NEW YORK CITY DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATER SUPPLY

Research Objectives Report

This report provides the status of various research programs addressing the sources, fate, and transport of key constituents, and the status of the evaluation of data generated by other agencies. This report also addresses research on watershed processes affecting water quality, special research projects, and contains abstracts from a watershed monitoring seminar later in the year.

May 15, 2005
(Revised June 28, 2005)

Prepared in accordance with the November 2002 United States Environmental Protection Agency Filtration Avoidance Determination

Prepared by: Division of Drinking Water Quality Control
Bureau of Water Supply

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1. Introduction

1.1 Purpose

This report addresses the requirement “Submit Research Objectives Report” under Section 5.1 (Watershed Monitoring Program) of the November 2002 New York City Filtration Avoidance Determination (for the Catskill/Delaware Water Supply System). This requirement states: “This report will provide the status of various research programs addressing the sources, fate, and transport of key constituents, and the status of the evaluation of data generated by other agencies. This report will also address research on watershed processes affecting water quality such as key modeling programs. It will also identify special research projects that will be conducted during the following year and will assess the need for conducting a watershed monitoring seminar to disseminate data in the upcoming year and, as appropriate, identify a target date." This report is required to be posted on the DEP website.

1.2 Scope

This report may be viewed as a companion to the Bureau of Water Supply’s (BWS) Watershed Water Quality Annual Report (due at the end of July each year). The Annual Report addresses DEP data, obtained from the previous calendar year, whereas this Research Objectives Report focuses on current research, future research still in the developmental stage, and research programs on the watershed conducted by outside agencies, the aim being to provide an update on progress at the end of 2004.

This report is laid out parallel to the structure of the FAD. The order of studies described is under the following headings: Environmental Infrastructure; Protection and Remediation Programs; Watershed Monitoring, Modeling and GIS; and Data and Methods Development.

Although the requirement for this report, as stated in the Purpose above, is to describe ongoing research pertinent to the Filtration Avoidance Determination (FAD—which is directed towards the Catskill/Delaware Water Supply System) we have included other studies for completeness including those being conducted East-of-Hudson and those conducted on analytical method development, e.g., for pathogen enumeration, fisheries studies, and work carried out under the Croton Process Studies contract (now complete).

Periodic seminars on watershed monitoring are part of the City’s efforts to foster communication about NYC’s watershed. The need for such seminars must be evaluated on a regular basis and “identified” in the Research Objectives Report. To comply with this requirement, on September 21/22, 2005, the Third Annual New York City Watershed Science and Technical Conference will take place in Fishkill, N.Y. DEP staff have submitted 24 papers for consideration out of a total of 48. The abstracts from DEP submissions are presented in the Appendix of this report.

2. Current BWS Research

2.1 Environmental Infrastructure

2.1.1 Stormwater Management Practices Monitoring Demonstration Project

Managers: James Benson/Eve Bocca
Start & Completion Date: February 2001 to August 2005
Status (% Complete): 68
Project Cost: $60K
Objective and Justification:

The goals of this project are to 1) assess watershed conditions, monitor water quality and evaluate sampling data, and identify incidences of improperly controlled stormwater that result in the discharge of pollutants to the water supply, and 2) through the design, construction and monitoring of stormwater management practices, reduce nonpoint sources of pollution in the water supply watersheds and generate important data concerning the effectiveness of stormwater management practices in reducing stormwater related pollution.

Following an initial monitoring period, DEP will retrofit two existing Stormwater Management Practices (SMPs) in the West Branch and Croton Falls reservoir drainage basins, in the Town of Carmel, New York. Specifically, the objectives of this program are:

- To initiate and provide high runoff (storm event) monitoring in a manner that is sufficient to compare the percent removal of two wetland extended detention basins to the design pollutant removal efficiencies for wetland extended detention basins, as specified in the New York State Department of Environmental Conservation's (DEC's) "Reducing Impacts of Runoff from New Development.
- To quantify the effectiveness of the retrofitted wetland extended detention basins by comparing pre and post retrofit monitoring data as well as comparing the monitoring data from the retrofitted inlet and outlet structures. Specifically, an annual load reduction of Total Phosphorus (TP), Total Dissolved Phosphorus (TDP), Total Suspended Solids (TSS), and Dissolved Organic Carbon (DOC), will be calculated.

Implications for Watershed Management:

Numerous stormwater management control facilities are being installed throughout the New York City drinking water supply watershed to remediate nonpoint sources of water pollution and minimize the impact of new and existing development on water quality. The New York City Watershed Regulations require that the stormwater management facilities meet certain design and performance standards. While not mandated by EPA, these types of management practices are recommended to treat stormwater runoff from land use development projects. Within the East of Hudson watersheds of the New York City drinking water supply watershed, stormwater pollution prevention plans that include SMPs such as these are required to reduce total phosphorus and total suspended solids from stormwater runoff to pre-construction levels.

The information gained in this study will be directly applied to DEP's regulatory and non-regulatory stormwater and nonpoint source management programs. This study will provide critical site-specific information on facility performance, design standards and maintenance needs. This project is particularly important because little site specific information is available concerning the treatment abilities of SMPs as they relate to New York City's drinking water quality goals, SMP performance standards and programs.

Problems Encountered:

There were delays in starting this project, therefore, only Phase 1 of the project will be completed within the grant #3 period. In order to close out the project on time, we will have to continue the monitoring after the SMPs are constructed in a second phase of the project. Phase II will be implemented under SDWA Grant #5.

2.1.2 Stormwater Retrofit Sampling Partnership Program

Manager: Tracy Lawrence
Start & Completion Date: September 2003 to December 2005
Status (% Complete): 25
Project Cost: $60K (DEP) + $60K Laboratory Analysis Contract (CWC)
Objectives and Justification:

The West-of-Hudson (WOH) Stormwater BMP Retrofit program was set forth as part of the NYC Watershed Agreement. In the agreement, the City allocated $7.6 million for stormwater BMP retrofits to treat stormwater runoff in concentrated areas of impervious surfaces in the WOH District. The Water Quality Impact Assessment group of DEP is developing and implementing this stormwater BMP monitoring program to determine the effectiveness of retrofitted BMPs to improve water quality. In a partnership role with DEP, the Catskill Watershed Corporation (CWC) is funding a contract, which will provide for the analyses of all of the project's samples by a commercial laboratory. In 2004 automated monitoring equipment was installed at all four BMP sites. However, the project encountered many difficulties in measuring flow into and out of the BMP structures. At two sites constant flow enters the BMPs unrelated to any recent storm events making sampling and determining storm related flow contributions difficult. To address flow-monitoring problems, weirs were purchased and installed at many sampling locations. This inability to accurately measure flow prevented the collection of flow-weighted composite water quality samples. Therefore, in 2004 only rainfall and flow data was collected for this project. In 2005 the improvement in flow measurement techniques should allow for the project to begin storm event sample collection so that the project's objectives can be met.

Implications for Watershed Management:

This research will determine which stormwater BMP technologies perform best at meeting DEP's water quality objectives and ultimately help quantify the success of the BMP retrofit program. It is hoped that results from this research will be used to help guide the selection of future stormwater BMP practices by identifying those that provide the greatest benefit in water quality.

Problems Encountered:

An inability to accurately measure flow prevented the collection of flow-weighted composite water quality samples. Improved flow measurement techniques will be implemented in 2005 to alleviate this problem.

2.1.3 Kensico Stream Best Management Practices Monitoring Project

Manager: Dale Borchert
Start & Completion Date: January 2000 to December 2007
Status (% Complete): 40
Project Cost: N/A
Objectives and Justification:

The objective of this project is to evaluate the effectiveness of Kensico BMPs at reducing storm loads of fecal coliform, total suspended solids, turbidity and total phosphorus. During 1998 - 2004, ten extended detention basin Best Management Practices were installed on streams discharging to Kensico Reservoir. The purpose of these BMPs was to reduce the loads of fecal coliform and turbidity discharged to Kensico Reservoir from its tributaries during storm events. During 1999, DWQC developed a plan to monitor these BMPs to evaluate their effectiveness at controlling these loads. In addition, the analytes of total phosphorus and total suspended solids were added, as most extended detention basins BMPs are constructed to address these analytes. This monitoring plan has been modified to rotate among five of the constructed BMPs over a 7-year period. This rotational schedule intends to allow sufficient time for the collection of data that would be necessary to evaluate the effectiveness of these selected BMPs.

Implications for Watershed Management:

Data collected from this project will be used to evaluate the effectiveness of structural nonpoint source pollution control programs. Data may also be used to provide information to Stormwater Pollution Prevention Plan applicants.

Problems Encountered:

During the first four years of monitoring, we learned that our original monitoring time frame was too ambitious, considering the logistics of collecting sufficient data for the analysis of each BMP. Specifically, fecal coliform monitoring required the adherence to strict holding times. This limited our ability to coordinate sampling and laboratory analysis, reducing the number of storm events that could be satisfactorily monitored during one year.

This problem was addressed by allowing for a 24-hour holding time for fecal coliform. This change should not affect the quality of our results, but will provide us with a greater opportunity to monitor more storm events during a given year.

2.1.4 Red Falls Monitoring Report

Manager: James Porter

Start & Completion Dates: May 1998 to April 2010 based on Greene County's newest plan to install BMPs in 2006 (Red Falls) and 2007 (Conine). QAPP currently gives end date of December 2005 but this will be revised.

Report due date: Phase 1:December 2009; will include preliminary Red Falls data. Phase II (final report): December 2010; will include additional Red Falls data plus Conine data.

Status (% Complete): approximately 50, the same as last year due to significant extension of monitoring period following delays in BMP construction (originally scheduled for 2002).

Project Cost: N/A

Objective and Justification:

The objective of this study is to quantify the effectiveness of best management practices (BMPs) at reducing turbidity and suspended sediment in the Batavia Kill stream. Observations and sampling have documented that the Batavia Kill delivers a significant quantity of suspended sediment and turbid water to Schoharie Creek, the main inflow to Schoharie Reservoir. Major sediment source areas are known above and below Red Falls. Through a contract with the Stream Management Program of DEP's Division of Watershed Lands and Community Planning (WLCP), Greene County Soil and Water Conservation District will design and implement BMPs to reduce the sediment and turbidity originating in the Red Falls area. DWQC's Hydrology Program has been monitoring several sites on the Batavia Kill prior to BMP implementation, and will continue to do so for several years after implementation (currently scheduled for 2006 and 2007). As turbidity and suspended sediment are one of the most important water quality issues facing the NYCDEP in the Schoharie watershed, evaluating the effectiveness of methods intended to reduce them is a priority research need.

Implications for Watershed Management:

By quantifying the turbidity and suspended sediment loads in the Batavia Kill before and after BMP implementation, we will be able to evaluate the effectiveness of the approach used, and that in turn will guide BMP design for other problem sites in the watershed. Ultimately, information gleaned from this project should help the NYCDEP be more effective and cost-efficient in reducing sediment and turbidity in watershed streams.

Problems Encountered:

Wet weather and archaeological investigations have caused Greene County Soil and Water to repeatedly reschedule the construction of BMPs at this site. The original construction date was Summer 2002. The current plan is for construction in Summers 2006 and 2007. This has significantly extended the monitoring period for Hydrology, from 8 years to 12 years. A letter detailing the changes in the reporting schedule was delivered to EPA on April 4, 2005.

