major objectives were:

1. Develop and evaluate future water supply options and costs
2. Develop a user friendly model that will optimize water supply options

The results from using the concept of Total Water Management to two projects will be presented along using a unique model, VOYAGETM, that is user friendly and allowed the development of these water supply plans.

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Optimization of Nutrient Removal

Robert Lagrange

1. The use of instrumentation in standard nitrification plants has limited acceptance. Flow and dissolved oxygen (DO) measurements are well accepted. Most of the time only flow is included in an automatic control strategy. Mixed liquor Suspended Solids, pH and ORP are used at times. The use of chemical analyzers to determine the concentration of ammonia and the inclusion in a control strategy remains an exception.

2. The complexity of the processes increases when denitrification and phosphate removal are added. Additional measurements such as nitrate and phosphate concentration become a requirement. Depending on the plant configuration the measurement of BOD, TOC or Methanol concentration could also be beneficial.

All the measurements required in the optimization of a process for nutrient removal require justification and recommendation for installation and use in a control strategy.

For each process we will define the best technology, the installation requirements for optimum performances and the role in the process optimization.

Those are some basic examples that can then be extrapolated to other processes

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Integrating River Science and GIS Technology

Gregory Liberman

Expanding suburban development is increasing the impacts to our rivers and streams. Increased rates of surface run-off, undersized culverts and reduced riparian zones are causing devastating problems to a variety of river systems. Although restorative measures can be implemented in order to make degraded channels functional, a lack of accurate data can limit restoration approaches at both the site and regional level.

By integrating river morphology principles with GIS and GPS technologies, environmental scientists can develop comprehensive datasets that can act as a baseline for widespread restoration and planning efforts. One such example involves an erosion mapping study which blended BEHI (Bank Erosion Hazard Index) characteristics into a GIS in order to accurately map, catalogue and disseminated riverbank erosion information. The BEHI characteristics mapped included Bank Height, Bank Slope, Bank Material and Quantity of Vegetation (root mass). The mapping was completed from a boat, using a GPS antennae running through a digital video recorder. The video recording allowed for a documented piece of information which could be used as reference in the future. Once BEHI was mapped, the datasets were overlaid in GIS with contextual spatial datasets (roads, property lines, town lines, etc . . .) and areas of significant erosion were quantified.

When both are utilized separately, mapping capabilities such as GIS, and river morphology principles such as BEHI can be limited in scope. Through the process of integration, environmental scientists can achieve a variety of project goals including; locating areas of significant erosion in need of future restoration, plan site specific restoration measures and implement the zoning and regulatory changes based on accurate baseline data.

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