2.2 Protection and Remediation Programs

2.2.1 Identify Watershed Sources of *E. coli*

Manager: Neil deLuca
Start & Completion Date: November 2003 - August 2005
Status (% Complete): 75
Project Cost: $323K
Objective and Justification:
Part I:

The objective is to attempt to link *E. coli* isolates from the NYC water supply to potential sources of contamination within the watershed, through the comparison of ribotypes (RT). DEP has been collecting *E. coli* from water samples with elevated fecal coliform counts, geese and gull feces, human feces, wild and domestic animals feces and other potential sources of pollution since 1991. This collection of approximately 2500 *E. coli* has been serotyped and is being stored at the Penn State University, Gastroenteric Disease Center. For this project, DEP's collection of these 2500 *E. coli* will be ribotyped with the DEP RiboPrinter from Qualicon.

The RiboPrinter Microbial Characterization System is an automated ribotyping system that generates restriction-cut DNA fragments containing RNA sequences that, after processing through algorithms, produces a genetic fingerprint (RiboPrint pattern) of each isolate. These genetic fingerprints are normalized digital representations of the genetic data for each sample. They serve as stable, reproducible depictions of the genetic data for each isolate analyzed with the RiboPrinter system.

We have ribotyped only a small portion of this collection to date using *Eco*R1 restriction enzyme and have had very mixed results. For this current project, we are using *Hin*d III restriction enzyme instead of *Eco*R1 because of its reported superior discriminatory ability with *E. coli*. This decision was made after reviewing research performed by Dr. Charles Tseng, et al. In a comparison involving combinations and single restriction enzymes for *E. coli* using a RiboPrinter, Dr. Tseng concluded that H*ind* III was the best single restriction enzyme when ribotyping *E. coli,* (Tseng, C.C., et al. "Automated Ribotyping of *Escherichia coli* Isolates from Humans and Animals", American Society for Microbiology General Meeting. 2001).

A temporary staff member has been hired, whose responsibilities include; reconciling DEP's *E. coli* archived at Penn State University with DEP's dataset, re-isolation and confirmation of all *E. coli*, ribotyping the *E. coli* through the RiboPrinter® along with QC samples. In addition, the staff will maintain the RiboPrinter and assist with data analysis.

DEP has received 2500 *E. coli* from Penn State University, of which 2250 have been ribotyped. When each group of *E. coli* has been ribotyped, the data will be placed into newly created source libraries and also into BioNumerics data analysis program.

Under a different project manager, in a separate part of this study (see 2.2.2), DEP will estimate phosphorus and nitrogen loading to reservoirs from Canada Geese (*Branta canadensis*), gulls (*Larus spp.*), other waterfowl, and beavers. Up to 200 fecal samples will be collected and submitted for P and N analysis. Utilizing these samples, approximately 200 *E. coli* isolates from these fecal samples will be ribotyped using Hind III restriction enzyme. Since waterfowl and small mammals contribute fecal coliform to DEP reservoirs, the addition of the *E coli* from upstate animals to our RiboGroup libraries will increase our confidence in identification of bacterial sources.

Implications for Watershed Management:

Once DEP has expanded the ribotyping (RT) library at the conclusion of this project, DEP will have an increased confidence in the conclusions from this analysis. This capability will help identify the sources of *E. coli* in the watershed and allow management to apply remedial measures in the appropriate locations. The RT library will aid in identifying whether coliform are from anthropogenic or non-anthropogenic sources. This is important in defining coliform–restricted basins.

Problems Encountered: None

2.2.2 Estimating Waterbird and Aquatic Mammal Nutrient Loads to Cannonsville Reservoir

Manager: Christopher A. Nadareski
Start & Completion Date: August 1, 2004 - Ongoing
Status: Ongoing
Project Cost: $124,426
Objective and Justification:

The objective of this study is to estimate phosphorus and nitrogen loading to a New York City reservoir from Canada Geese *(Branta canadensis*), gulls (*Larus spp.*), other waterfowl, and water mammals (i.e. beaver). Up to 730 fecal samples will be collected and submitted for P and N analysis. To date, 173 fecal samples have been collected. Additionally, waterbird population surveys have been conducted on a weekly basis since August 2004 to collect data on the number of

birds utilizing the reservoir including their residency time. Nutrient loading will be calculated using these data, and these results may be incorporated into DEP's eutrophication models as appropriate.

Implications for Watershed Management:

A sufficient roosting and foraging population of geese, gulls, other waterfowl, and water mammals could have the potential to impact the nutrient budget of a water supply reservoir by moving nutrients into the reservoir from the surrounding foraging areas and cycling nutrients within the reservoir. To elucidate the role waterfowl play in the nutrient balance, this study is being implemented to calculate P and N loadings via direct deposition by roosting birds and water mammals.

Problems Encountered: None

2.2.3 Waterfowl Management at Kensico Reservoir

Manager: Christopher A. Nadareski
Start & Completion Date: 1993 - Ongoing
Status: Ongoing
Project Cost: Nearly $5.5M from 1995 to 2005
Objective and Justification:

The objective of the Waterfowl Management Program (WMP) at Kensico Reservoir is to quantify wildlife pollutant contributions and mitigate where possible. As part of DEP's Watershed Protection/Filtration Avoidance Program, a Waterfowl Management Program was established to measure the level of pollutant impact imposed by wildlife. Comprehensive wildlife surveys were conducted at Kensico to identify potential pollutant sources. Waterfowl species which include most waterbirds were routinely surveyed to determine species richness (species diversity) and evenness (species population). Preliminary surveys conducted by DEP indicated that populations of several water bird species fluctuated daily (diurnal/nocturnal), seasonally, and spatially on the reservoirs. A relationship between avian populations and bacteria (fecal coliform) levels from untreated water samples revealed a positive correlation. As a result, DEP instituted a permanent Waterfowl Management Program through a contract to reduce or eliminate waterfowl activity in order to mitigate seasonal fecal coliform bacterial elevations.

Implications for Watershed Management:

Since waterfowl were identified as a significant contributor of fecal coliform bacteria, a bird harassment program was developed to eliminate resident and migratory waterfowl populations from Kensico. The program was initially implemented in December of 1993 and has continued through the present resulting in a successful elimination of bird concentrations and corresponding lower bacteria levels.

The basis for the Waterfowl Management Program Contract is to continue the success of waterfowl management at NYC's Kensico Reservoir (which resulted in the elimination of the seasonal fecal coliform bacteria elevations), and expand its waterfowl management operations (bird deterrence-harassment). EPA's Filtration Avoidance Determination in the November 2002 FAD (WMP) required DEP to expand the Waterfowl Management Program to include several reservoirs throughout the NYC Water Supply on an "As Needed" contingency. Each NYC reservoir has been categorized with a different level of mitigative intensity using similar waterfowl management techniques including a standard daily operation at Kensico and an "As Needed" program triggered by elevated waterfowl populations and increases in bacterial levels at several other reservoirs (West Branch, Rondout, Ashokan, Croton Falls, and Cross River). This standard program will be conducted annually from August through March and "As Needed" into mid-April. A supplemental program to monitor and curtail breeding populations of three waterfowl species (geese, cormorants, and swans) will be implemented annually from April through June.

Additional water bird surveys and bird deterrent measures have been instituted at Hillview and Jerome Reservoirs. Year-round populations of water birds have been recorded at both distribution reservoirs resulting in elevated fecal coliform bacteria counts (E. coli). Recommendations for overhead wires covering the surface water have been largely successful eliminating roosting and defecating birds.

Problems Encountered: None

2.2.4 Wetland Characterization and Preliminary Functional Assessment

Manager: Laurie Machung
Start & Completion Date: March 2002 to October 2004
Status (% Complete): 100
Project Cost: $83,900
Objective and Justification:

To better understand the distribution, types, and functions of wetlands in the NYC watershed, the NYCDEP contracted with the U.S. Fish and Wildlife Service to conduct a "Watershed-based Preliminary Assessment of Wetland Functions" (W-PAWF). For the W-PAWF, the USFWS attaches modifiers depicting the landscape, landform, and water flow path to each wetland polygon in the National Wetlands Inventory (NWI) database to support preliminary, basin-wide assessments of eight wetland functions: surface water detention, streamflow maintenance, nutrient cycling, sedi-

ment and particulate retention, shoreline stabilization, fish habitat, waterfowl and waterbird habitat, and other wildlife habitat. Pilot WPAWF projects were first completed in the West Branch and Boyd Corners Reservoir Basins in 1999 and in the Neversink and Cannonsville Reservoir Basins in 2002. The USFWS completed a final W-PAWF for the entire Croton, Catskill, and Delaware watersheds in December 2004.

Implications for Watershed Management:

In its current state, the NWI provides information on the cover types and other general characteristics of wetlands. This project will provide additional information about individual wetlands, such as their landscape settings and hydrologic connectivity that will enable a watershed-scale functional assessment. This type of characterization will also enable the NYCDEP to quantify the abundance of wetlands among various landscape settings. This type of analysis has already proven beneficial for the NYCDEP to quantify the acreage of isolated wetlands that were potentially removed from federal jurisdiction in 2002. Thus, the W-PAWF will enable DEP to focus its wetland programs by identifying functionally significant wetlands in need of protection.

Problems Encountered: None.

2.2.5 Forest Ecosystem Health: Phase I

Manager: Deborah Layton
Start & Completion Date: April 1999 to December 2004
Status (% Complete): 100
Project Cost: N/A
Objective and Justification:

This pilot project tests a systematic method for gathering information on NYC-owned forest lands, as well as performs an initial inventory of EOH forest conditions. This inventory will be used:

- To ground-truth GIS data derived from aerial photography that will be used by several disciplines within DEP;
- To quantify forest ecosystem health and determine further research needs for its management to enhance water quality as it relates to nutrient and sediment retention and;
- To assess the sampling protocol and sample size needed for adequate capture of stand variability.

The initial phase of the study was short-term and laid the groundwork, in consultation with Watershed Lands and Community Planning Land Management Program personnel, for further forest inventory and research work to be carried out both EOH and WOH.

Sixteen sites were chosen in the West Branch, Bog Brook, East Branch, Amawalk, Titicus, Cross River, Middle Branch, Muscoot, and Kensico Reservoir watersheds and 235 plots established.

A draft report of findings was issued for internal DEP use in December 2002. No further measurements or reports are planned for this study. Plots from this study will be folded into the Phase II Forest Ecosystem Health Assessment (discussed below). The West Branch, Amawalk and Bog Brook plots are scheduled for re-measurement during the 2005 field season as part of the Effects of Silvicultural Treatment study (also described below). Data analysis for these plots six years into the project will serve to provide a preliminary report on forest growth, mortality and recruitment that may assist with development of forest management and forecasting tools for use by the Land Management Program in those basins.

Implications for Watershed Management:

The sampling regime used in this project was found to adequately represent vegetation in the overstory and at the sapling/shrub level of the stand for all sites. At the herbaceous/seedling level of vegetation, however, where four meter-square plots were sampled per acre, species present were not adequately represented in samples from larger study areas with more variable terrain, soils, etc. In smaller, more homogeneous study sites, though, this sampling strategy worked well. Plots up to four times larger did not capture more variability than the size used (meter squared). The additional time required to sample these much larger plots, therefore, does not appear to be justified.

Problems Encounter: None

2.2.6 Forest Ecosystem Health Assessment Phase II: Continuous Forest Inventory West of Hudson

Manager: Deborah Layton
Start & Completion Date: Long-term study began May 2002
Status (% Complete): ongoing, first round of measurements 35% complete
Project Cost: N/A
Objective and Justification:

The objective of this project is to establish permanent plots for the purpose of gathering information about longer-term forest processes, such as average tree height, diameter and volume growth rates; mortality and recruitment; and general changes in species composition. Continuous Forest Inventory (CFI) plots will provide these data and track larger-scale changes in forests over time in a way that is similar to the Forest Service Forest Inventory and Analysis or Forest Health Monitoring plots, but at a scale that is better suited to management of City-owned lands.

The first season of plot establishment and data collection performed in the Ashokan basin in 2002 serves as the pilot project for other CFI plots to follow. The plot measurement parameters were streamlined following the first year's work. Plots were established on City-owned lands in the Rondout and Neversink basins in 2003. In 2004, work continued with establishment of approximately half the desired number of plots in the Boyd's Corner and West Branch basins EOH to cover the large land area acquired in recent years. CFI plots will continue to be estab-

lished in the Boyd's Corner and West Branch basins during 2005 and in each major basin each year until plots are distributed on all basins. Plots will be re-measured at approximately 10-year intervals in order to monitor overall stand dynamics.

Implications for Watershed Management:

Land managers on New York City watershed lands intend to manage the watershed's forests for ecosystem integrity and sustainability as existing literature indicates that higher water quality can be expected from lands that recover quickly from disturbance. Many kinds of information are needed to gain an overall picture of the health and sustainability of NYC-owned forests.

A substantial database and scientific study of local conditions is required to write Basin Management Plans for City-owned lands and to offer guidance to local governments concerning land and forest management for water quality. This study will contribute to this database and will serve in the development of useful tools and equations that will expedite continuing inventory and management efforts throughout the watershed.

Problems Encountered: None.

2.2.7 Effects of Silvicultural Treatment on Forest Ecosystem Health

Manager: Deborah Layton
Start & Completion Date: April 1999 to May 2010
Status (% Complete): 30
Project Cost: N/A
Objective and Justification:

The objectives of the study are:

- To determine whether enhanced seedling germination, survival and growth, or other aspects of forest health are desirable to enhance water quality;
- To determine whether recruitment of desirable species is increased and undesirable species decreased by application of current silvicultural methods on these lands and;
- To determine whether observed improvements, if any, are adequate to ensure forest cover without further intervention.

Silvicultural treatments were applied to selected areas near reservoirs as part of dam rehabilitation projects. Work consisted of removal of hazardous trees (particularly along highways, utility corridors, and property boundaries), management of exotic shrubs and vines by cutting, removal (when feasible), and cut-stem treatment with herbicide (as needed), and thinning of stands to encourage establishment and growth of native regeneration.

Baseline measurements were completed during the summers of 1999, 2000 and 2001 at West Branch, Bog Brook, East Branch, Amawalk, Titicus, Cross River, and Kensico Reservoirs. At Amawalk, Titicus, and Cross River Reservoirs, the silvicultural treatment had already taken

place prior to plot installation, so an attempt was made to locate sites with similar species and conditions to serve as control plots to match with these treated sites. To determine whether the treated and untreated areas could be used for statistical analysis, the following conditions must be met:

- The treated site must have a lower average basal area than the untreated site;
- The overstory species must be similar with evidence that undesirable species, if any; were partially or completely removed from the canopy in the treated area and still exist in at least a portion of the plots in the untreated area and;
- The understory species must be similar with evidence that any exotic/invasive species were removed from the treated area and continue to exist on at least a portion of the untreated area.

Of the sites selected for possible side-by-side comparison, only one of the Amawalk sites met the necessary criteria for similarity between the treatment and control. The remaining sites at Amawalk as well as the sites at Titicus and Cross River were deleted from this study due to the inability to compare to a pre-treatment or non-treatment condition. At the other reservoirs, a before-and-after sampling scheme was initiated.

Pre-treatment plots were established at West Branch, Kensico, East Branch, and Bog Brook Reservoirs. Kensico has not yet received treatment. Silvicultural treatment work was completed at West Branch from early September 1999 through late April/early May 2000 and at Bog Brook and East Branch during 2004. As the sites require at least one growing season to recover from treatment, no measurements were taken in the summer immediately following cutting.

Initial post-cut measurements were completed at West Branch in the summer of 2001. A second round of measurements was completed there in 2003.

Implications for Watershed Management:

On the Amawalk site there has been a favorable reduction in overall coverage of exotic species in accordance with DEP's policy to promote native species but, to date, the number of tree seedlings has not reached a number consistent with forestry health objectives.

The study will be measured and reported at least two more times over the next 5 years before any recommendations can be made about continuing this treatment on other sites. Initial post-treatment measurements are scheduled to occur at Bog Brook and East Branch and second post-treatment measurements will be taken at Amawalk and West Branch reservoirs during 2005.

Problems Encountered: None.

2.2.8 Deer Herbivory Impacts on Forest Regeneration: Deer Exclosure Study

Manager: Deborah Layton
Start & Completion Date: September 1999 to December 2008
Status (% Complete): 50
Project Cost: N/A
Objective and Justification:

The objective of this project is to obtain basic information on the impacts of deer on the watershed. It is generally believed that locally high deer populations in the Croton watershed are adversely impacting forest tree seedling regeneration and overall plant ecosystem structure and diversity. Many researchers have used deer exclosures as a way of observing the direct impact of deer herbivory on the understory in forests.

Some very small (1 meter diameter) plots were previously established in the watershed to observe deer herbivory impacts. These showed increased numbers and sizes of tree seedlings within the small fences but findings were somewhat difficult to interpret as the small exclosures tended to collect large quantities of leaves that may have improved microsite conditions (increased moisture and nutrients, improved protection from cold) beyond that of simply removing deer herbivory. For this reason, DWQC's Natural Resources Division constructed larger deer exclosures to further study local deer herbivory impacts.

In the spring of 2000 two large deer exclosures were constructed on the Croton watershed –one at Bog Brook Reservoir and one at Kensico Reservoir. These consist of a 60 foot by 60 foot square chain-link fence eight feet high, with a locked gate at one corner of the fence for researcher access. Each exclosure plot has a companion plot nearby in the same forest stand. The Bog Brook 1 site primarily has a red pine overstory while the Louden Cove 1 site is primarily hardwood. In the spring of 2001, a second deer exclosure was erected at Bog Brook Reservoir in a Norway spruce stand nearby the first exclosure. A companion control plot was also established in this stand. An additional deer exclosure was constructed at Titicus Reservoir, using different fence materials, in spring 2003.

Baseline measurements were taken one growing season following installation of the plots. Measurements have been repeated annually through the fall 2004. Results to date have not shown any statistically significant difference between the fenced and unfenced areas. The Bog Brook site was thinned in 2003-4. The Titicus site is not scheduled for silvicultural treatment. The Kensico site is scheduled for thinning within the next two years. It is expected that differences in herbivory will become more apparent following the thinning operation.

Implications for Watershed Management:

This project will obtain basic information on the impacts of deer on forest ecosystem health to help guide decisions on proper forestry and deer management.

Problems Encountered:

The Division of Watershed Lands and Community Planning's Land Management Program opened the area surrounding the Kensico deer exclosure to deer hunting in 2003. The control plot at this location, therefore, has a different treatment from other sites. Although measurements will continue to be taken at this site, it cannot be compared with the exclosures at Titicus and Bog Brook Reservoirs and will be used for observation purposes only.

2.2.9 Deer Herbivory Impacts on Forest Regeneration: Before and After Hunting on Watershed Lands

Manager: Deborah Layton

Start & Completion Date: Pilot study August to November 2002, Full Study July 2003 to December 2013

Status (% Complete): 40

Project Cost: N/A

Objective and Justification:

Deer herbivory has been noted in forested areas of New York City DEP lands both east and west of the Hudson River (EOH, WOH). This feeding activity is suspected to have reduced the quantity of desirable tree seedlings to sub optimal levels. The U.S. Forest Service recommends a minimum of 10,000-15,000 desirable seedlings/acre in order to expect successful regeneration following a disturbance. It is thought that allowing deer hunting improves regeneration numbers and this method has been used successfully in other areas. DEP has begun allowing hunting on certain lands.

A pilot study was placed on a tract scheduled to open for hunting near Ashokan Reservoir in August 2002 to determine an appropriate sampling technique that would capture variability in sapling-size material and smaller across the landscape. The method devised places transects at 90-meter spacing across the topography with 3 meter by 10 meter plots placed along the transects, beginning at a random point zero to 90 meters from a starting point and with 90 meters between the plots. Additional plots were established during the summer of 2003 at areas that will not be opened for hunting at Ashokan Reservoir as well as hunted and non-hunted areas at Rondout and Boyd's Corners Reservoirs. Baseline measurements were taken at all plots in 2003. The first measurements following establishment will be taken in 2006 and approximately every 2 years thereafter through 2013.

Implications for Watershed Management:

This project will obtain basic information on the impacts of deer on forest ecosystem health in three basins as well as provide some information regarding success of hunting programs to reduce deer herbivory

Problems Encountered: None.

2.2.10 New York State Freshwater Wetlands Remapping Program

Managers: Laurie Machung/James Benson
Start & Completion Date: August 2002 to December 2005
Status (% Complete): 50
Project Cost: N/A
Objective and Justification:

At the NYCDEP's request, the NYSDEC is currently examining existing data sources and conducting field work to revise the NYS Freshwater Maps for the EOH watersheds. Specifically, the NYSDEC is verifying the boundaries of existing regulatory wetlands, locating additional wetlands that meet the regulatory threshold of 12.4 acres, and identifying smaller wetlands of Unusual Local Importance (ULIs) that are adjacent to the reservoirs.

The NYSDEC completed revisions of the NYS Freshwater Wetland Maps for the Croton and Kensico watersheds and the amendments were officially adopted in July 2004. The NYSDEC also completed field work for the Putnam County map revisions in 2004. The NYSDEC tentatively anticipates holding public hearings on the proposed amendments for Putnam and Dutchess counties in June and July 2005, respectively. This would result in the filing of the final amendments in December 2005.

Implications for Watershed Management:

When adopted, these amendments would increase the area of wetlands subject to both NYSDEC regulations and the Watershed Rules and Regulations.

Problems Encountered: None.

2.2.11 Reference Wetlands Monitoring – Year 1

Manager: Laurie Machung
Start & Completion Date: October 2003 to April 2005
Status (% Complete): 95
Project Cost: $262K
Objective and Justification:

The objectives of the reference wetland monitoring program are to compare the baseline characteristics and water quality functions of wetlands among the various landscape positions described by the USFWS in the Watershed-based Preliminary Assessment of Wetland Functions. In 2003, a two-year monitoring program was initiated in the Catskill and Delaware Watersheds through Safe Drinking Water Act funds. In the first year of the Catskill/Delaware Monitoring Program, 22 reference wetlands occupying terrene and lentic landscape positions throughout the Catskill and Delaware Watersheds were selected. Monthly baseflow sampling commenced at these sites in June 2004. Water quality samples were collected from the wetland outflows and analyzed for dissolved major cations, pH, specific conductance, total alkalinity, Cl, TN, TP, and

DOC. Routine sampling will continue in Year 2 of the project. Water table monitoring wells were installed and soil sampling was completed at all of the 22 sites. The wells will be routinely monitored throughout the 2005 growing season. Vegetation sampling was initiated and will be continued in Year 2. Four of the study sites were selected and instrumented for storm- and ground- water monitoring.

Implications for Watershed Management:

Results from this monitoring program will enable the NYCDEP to compare water quality functions of terrene and lotic wetland types. Analysis of water quality and vegetation data from wetlands among various landscape positions will also provide a framework for the development of wetland assessment methodologies to guide both regulatory and non-regulatory wetland protection programs.

Problems Encountered: None

2.2.12 Mapping Update of Watershed Wetlands and Wetland Trend Analysis in EOH Watershed Wetlands

Manager: Barbara Dibeler

Start & Completion Date: September 2003 to July 2005 (US Fish and Wildlife Service (USFWS) contract registered in September 2003)

Status (% Complete): 80

Project Cost: $99,300

Objective and Justification:

I. NWI Mapping Update in WOH and EOH Watersheds

This project involves a contract with USFWS to update the National Wetland Inventory (NWI) through analysis of recent color infrared (CIR) aerial photography (spring 2003, 1:40,000 scale). USFWS completed the original NWI in 1995, using 1:58,000 scale CIR aerial photography dating from 1982-1987. This update will improve knowledge of present wetland resources by mapping recently constructed ponds and identifying filled or altered wetlands, as well as wetlands that were omitted from the original NWI due to the scale and quality of the source photography. For the WOH NWI update, differences in mapped wetlands between the original, 1980s NWI and the update are identified in the attribute data.

The WOH GIS data have been through several DEP quality reviews and field checks. The reviews and ground truth data have resulted in improved mapping of existing wetlands, particularly palustrine emergent wetlands. USFWS is currently finalizing the WOH GIS data and report. The first draft of the EOH GIS data is being reviewed.

II. Wetland Trend Analysis in EOH Watershed Wetlands

The 1999 USFWS EOH wetland trends project analyzed wetland trends for a 26-year period (1968-1984-1994). This project extends the analysis of EOH wetland trends from 1994 through 2004. The extent and causes of EOH wetland losses and changes since 1994 are being

mapped through the analysis of CIR photography (spring 2004, 1:40,000 scale). The project will support EOH wetland protection efforts by providing current information on the types of wetland change and causes of wetland change and loss for a 36-year period. The first draft of the EOH GIS data is being reviewed. The project is scheduled for completion by July 2005.

Implications for Watershed Management:

Results from the two mapping projects will support wetland protection program goals, inform regulatory permit decisions, and provide inputs to water quality models.

Problems Encountered: None. Expect on-time completion.

2.2.13 Hydroacoustics Monitoring Program (Fisheries)

Manager: Thomas P. Baudanza
Start & Completion Date: June 2003 - Ongoing
Status (% Complete): on-going
Project Cost: $191K
Objective and Justification:

Hydroacoustic surveys of reservoir fish populations will be conducted to assess potential impacts associated with chemical treatments. The purpose of this program is to: 1) assess potential fish impacts (mortality) associated with applying copper sulfate for the control of phytoplankton; 2) evaluate fish behavioral response (potential avoidance) to copper exposure; and 3) through long-term monitoring, assess population recoveries where impacts are determined. The monitoring will include initial pre-treatment stock assessments at Rondout, West Branch, New Croton and Kensico Reservoirs to determine annual population levels and distribution patterns prior to chemical exposure. Surveys will then be conducted during chemical treatments to evaluate both distribution patterns and behavioral response (potential avoidance) to chemical exposure. Post treatment surveys will be conducted and compared with pre-treatment population estimates for evaluating possible impacts. Permanent transects (open water and shoreline) will be established with a Geographic Positioning System (GPS) to precisely determine data point locations and allow for conducting identical follow-up surveys during and after chemical applications. Population recoveries will also be evaluated as part of the annual post-treatment monitoring.

Hydroacoustic surveys will also be used to assist Operations in selecting withdrawal elevations to minimize fish entrainment impacts. Entrained fish have been shown to result in waterfowl foraging areas and associated elevation in fecal coliform levels.

Hydroacoustic surveys involve placing a hydroacoustic system on a boat, traversing predetermined GPS transects of the reservoir and sampling fish as they pass through the acoustic beam. Targeted fish produce characteristic traces on chart recorder echograms. The returning

signal is relayed to the computer-based echo processor to produce estimates of fish density, biomass and size. Gill nets will be deployed during the hydroacoustic surveys to validate species composition.

Equipment upgrades for program surface units and software were acquired in March 2005. Year 2005 survey efforts will concentrate on Kensico Reservoir.

Implications for Watershed Management:

The implementation of Hydroacoustics Monitoring will provide several benefits for the NYCDEP goals and mission. The determination of potential impacts to reservoir fisheries will insure compliance with state regulations governing chemical applications for water quality treatment. In addition, acoustic survey information will allow NYCDEP Operations to adjust intake elevations to minimize fish entrainment and subsequent elevations in fecal coliform from concentrations of foraging birds.

Problems Encountered: None

2.2.14 Stream Reclassification Program (Fisheries)

Manager: Thomas P. Baudanza
Start & Completion Date: June 1996 to 2113 (projected)
Status (% Complete): 33
Project Cost: $14K plus in-kind
Objective and Justification:

The DWQC Stream Reclassification Program (Fisheries) began in 1996, as part of the DWQC Biological Monitoring Program. Streams in New York State are classified and regulated by NYSDEC based on existing or anticipated best use standards. The purpose of this program is to enhance the protection of water supply source tributaries under the New York State Codes, Rules, and Regulations (NYCRR) Title 6, by determining best use standards for trout and trout spawning. These standards strengthen compliance criteria permitted under any regulated action, and further increase the number of protected streams in the watershed.

Reclassification surveys concentrate on likely trout habitat sections of stream including riffles, pools and undercut banks. Streams are electrofished using a Smith-Root Model 12 Electrofisher. All fish collected are held for processing (identification, length & weight) and examined for external anomalies prior to release. Presence of trout under 100mm (young-of-the-year) is used to indicate the occurrence of trout spawning. Physical and chemical stream data collected includes temperature, depth, width, D.O., pH, conductivity, stream gradient and estimated discharge. Bottom substrate and land characteristics are also described. Collection reports and reclassification petitions are submitted to the NYSDEC on an annual basis.

To date, streams in the watersheds of the Kensico, West Branch, New Croton, Rondout, Neversink. Ashokan and Schoharie Reservoirs have been inventoried and petitions submitted to NYSDEC for final determination of classification upgrades. Year 2004 surveys were in the Pepacton watershed. Year 2005 efforts are anticipated to complete the Pepacton drainage.

Water quality data has been provided through the support of DWQC Hydrology. Field support for the electrofishing surveys was provided through the Ulster County Community College Internship Program.

Implications for Watershed Management:

Classification upgrades reflecting trout spawning function to ensure that enhanced regulatory criteria and standards for dissolved oxygen, ammonia, ammonium, temperature and volume for streams supporting trout and trout spawning are in place for the protection of fishery resources and overall water quality.

Problems Encountered: None

2.3 Watershed Monitoring, Modeling, and GIS

2.3.1 New York City's Ambient Surface Water Monitoring

Manager: Dale Borchert
Start & Completion Date: January 1, 2004 to December 31, 2004
Status (% Complete): 100
Project Cost: $187K
Objective and Justification:

The project objectives are:

- To quantify the analyte load removal efficiency of best management practices that can be determined through high runoff monitoring;
- To quantify the changes in analyte loads from selected catchments that can be observed through high runoff monitoring before, during and following land development activities;
- To provide high runoff monitoring input data for the Reservoir Modeling Program.

During this phase of the study the objectives and accomplishments have been:

- To continue storm event monitoring at the two impact sites and one control site identified and monitored under previous funding awarded for the first two years of this project. The initial proposal involved monitoring two small watersheds, approximately 100-200 acres in area, where a land use change is expected to occur sometime in the next few years. High Runoff monitoring would occur for approximately 10 years, allowing for approximately 2 years of pre-development monitoring, 2 years of monitoring during construction and 6 years of post-development monitoring. The analytes collected at the site will be Total Phosphorus, Total

Dissolved Phosphorus, Nitrite-Nitrate, Dissolved Organic Carbon and Total Suspended Solids. Approximately eight (8) storm events will be sampled each year;

- To extend for one year the contract for laboratory services that was obtained with the funding for the first three years of this project. This contract has been awarded to Aqua-Pro Tech Laboratories in New Jersey;
- To extend for one year funding for temporary staff, whose responsibilities will be the collection and processing of data from these sites and;.
- To purchase small parts or accessories that become necessary for the maintenance of previously purchased equipment.

Implications for Watershed Management:

The results of this project have the potential to guide the Department's regulatory section in their application of the City's Watershed Rules and Regulations. This project could identify whether stormwater pollution prevention plans required under the City's watershed regulations are effective at reducing the water quality impacts associated with land use development. It could also identify the change in pollutant loads associated with land use development. This study could contribute to a revision of the Department's expectations of stormwater pollution prevention plans, providing a way to quantify the impact DEP's Regulations have on water quality.

Problems Encountered:

Land use changes did not occur as expected on the two study sites. As a result, the project was discontinued at the end of this year of monitoring. Monitoring stations were dismantled, and the data were instead used to approximate export loading coefficients for the Croton watershed.

2.3.2 Occurrence and Transport of *Giardia* and *Cryptosporidium* within the New York City Watershed – Year 1

Manager: Patrick O'Brien

Start and Completion Date: Started in May 2004. Sampling will be completed by May 2005. Final report will be submitted by August 2005.

Status (% complete): 75

Project Cost: $390K (Original cost was $440K; $50K was redistributed to other grant projects)

Objective and Justification:

The objectives of this project are to: (a) validate the use of ColorSeed™ as the QC spiking material using USEPA Method 1623 for the detection and enumeration of *Giardia* cysts and *Cryptosporidium* oocysts; (b) determine differences in the spatial distribution of (oo)cysts within the watershed through a synoptic "range finding" effort while locating potential "hot spots" for (oo)cyst occurrence; and (c) perform targeted, pair-wise (upstream and downstream), sampling in response to elevated (oo)cyst occurrence to determine areas of non-point source (oo)cyst contamination.

DEP's pathogen monitoring program has developed, since 1992, an extensive database on the protozoan pathogen concentrations at our keypoints, as well as in various streams within the watershed through a substantive fixed frequency, fixed location sampling network. Moreover, the pathogen group has a substantial database on the temporal changes in pathogen concentrations in streams resulting from storm events. These data are being used to correlate pathogen concentration data with differences in surrounding land-use, and other factors in order to identify potential sources of pathogens in the watershed. Ultimately, it is DEP's goal to obtain data not only on the sources of pathogens but also on transport properties. This information is needed for both watershed and risk management purposes. However, due to the sampling constraints, DEP has been unable to systematically monitor and assess the many different small scale projects or locations that might be potential sources or sinks of protozoan pathogens. This type of monitoring should be done in and near the project site, with a sampling approach that is flexible and that can respond to immediate concerns (e.g. an overflowing sewer). Locations of potential interest include, for example, areas of potentially failing septic system, housing developments, wetlands, industrial parks, shopping centers, stormwater outfalls, BMPs, etc.

Task1: The first task was to complete a validation study of ColorSeed™ for use with USEPA Method 1623. ColorSeed™ is a killed, dyed, preparation of *Giardia* cysts and *Cryptosporidium* oocysts that is designed to be differentiated from intrinsic (oo)cysts in an environmental sample. This allows both the enumeration of environmental (oo)cysts and the determination of matrix recovery percentages with one sample. This task has been successfully completed and the product has been implemented since the completion of the validation.

Task 2: The second task was to conduct a synoptic "range finding" study to determine differences in (oo)cyst occurrence throughout the watershed by sampling a large number of sites that were not sampled for pathogens at the start of the project. Based upon historical data, and the results from this portion of the study, "hot spots" within the watershed that present with high (oo)cyst occurrence were determined. At the time of submission, three of four sampling replicates have been completed. Sampling and processing for this task is projected for the end of May 2005.

Task 3: The third task of this study utilized the results from Task 2 to conduct targeted follow-up sampling in areas of the watershed that contain "hot spots." Pair- wise (upstream and downstream) sampling will be conducted in response to high (oo)cyst occurrence in an attempt to determine non-point sources of (oo)cyst contamination (i.e. wildlife dwellings, failing septic systems, etc.). At the time of submission, follow-up sampling was conducted at 6 sites presenting with elevated *Giardia* or *Cryptosporidium*. Wildlife was the suspected source in each case. This task is ongoing and will continue through May 2005.

Implications for Watershed Management:

The understanding of pathogen (*Cryptosporidium* spp. and *Giardia* spp.) transport from source

points to reservoirs is integral to the assessment of watershed and risk management. The identification of sampling sites with elevated (oo)cysts within the watershed will provide opportunities to both investigate the land use types associated with the affected sites and remediate anthropogenic sources.

Problems Encountered:

The ColorSeed™ validation and procurement process was longer than anticipated due to issues with both aspects of the implementation. Therefore, while four sampling replicates will be collected, the temporal separation of the replicates will be less than quarterly since there were less than 12 months available for sample collection.

2.3.3 Monitoring Crossroads Ventures Proposed Development of Belleayre Mountain

Manager: Tracy Lawrence
Start & Completion Date: August 2000 to August 2010
Status (% Complete): 20
Project Cost: N/A
Objectives and Justification:

In response to the "Belleayre Resort at Catskill Park" development project proposed by Crossroads Ventures LLC (CRV), the Water Quality Impact Assessment group (WQIA) designed a program to monitor the water quality of area streams before, during and after project construction. The project site straddles the watershed divide between the Ashokan and Pepacton Reservoirs near the Village of Pine Hill. The developer envisions two 18-hole golf courses, a 17 lot residential subdivision, 700 hotel units, associated clubhouses, and maintenance and staff buildings disturbing 573 of the project's 1900 acres, making this one of the largest proposed land use changes in the Catskill Region in decades. DEP developed a Quality Assurance Project Plan (QAPP) with an objective to monitor the water quality of five tributaries in the vicinity of the proposed development area plus one nearby stream, which will not be affected by this development. In 2004, Phase II Pre-Development Monitoring of the four-phase program continued with monthly routine sampling, storm event sampling, automated monitoring of stream stage, and maintenance/development of stage-discharge rating curves for all sampling locations. Phase III is the construction monitoring phase, and Phase IV is the post-construction monitoring period during which DEP expects water quality to stabilize. Monitoring will be completed when either the resort has been built and water quality parameters stabilize or the developer abandons efforts to construct the resort. The draft EIS for the project was accepted by the NYSDEC, but this acceptance and subsequent State-issued permits were contested by several parties including DEP at an Issues Conference in 2004. Recently, NYSDEC supported DEP's assertion that the hydrologic analysis of pre-construction conditions presented in the DEIS does not agree with actual pre-development monitoring conducted by this program and therefore cannot be used as the basis for issuing SPDES Permits for stormwater discharges. As of this writing, the Administrative Law

Judge has not issued a final decision on whether or not this case can proceed to adjudication. DEP continues to contest the developer's modeled pre-development phosphorus and total suspended sediment load values.

Implications for Watershed Management:

Little information exists on the effects of large-scale land use changes on water quality in the Catskills Mountains, or on the water quality of headwater streams. Headwater streams of the Catskills are major sources of high quality water to the NYC Catskill and Delaware Water Supplies. Information gained from this research will assist in the future management and review of development projects and land-use changes in the Catskill Region.

Problems Encountered: None

2.3.4 Monitoring of NYC's Reservoirs for Zebra Mussels

Manager: Sharon Neuman
Start & Completion Date: April through November, annually
Status: On-going
Project Cost: Approximately $37,060 per year
Objective and Justification:

The objective of this contract is to monitor all 19 of New York City's Reservoirs for the presence of zebra mussel larvae (veligers) and settlement on a monthly basis including April, May, June, October and November, and on a bi-monthly basis during the warm months of July, August, and September. Sampling includes pump/plankton net sampling to monitor for veligers, and substrate sampling as well as bridal veil sampling to monitor for juveniles and adults. The contract lab analyzes these samples and provides a monthly report to the project manager as to whether or not zebra mussels have been detected. To date, zebra mussels have not been found within the NYC reservoir system.

Zebra mussels were first introduced to North America in the mid-1980s, and first identified on this continent in 1988. It is believed that they were transported by ships from Europe in their freshwater ballast, which was discharged into freshwater ports of the Great Lakes. Since their arrival in the United States, zebra mussels have been reproducing rapidly and migrating to other bodies of water at a much faster rate than any of our nation's scientists had predicted. They have been found as far west as Oklahoma, as far south as Louisiana, as Far East as New York State, and north well into Canada. They have been found in all of the Great Lakes and many major rivers in the Midwest and the South. In New York State, in addition to Lakes Erie and Ontario, zebra mussels have migrated throughout the Erie Canal, and are found in the Mohawk River, the St. Lawrence River, the Susquehanna River, and the Hudson River, as well as several lakes. DEP is concerned about infestation of New York City's reservoirs by this mollusk. Zebra mussels reproduce quickly and are capable of clogging pipes, which would seriously impair DEP's operations, preventing an adequate flow of water from the reservoirs to the City and those upstate com-

munities dependent on the New York City water supply. As suppliers of water to over nine million people, it is DEP's responsibility to monitor New York City's water supply for zebra mussels, since early identification of a zebra mussel problem will allow us to gain control of the situation quickly and will save us money in the long run.

Implications for Watershed Management:

Monitoring for zebra mussels is critical for watershed management, at this point in time. In addition to zebra mussels potentially preventing an adequate supply of water from reaching communities meant to use this system for drinking water, they also create taste and odor problems in the water. Early detection of zebra mussels would allow us to gain control of the problem quickly, as mentioned above, and would allow us to preserve the excellent water quality of this system, as well as save us money, in the long run.

Problems Encountered: None.

2.3.5 Development and Application of Watershed Loading Models for Evaluating Effects of Watershed Management on NYC Reservoir Water Quality.

Manager: Elliot Schneiderman
Start & Completion Date: Ongoing
Status (% Complete): Ongoing
Project Cost: N/A
Objective and Justification:

The NYC DEP Modeling Program is engaged in ongoing research to develop, improve and apply Watershed Loading Models for simulating water, nutrient, and sediment loads to the NYC reservoirs under various watershed management and climate scenarios. Watershed Loading Models are linked to Reservoir Receiving Water Models for evaluating the effects of watershed management on reservoir trophic state. GWLF models have been developed for Catskill and Delaware system reservoir watersheds. Model improvement and testing is focused on refining the watershed hydrology and chemistry algorithms in GWLF, and on improved calibration of model parameters as additional data become available. NYCDEP, in collaboration with T. Steenhuis of Cornell University, is incorporating Variable Source Area (VSA) hydrology into the DEP GWLF model, to more accurately simulate the spatial distribution of runoff generating areas. Seasonal variations in dissolved nutrient concentrations, based on USDA-SWAT model calculations, are being incorporated into GWLF. Additional storm event monitoring data for stream chemistry is being used to recalibrate the DEP watershed models. These improvements will provide increased reliability and confidence in model simulation of watershed processes that effect water quality.

Implications for Watershed Management:

Simulation modeling is a powerful tool for evaluating the effects of watershed land use and management on reservoir water quality. Evaluation of watershed management scenarios using models provides guidance to DEP and watershed management programs for the most effec-

tive utilization of resources for improving reservoir water quality. The DEP models have been used for a preliminary evaluation of the effectiveness of watershed management programs to control eutrophication in the Cannonsville and Pepacton Reservoirs (NYC 2001 Watershed Protection Summary, Assessment, and Long-term Plan 12/01). This application involves analyses of long-term scenarios, and will be revisited, using updated and improved models and data, in the next five-year Comprehensive Water Quality/Program Evaluation Report due to EPA 3/31/06.

Problems Encountered: None.

2.3.6 Analysis of Nutrient and Sediment Loads at Beerston – Cannonsville Watershed

Manager: Don Kent
Start & Completion Date: October 1991 to September 2005
Status (% Complete): 93
Project Cost: $560,780 (based on the maximum number of samples analyzed)
Objective and Justification:

The objective of this project is to provide continuous long term nutrient load data needed to support the NYCDEP's ongoing research of the Cannonsville Watershed and Reservoir Models. Beginning in October of 1991, the NYCDEP has funded, under a series of 24 month contracts with Health Research, Inc. (HRI), the storm event and routine sampling of the West Branch of the Delaware River at Beerston, NY. Under these contracts the NYS Department of Environmental Conservation (NYSDEC) collects storm event and routine samples which are analyzed by the NYS Department of Health (NYSDOH). To date, approximately 18,967 data points have been collected over the thirteen year period of this project. An additional 12 month contract has been renewed which, after contract completion in September 2005, will result in a total of 14 years of data from all the contracts combined. The table below outlines the parameters measured.

Implications for Watershed Management:

Accurate and continuous nutrient loads are a critical aspect of ongoing research designed to increase the reliability of and confidence in the Cannonsville Reservoir and Watershed Model simulations. As these models are used to evaluate the effects of watershed land use and management on reservoir water quality this monitoring needs to be continued so that reservoir responses to watershed management actions may be evaluated. Additionally, the information gained for Cannonsville in terms of data requirements for model testing and management action evaluation will be useful in assisting similar efforts on the other watersheds.

Problems Encountered: None

2.3.7 Assessing Management Alternatives for Achieving Phosphorus TMDLs to Control Eutrophication in NYC Reservoirs

Manager: Mark Zion
Start & Completion Date: January 2002 to December 2007
Status (% Complete): 75
Project Cost: N/A
Objective and Justification:

Phosphorus TMDLs have been established to control eutrophication in NYC reservoirs. The TMDLs are expressed as an annual load of total phosphorus into each reservoir that will result in a target in-lake phosphorus concentration. The objectives of this study are to use DEP's Nutrient Management Eutrophication Modeling System (NMEMS) to: (1) further understand the implication of the annual phosphorus TMDL using more complex modeling tools such as the NMEMS; and (2) to assess how different phosphorus reduction strategies, consistent with the annual TMDL, affect reservoir trophic state as indicated by growing season chlorophyll-*a* concentrations in the reservoirs. For reservoirs that exhibit water quality impairment, TMDLs provide an important regulatory framework for reducing pollutant loads and improving water quality in these waterbodies to acceptable levels. NYCDEP is required under the FAD to evaluate the effectiveness of phosphorus TMDLs.

Implications for Watershed Management:

Cannonsville Reservoir is the only watershed with historical loads exceeding the Phase II TMDL. Results for this reservoir indicate that load reductions due to implementation of planned watershed management activities exceed the reductions required under the TMDL guidelines, and reduce trophic indicators in excess of the TMDL goals. The trophic state for Cannonsville Reservoir is more sensitive to dissolved phosphorus loads than to particulate phosphorus and to loads entering the reservoir during the late spring and summer months. The combination of these two reservoir water quality sensitivities has implications for the effect of different types of watershed management activities on reservoir water quality, with greater reductions in reservoir trophic status achieved via reductions in point source phosphorus loading versus non-point source loading.

Further analyses on the relationship of phosphorus loading to trophic status are planned for those reservoirs that exhibit current phosphorus loads below the TMDLs and are not nutrient impaired.

Problems Encountered: None.

2.3.8 Initial testing of CE-QUAL-W2 Model in the Croton System

Manager: Todd Echelman
Start & Completion Date: June 2003 to June 2004
Status (% Complete): 100
Project Cost: $5K
Objective and Justification:

This project completed preliminary tests of Version 3.1 of the CE-QUAL-W2 model New Croton and Muscoot Reservoirs, and provided the setup and parameterization files for the two reservoirs. A feature of this project is the ability to combine multiple reservoirs and river reaches into a single application consisting of two water bodies, and a merged Muscoot and New Croton Reservoir model setup was provided to NYCDEP.

Implications for Watershed Management:

Water quality issues that the Croton System faces include eutrophication, seasonally high color, oxygen depletion, release of hydrogen sulfide and metals (i.e. Fe and Mn) from the sediments, and bacterial contamination from, for example, wildlife, sewage, and spills. Monitoring suggests that the New Croton and Muscoot reservoirs can show distinct spatial gradients in water quality, suggesting that 2-dimensional models will be useful for managing these reservoirs.

Problems Encountered: None.

2.3.9 Update of 3-D Kensico Reservoir Model

Manager: Todd Echelman
Start & Completion Date: June 2003 to June 2004
Status (% Complete): 100
Project Cost: $5K
Objective and Justification:

The original Kensico Reservoir water quality model (developed in 1995) ceased to function properly, presumably due to UNIX operating system changes over the years. This project's objective was to re-acquire functionality to this model. To accomplish this, the most recent (UNIX compatible) FORTRAN RMA-10V and RMA-10Q codes were located and sent to our modeling vendor. These codes, comprising the primary components of the Kensico Reservoir water quality model, were tested for compatibility with present versions of the Microsoft Windows operating system and installed at DEP's Valhalla offices.

Implications for Watershed Management:

The present Kensico 3-D water quality model is now operational under the Windows operating system, and capable of providing interim 3-D Kensico model investigations. This model's original development included simulation capabilities for tracers (conservative substance), coliforms, and suspended solids. Completion of this project renews DEP's ability to simulate trac-

ers, coliforms, and solids in a three-dimensional framework. Further, other constituents of concern, such as pathogens and turbidity, can also be approximated using the coliforms and solids constituents.

Problems Encountered: None.

2.3.10 Weather Generator Development

Manager: Don Pierson
Start & Completion Date: June 2003 to June 2004
Status (% Complete): 100
Project Cost: $10K
Objective and Justification:

Weather generators are programs which provide realistic time series of synthetic weather data — data that are randomly generated, but retain key stochastic characteristics of the historical weather record. This project will undertake research to identify the most suitable weather generator program(s) available that meets the requirement to provide driving data for DEP's eutrophication modeling system and to provide DEP with a working weather generator program, calibrated to generating synthetic weather sequences at the locations of present day national weather service (NWS) climate stations in the WOH watersheds.

The choice of weather generator was guided by its availability, portability, ability to modify the code, and documentation. CLIGEN, a United States Department of Agriculture product, was chosen based on these criteria. Realistic (synthetic) 30-year time series of daily maximum and minimum temperature, dew point, precipitation, precipitation intensity, and winds for Cooperative Observer stations within the DEP WOH watershed were produced. Spatial correlations were generated for these stations, reflecting horizontal (distances between stations) and vertical (elevation) characteristics of the network.

Implications for Watershed Management:

This project is intended as an enhancement for the 1-D reservoir management system by providing stochastically variable weather data, which serves as input to the models. Such variability can be used to further assess the role of variations in the weather in influencing the variability of model predictions.

Problems Encountered: None.

2.3.11 Catskill/Delaware resuspension upgrade for 1-D Reservoir Models

Manager: Don Pierson
Start & Completion Date: June 2003 to June 2004
Status (% Complete): 100
Project Cost: $10K
Objective and Justification:

The project replaced the empirical resuspension approach used in the earlier Catskill-Delaware 1-D models, with that developed for Cannonsville Reservoir, which mechanistically simulates resuspension of particles and the cycling of phosphorus between the water column and reservoir bottom associated with resuspension and settling. The project was completed during 2004 and DEP now has an upgraded version of the 1-D models for all of the WOH System.

Implications for Watershed Management:

This project provided a needed enhancement to the WOH 1-D water quality models that now allows us to:

- Simulate the input and transport of suspended particles to WOH reservoirs, when it is assumed that the particles have a fixed sinking rate;
- Simulate sediment resuspension and the effects of resuspension on light attenuation and P availability.

Both of these capabilities, particularly the first one are required to allow us to assess the importance of Total Suspended Solids (TSS) loading on WOH reservoirs. We plan to make use of this capability in a number of upcoming modeling based assessments.

Problems Encountered: None.

2.3.12 Suspended Sediment Dynamics in Ashokan West Basin

Manager: Allison Bennett
Start & Completion Date: April 1997 to December 2005
Status (% Complete): 80
Project Cost: N/A
Objective and Justification:

The objective of this study is to quantify the longitudinal and annual variations in sediment deposition in the Ashokan Reservoir and to identify potential source or sink areas within the basin. High runoff events in the Catskill District periodically result in increased turbidity in the streams. Since the West Basin of the Ashokan Reservoir receives water directly from the Esopus Creek, it is susceptible to turbidity changes which occur in the creek. Sediment traps were deployed at a number of sites in the West Basin of Ashokan Reservoir for a five-year period start-

ing in April 1997 to measure the downward flux of sediment over a range of hydrologic conditions. The placement of the sediment trap sites, and the period of study will allow spatial and temporal resolution of the sediment flux throughout the reservoir.

Implications for Watershed Management:

The study has identified spring and fall precipitation events to be the primary cause of elevated turbidity, with resuspension playing a much smaller role. With information about the sediment dynamics in the Ashokan West Basin, and understanding how the reservoir responds to periodic turbidity events, Management will be able to make more informed decisions about operations to minimize effects of spring and fall storm events. Reservoir elevation plays a key role in how the West Basin will respond to high turbidity flows. Low reservoir elevation will increase the quantity of sediment resuspended within the reservoir due to wave action on the exposed shoreline. Low reservoir elevation will also increase bottom sediment resuspension by decreasing the water column depth, which will increase the effect of surface waves on the bottom. At higher elevations, the travel time through the reservoir is longer, which better enables the reservoir to buffer the effect of the stream. Reservoir thermal structure also plays an important role in how a turbidity plume will travel across the basin. During stratified periods, a plume of turbid water will travel across the basin as an interflow, and reach the dividing weir much quicker than under isothermal conditions. Management can use this information to determine the best operational changes to make during an event depending on the reservoir elevation and thermal structure at the time of the event. Data collected from this study will also be incorporated into the turbidity model being developed by the Upstate Freshwater Institute which will be a useful management tool in the prediction of water turbidity leaving Ashokan Reservoir.

Problems Encountered: None. Data analysis continuing.

2.3.13 Modification of Reservoir Operations by Linking GWLF, CE QUAL W2, and OASIS Models

Manager: Paul Costa, BEE (Don Pierson and Elliot Schneiderman - DWQC staff involved)
Start & Completion Date: November 2004 to September 2006
Status (% Complete): 5% - initial discussions taken place
Project Cost: $540K
Objective and Justification:

To simulate the effects of natural events such as storms and/or the consequences of reservoir operations on the water quality of a reservoir and its discharge as either spill or a controlled release, a linked system of watershed and reservoir models is needed. Presently, DEP has linked the Generalized Watershed Loading Function (GWLF) hydrologic model to a 1D reservoir water quality model, and also has a linked system of 2D reservoir models (LinkRes CE Qual W2) that can simulate the transport of substances through the West of Hudson Reservoir System, but that is not linked to GWLF. This project will build on DEP's present reservoir modeling capabilities by:

- Linking GWLF to the CE Qual W2 two dimensional (2D) reservoir model. We find that for simulations to support reservoir operational decisions (i.e. withdrawal elevation, timing and amount), the two dimensional model is required
- Linking the watershed - reservoir models into a system which encompasses the entire NYC watershed area. A strength of the NYC water supply is that it encompasses a large number of reservoirs that can be used in differing ways at differing times. A Linked reservoir modeling system will allow system wide simulations of water quality in response to natural forcing and operational decisions.
- Linking all of the above to the OASIS water use optimization model of the NYC reservoir system. DEP presently uses the OASIS model to develop reservoir operation strategies that achieve required release objectives (Delaware River) while optimizing the use of the water for drinking water supply. By linking OASIS with GWLF and CE Qual W2, DEP will have a system of models which examine reservoir operating rules in respect to predicted variations in water quality as well as water quantity. Simulations of changes in water quality that will affect the use of parts of the water supply can be related to system wide water demand and use.

This project's goal is to provide the proof that the above linked modeling concept can be developed and used to better define reservoir operating strategies that meet both water quality and quantity criteria. The project will be undertaken as part of the Catskill Turbidity Control Study, and as a proof of concept project will not fully consider all reservoirs or all water quality parameters. This study will focus on fully linking the reservoir in the Catskill system (Schoharie, Ashokan, and Kensico), and will simulate water quantity, temperature and turbidity. Water quantity (only) will be simulated by OASIS throughout the entire NYC water supply.

Project Tasks

- Update GWLF CE Qual W2 model data sets in order to support a longer time series of simulations that better defines the climatic variability influencing the NYC water supply.
- Provide a updated and calibrated temperature turbidity models for the Schoharie , Ashokan and Kensico reservoirs
- Update OASIS model to include current NYC reservoir operating rules including Delaware system rules that account for Delaware River Basin Commission release requirements.
- Develop a linkage between the OASIS, GWLF and CE Qual W2 models.
- Develop new operating rules based on revised Schoharie temperature and turbidity release criteria. Simulate the effects of these rules on the water quality in the Catskill reservoir system, and the effects on system wide water yield.
- Provide a set of recommendations regarding the feasibility of this modeling approach; and if feasible, recommendations on how to develop a fully operational modeling system for the entire NYC water supply — this is likely to be a major and costly effort.

Implications for Watershed Management:

This project will test a modeling system which may assist DEP develop a comprehensive set of reservoir operating rules that account for both water quality and quantity concerns. Furthermore, the modeling system could be used provide near real time simulations to aid in operational decisions in response to water quality or reservoir supply infrastructure problems, i.e. turbid storm events, spills, aqueduct shut downs etc. This system should assist the City in providing the highest quality drinking water at the lowest cost by using available water in an optimal manner.

Problems: None

2.3.14 Development of a Watershed Land Information System to Support the Management of New York City Water Supply Lands

Manager: John Potter
Start & Completion Date: June 2001 – ongoing
Status (% Complete): ongoing
Project Cost: N/A
Objective and Justification:

This purpose of this project is to develop a state-of-the-art watershed land information system to support Bureau of Water Supply staff in the management of over 120,000 acres of New York City-owned water supply lands and conservation easements. A land information system is a geo-spatial database with maps, but it also contains documents, photographs, cadastral surveys, and notes. It is designed to track relevant data and land records relating to the ownership and management of both real property and natural resources. A land information system is at once an information repository, a query tool, and an analytical tool. This particular system (WaLIS) will provide land managers with workflow guidance, data automation, geo-spatial analysis, and decision support. The objectives of the project are to improve the effectiveness of Bureau land management through:

- Better access to land and resource information;
- Increased productivity and automation;
- User satisfaction;
- Better decision-making consistency and equity;
- Improved accountability and reporting; and
- Reduced business cycle times.

By meeting these objectives, there will be tremendous cost savings in how land management activities are conducted as well as an enhanced ability to meet the City's watershed management goals.

Implications for Watershed Management:

Land conservation is one of the best methods for watershed protection, but only if the protected lands are subsequently well managed. A scattered and diverse land holding is difficult to keep track of and to harness for optimum source water protection. Inappropriate land use can lead to water quality impacts, inefficiencies in natural resource management, and increased long-term costs to repair neglected

situations. This software product is resulting in innovative and advanced approaches to watershed land management in the areas of natural resource planning, forestry, public access/recreation, road maintenance, granting of land use permissions, conservation easement stewardship, and the general administration of lands. These developments should be of interest to other watershed programs.

Problems Encountered: None

2.4 Data and Methods Development

2.4.1 Communication of Water Quality Data Analyses and Model Applications

Manager: Dave Smith
Start & Completion Date: October 2000 to September 2005
Status (% Complete): 80
Project Cost: $646K (now $455K)
Objective and Justification:

This project is devoted to the improvement of data analysis and information communication and was described in some detail in last year's Research Objectives Report. The tasks have not changed in intent but their content has been refined and enhanced; these changes are documented below.

Task I Automation of DWQC's Annual and Trends Reports:

To enhance production of these reports, the "Lakewatch" software was purchased. This enables rapid parametric trend evaluations, hypolimnetic volumetric oxygen depletion rate calculations and trends, and probability calculations of trophic level change. This software was used for trend evaluations in the City's "2001 Watershed Protection Program Summary, Assessment and Long-term Plan Report", a major FAD deliverable .

Further, to allow simulations of the influence of climate change on reservoir water levels and trophic status to better assist with trend analysis and projection into the future, DEP requires the development, under contract, of a Regional-scale Future Climate Scenario for its Reservoir Modeling Program. This will provide DEP with data sets of estimated meteorological parameters for two decades: a control period (1990s) and a future scenario (2080s). These data will cover the total NYC reservoir watershed area, and will be used to drive the DEP eutrophication modeling system. They will also be used to give insight into the effects of meteorology vs. those of land use change and MOA programs, and these insights will be reported, as appropriate.

Task II Condensed Version of the Report on Effectiveness of DEP's watershed protection and remediation programs:

This document, expected to be about 32 pages, will be produced for public/lay distribution as well as peer groups. Its purpose is to succinctly and effectively characterize the work that DEP has done since it began its watershed protection programs in earnest, with the Watershed Agricul-

tural Council in 1992, and of course greatly accelerated in the years since. The booklet will articulate the benefits that these programs are generating in the watershed as well as New York City, focusing on water quality improvement and protection, sustainable economic development, improved recreational opportunities, and the most sophisticated scientific monitoring technologies on site and laboratories. The goal is to produce a full-color booklet that is visually appealing, simply written, interestingly illustrated and comprehensive.

Task III Bureau-wide, long-term development of Intra/Internet:

The goal of this task is to meet information demands and to improve the availability of information for decision makers. As of this time, DEP has developed Internet and Intranet websites with basic descriptive information about the Department, reports, and periodic updates of current information about water quality and *Cryptosporidium*. However, there are increasing demands for more information to be made readily available on a more current basis. Using a web application would enable efficient distribution of information.

This task will be accomplished through the purchase of hardware (server and workstations) and web application software. Web collaboration software (Macromedia Contribute) has been purchased. Bureau staff will be trained and given the responsibility of updating their own unit's web pages.

Task IV. Media Conversion of Historical Water Quality Data:

The objective of this contract is to make DWQC's historical water quality data more accessible. Microfiche copies of original handwritten lab books will be converted to digital format. The data is currently contained on seventy-one 16 mm micro-cartridges that require an optical reader. The lab books contain the results of chemical, biological and physical examinations made at the Mt. Prospect, Mt. Pleasant, Mt. Kisco, Kensico, Ben Nesin, Grahamsville and Central Laboratories between 1897-1985. These records are essential for analysis of long-term trends and conversion to digital format will make this feasible. This project (which will produce an electronic version of over 70 16mm micro-cartridges) is unchanged and is continuing (under contract).

Task V Implementation of a Water Quality Information System (WQIS) for Enhanced Data Organization:

To further enhance the reporting process described earlier, DEP now considers it essential to develop a Laboratory Information Management System, (LIMS), and efforts are underway to acquire off-the-shelf proprietary software called StarLIMS and the appropriate licenses and hardware, plus training of staff. (The funding for this will now largely come from an earlier DEP LIMS project.)

The goal of this task is to meet information demands and to improve the availability of data, and hence information, for decision makers via a browser, and for some users to have this data linked to GIS data. The mechanism for such data availability is being developed. This is

being accomplished through the development of the architecture (via PAR), conversion of DEP's SAS database to SQL (the original intent to convert the data to an Oracle database has now been superseded) and purchase of specialist hydrometric software (WISKI, Kisters AG).

This necessarily complex WQIS architecture will likely involve "thin client" use (i.e., a simple Wide Area Network browser-based desk-top system), more complex hydrologic and limnological use, (via specialist hydrometric software), and "power" users (via ARCGIS tools). A user-based Questionnaire was developed and has assisted in the development of the architecture so that the requirements of all potential WQIS users are taken into account.

Implications for Watershed Management:

Better communication with the public, both lay and professional, about the breadth and depth of the City's watershed research and protection programs serves the interests of all involved. Using the medium of the internet puts the facts and many facets of the City's extensive efforts at the fingertips of millions of individuals who consume the water supply being protected as well as thousands of people who live near the supply's sources. These constituents can learn of their own stakes in these programs and the ways in which they are linked to each other, upstate and down. Many of the programs are the first of their kinds. Written documentation and a website will make this information more available. Increased accessibility can also help the City and its partners build support for new programs and innovations that may be needed in the future. Within the Bureau and the Division, this project will make water quality data more accessible to scientific and managerial personnel. Increased data accessibility will result in quicker and more efficient conversions of data into knowledge-based, operational and policy decisions.

Problems Encountered: None

2.4.2 DEP and National Weather Service (NWS) Data Coordination Project

Manager: James Porter

Start & Completion Date: April 2002 – ongoing

Status (% Complete): Ongoing indefinitely. Will be modified as data users' needs change, and with changes in technology.

Project Cost: N/A

Objective and Justification:

The are two main objectives of this project: 1) the NYCDEP receives Internet-accessible hydrometeorological products from the National Weather Service and associated River Forecast Centers (e.g., probabilistic forecasts of inflow to reservoirs, used by DEP's Division of Operations for reservoir balancing, and additional locations for river stage forecasts used in operating the storm event program; and 2) NWS receives near-real-time (NRT) data from the Hydrology Meteorological Network, which they use for numerous purposes including flood forecasting, emergency management, and calibration of Doppler radar aerial precipitation estimates. NWS will also add DEP rainfall data to the Integrated Flood Observing and Warning System (IFLOWS)

Internet page of NRT precipitation data, which will be a benefit to both agencies (by providing easy access to rainfall data from any Internet connection) and to Emergency Managers in watershed communities. Several types of historical data are also being shared between agencies for various research purposes.

This project is based on Recommendations S-1 and G-6 of the report "Recommendations to Address Flood Warning Deficiencies in the Delaware River Basin" (Delaware River Basin Commission, Flood Advisory Committee, April 2001). It was specifically requested by the Chair of the DRBC Flood Advisory Committee via a letter to the NYCDEP. The project is being formally tracked by the DRBC.

Implications for Watershed Management:

Specialized products from the NWS will permit the NYCDEP Division of Operations to better operate and balance the reservoirs, and will assist DWQC with storm event sampling. This project has also opened up useful channels of communication with NWS and River Forecast Center staff that the NYCDEP now uses to obtain even more detailed and timely information (beyond what is available on the Internet) in planning for, and during, major storm events, snowmelt, etc. Through acquisition of NRT data from the NYCDEP, NWS greatly improves their ability to make highly localized and timely forecasts of floods and other dangerous weather-related situations. This benefits local communities, in the spirit of the Watershed Agreement, and also benefits DEP staff and facilities located in the watershed. As part of this initiative, the Northeast Regional Climate Center has agreed to provide climate data to the DWQC Modeling Program for free (saving the NYCDEP approximately $1,500 per year) in exchange for receiving our NRT meteorological data. Additional benefits and management implications will surely arise in the future as this collaboration continues.

Since the last Research Objectives Report, the NYCDEP has met with NWS twice, resulting in over a dozen specific issues addressed. Two of the most valuable are described below.

In the winter of 2004-2005, the NYCDEP began a spill-mitigation program at Pepacton Reservoir, wherein the NYCDEP released water so as to create a void in the reservoir equal to 50% of the snowpack water volume. This was done to reduce or eliminate spilling the reservoir when the snow melted in the spring, thus reducing stream levels below the dam. Largely due to this Coordination Project, we were able to have the National Operational Hydrologic Remote Sensing Center (an NWS office) utilize the snow water equivalent data collected by the DWQC Hydrology Program to provide a daily estimate of basin-wide water equivalent, which was then used to set the required release rates.

In July 2004, DEP Operations and Hydrology staff met with staff at the Northeast River Forecast Center and assisted them with developing new or improved river forecast models for Rondout, Schoharie, and Esopus Creeks. These models will improve inflow forecasting for the respective reservoirs, in turn facilitating the NYCDEP's operation of the reservoirs. It proved to

be a productive consultation, as there were many important aspects of reservoir operations and watershed issues which we were able to clarify for NERFC, and which undoubtedly will lead to more accurate river forecasts.

Problems Encountered: None

2.4.3 Ribotyping of *E. coli* from Sewage Treatment Plants

Manager: Neil DeLuca
Start & Completion Date: November 2002 to September 2005
Status (% Complete): 80
Project Cost: $16K
Objective and Justification:

The objective is to provide links between *E. coli* in the water supply to *E. coli* from possible sources of contamination. DEP has been ribotyping *E. coli* isolates from the watershed from a variety of sources since December 1999. These sources included geese, gulls, dogs, wildlife and water samples. The addition of sewage treatment plant (STP) *E. coli* to our ribotype database will allow DEP to make a more comprehensive comparison of possible contaminants to NYC source water supply, by adding *E. coli* most likely from humans to the library. The inclusion of human E. *coli* will increase the size and versatility of our data set, since there has been a limited set of human *E. coli* in the library.

All *E. coli* isolated from STPs have been ribotyped, and the data entered into our source library. The restriction enzyme *Hin*d III was used for the ribotyping phase of this project.

The *E. coli* ribotyped for this project are most likely of human origin. These ribotypes will either create or be added to existing RiboGroups. Identification of individual host sources of fecal *E. coli* is our goal and a prerequisite for remedial action by DEP management. The comparison of RiboGroups will be made by two methods. First we will compare RiboGroups obtained from STPs to RiboGroups in our existing library. Secondly, data will be analyzed by BioNumerics (Applied Maths) which is a powerful statistical tool using a mathematical program, that analyzes datasets to produce correlations for tree and cluster figures.

Implications for Watershed Management:

One of DEP's priorities is to maintain and deliver drinking water of the highest quality to the residents of New York City and the surrounding areas. Our hope was to form distinct RiboGroups from the *E. coli* isolated from the STP facilities. These distinct RiboGroups would become part of our source library and provide information as to the sources of elevated fecal

coliform from water samples within the watershed. If successful, it will provide information important for the identification of coliform-restricted basins and allow DEP to make informed watershed management decisions.

Problems Encountered: None

2.4.4 Comparison of the Distribution of *Cryptosporidium G*enotypes in Storm Water Samples from Three Watersheds

Manager: Kerri Ann Alderisio
Start & Completion Date: December 2001 to April 2004
Status: (% Complete): 100
Project Cost: N/A
Objective and Justification:

The objective of this study was to assess the source and public health significance of *Cryptosporidium* oocyst contamination in storm water within three New York City Watersheds. A PCR-RFLP technique based on the small subunit rRNA gene was used in the analysis of storm water samples collected from the Ashokan Brook on Ashokan Reservoir and Malcolm Brook and the N5 stream on Kensico Reservoir over several years. All samples were collected and sampling ended in the spring of 2004. The distribution of *Cryptosporidium* spp. and genotypes in storm water samples collected at all three sites were compared. Results demonstrate some shared genotypes between the watersheds; however, there were also genotypes recovered that were specific to each site. DEP collected 29 storm water samples from Ashokan Brook, 44 from Malcolm Brook, and 44 from N5.

Another goal of this study was to compare land use with genotypes recovered. The Malcolm Brook catchment is approximately 95 acres in area. It consists of sewered, relatively high-density suburban residential lots (approximately 4 lots per acre), corporate office parks and forested areas. The Ashokan Brook drainage basin, in contrast, is mostly undisturbed and forested, and differs in topography, fauna and flora. Both of these watersheds were studied and compared to determine if there were any differences in the sources identified as contributors of *Cryptosporidium* oocysts, given the varied land use of these areas. The N5 basin has now been characterized as well, with 298 acres of greater than 90% residential area. Oocyst types were compared to the other two locations for a final assessment of the data.

Implications for Watershed Management:

Finding different types of oocysts in different land use areas may help to shape the future design of sampling efforts for *Cryptosporidium* oocysts. This information may be helpful in qualifying the public health risk of different watershed categories with respect to the potential contribution from different sources, since not all *Cryptosporidium* species or subspecies are infectious to humans. The fact that greater than 90% of genotypes from all three watersheds yielded types from animal species, rather than from humans, significantly helps qualify the risk of infection to

humans, and allows management to concentrate more effort on areas impacted by human sources. Altogether, 22 different *Cryptosporidium* genotypes were found in storm water samples from these watersheds, and 50% of which could be attributed to known species/groups of animals. The remaining types were attributable to unknown wildlife species with the exception of a human type recovered at Malcolm Brook in March of 2002. Additional work is needed in this area to help identify the sources of these other unknown wildlife subspecies. A manuscript summarizing this work has been accepted by Applied and Environmental Microbiology for publication in 2005.

Problems Encountered: None

2.4.5 Improved Recovery of *Cryptosporidium* spp. oocysts and *Giardia* spp. cysts in Water Samples

Manager: Kerri Ann Alderisio
Start & Completion Date: June 2002 – August 2005
Status (% Complete): 90
Project Cost: N/A
Objective and Justification:

The objective of this study was to determine if the recovery efficiency of *Giardia* cysts and *Cryptosporidium* oocysts varies when samples are collected at different filter pressures. Investigators challenged protozoan collection filters (Envirocheck HV) at three different pressures with a matrix created in the laboratory using local Catskill clay. Laboratory created matrix samples were spiked with equal amounts of (oo) cysts and filtered at three different pressures: 10psi, 25psi and greater than 50psi. Percent recovery of the target organisms was recorded for each pressure.

The most current US EPA method for the analysis of protozoan samples from surface waters (Method 1623HV) recommends performing a matrix spike sample along with the first sample collected at a particular site, with a follow up frequency of every twenty samples. The method does not currently require the monitoring and recording of pressure throughout the filtration process, only that the procedure maintains a flow rate of two liters per minute. Water quality and matrix quality vary within watersheds, as well as across the country, and these differences have the potential to affect the quality of the sample result. Some sample matrices may have high turbidity, but not raise filter pressure; whereas others may have relatively low turbidity yet increase filter pressure dramatically.

Implications for Watershed Management:

Preliminary data analysis of field filter pressure and the frequency of the detection of *Cryptosporidium* and *Giardia* indicate a signal of decreased recovery at increased filter pressures. Since there are distinctly different components within the matrices throughout the New York City watershed, the results of this study may have a great impact on the way samples are collected in the future. Results support that samples filtered at the lower pressure had greater (oo)cyst recov-

ery than those filtered at higher pressure – a result of pressure, or increased processing per 50L. These data indicate the importance of monitoring and recording pressure while collecting samples for protozoan analysis, as well as the need to be very familiar with the matrix in a sample in order to appropriately analyze samples and qualify the data produced at each collection site. This is true for samples collected in house, as well as those collected for national databases such as the upcoming LT2.

Problems Encountered:

The data analysis and write up required to finalize this study has been delayed due to other priorities. DEP has submitted this work for acceptance and presentation at the 2005 Watershed Science and Technical Conference in September.

2.4.6 Improved Recovery of *Cryptosporidium* oocysts in High Turbidity Matrix Spike Samples

Manager: Kerri Ann Alderisio
Start & Completion Date: October 2002 – December 2004
Status (% Complete): 100
Project Cost: N/A
Objective and Justification:

The objective of this work was to apply two method modifications to USEPA Method 1623HV to determine their effectiveness in improving the recovery of *Giardia* cysts and *Cryptosporidium* oocysts from high turbidity matrices. Sample filtration data resulted in high turbidity and high filter pressure mimicking local storm event measurements. Cyst and oocyst recoveries from these samples were significantly low compared to (oo) cyst recovery from less turbid samples. A dual IMS procedure and sodium hexametaphosphate wash were introduced, both independently and in combination, to attempt to improve the recovery of the (oo) cysts.

Researchers have endeavored to improve the recovery of protozoa from water samples for several years. As a result, there has been much emphasis on both laboratory analytical procedure and field sample collection. With the improved time saving steps of USEPA Method 1623 compared to the ASTM and ICR methodologies, there has been increased focus on the ability to process more quality control samples in a protozoan laboratory than ever before. This is particularly true in the area of matrix spike testing. Although the methods have not yet reached 100 % recovery of *Giardia* cysts and *Cryptosporidium* oocysts, laboratories are able to qualify data with the addition of more matrix spike samples in their quality assurance sampling plans. This information is helpful when performing data analysis and when comparing occurrence data for these pathogenic protozoa at different locations throughout various watersheds.

Implications for Watershed Management:

The initial average oocyst percent recovery using the 1623HV method (12%) was increased by the dual IMS procedure (58%), and the sodium hexametaphosphate wash (66%). Results from two trials combining both method improvements demonstrated the most significant *Cryptosporidium* oocyst recovery (81%). The recovery of *Giardia* cysts did not improve significantly with either of the tested methods. Data suggest that these procedures may also improve the recovery of *Cryptosporidium* oocysts from other difficult matrix samples. This information is extremely valuable to the sample collector and sample analyst, since these two techniques have been shown to improve recovery compared to samples analyzed not using these techniques. Triggers can be established in the field (turbidity/ pressure) that can identify the need to introduce analytical improvements back at the laboratory in order to improve (oo) cyst recovery from certain matrices.

Problems Encountered: None

2.4.7 Croton Watershed Strategy

Manager: Kimberlee Kane
Start & Completion Date: December 2000 to September 2004
Status (% Complete): 100
Project Cost: $2.64M
Objective and Justification:

The Croton Watershed Strategy project started in December 2000. The primary goal of this project was to develop an integrated watershed management plan for the Croton System that would allow the NYCDEP to optimize management efforts and focus limited resources on critical areas to achieve maximum water quality benefit. This was achieved by:

- conducting a sub-basin watershed assessment for four critical indicator variables: total phosphorus, total suspended solids, pathogens, and toxic chemicals;
- implementing the methodology in a Decision Support Tool and;
- recommending watershed management alternatives for DEP's consideration.

The watershed assessment examined both existing and full build-out conditions in the watershed for 74 sub-basins. The methodology focuses on impairment from point and nonpoint watershed sources to identify each sub-basin's relative potential to impair water quality. The results were compiled in a series of documents and released in March 2003.

During 2004, the project continued with development of a Project Tracking Tool, an additional management tool linked with the Decision Support System. This tool will track implementation of projects by basin (remedial, protective and new development), estimate reductions of

phosphorus based on existing or proposed implementation projects, estimate increases of phosphorus based on new development, and generate basin status reports. The Project Tracking Tool will primarily be utilized to track implementation of the phosphorus TMDLs. The NYCDEP is currently in the process of developing the project database of remedial actions to use in the Project Tracking Tool.

In addition to the Project Tracking Tool, several other tasks were completed in 2004:

- Stakeholder Reports, summarizing the watershed assessment results, were developed for the counties and municipalities;
- Impervious surface analysis, comparing the mapped impervious data to literature values and examining the results by land use category and by sub basin and;
- Water quality analysis, comparing the watershed assessment results to monitoring data at select sites.

Implications for Watershed Management:

The Croton Watershed Strategy project has provided a more detailed and comprehensive watershed analysis than was previously available. It will be valuable in a wide variety of NYCDEP activities such as: prioritization of mitigation projects, guidance for field investigations and water quality monitoring, and SEQRA review of new development projects. The Decision Support Tool will also allow the NYCDEP to update this analysis as new data is developed.

Problems Encountered: None

2.4.8 Total Phosphorus Tracking of Lawn Fertilizers

Manager: Vincent Giorgio & Charles Cutietta-Olson
Start & Completion Date: June 2004 to October 2005
Status (% Complete): 30
Project Cost: $50K
Objective and Justification:

The objective of this study is to obtain information on lawn care practices, types of fertilizer used and the frequency of application for the EOH watersheds. While many factors will affect the quantity of phosphorus exported from managed lawns, lawn care practices, particularly fertilizer use, are likely the most manageable.

This survey is being conducted by the Cornell Cooperative Extensions of Westchester and Putnam Counties and is intended to gauge whether or not fertilizers are applied routinely or in response to an identified need. The information obtained will be used to assess: percent of homeowners who fertilize, percent of homeowners who use landscaper services, phosphorus content of the fertilizer used, extent of routine versus “as needed” application.

Implications for Watershed Management:

Many of the Croton System reservoirs have elevated levels of phosphorus and require reductions in nonpoint sources of phosphorus in order to meet water quality standards. Since low-density residential land is the largest land use in the Croton watershed, effective management options to reduce phosphorus loading from residential areas are desired. This type of watershed-specific data is necessary to develop effective non-point source management plans for phosphorus in the Croton watershed.

Problems Encountered: None

3. Future BWS Research (Funded Proposals)

3.1 Protection and Remediation Programs

3.1.1 Reference Wetlands Monitoring – Year 2

Manager: Laurie Machung/Kimberlee Kane
Start & Completion Date: June 2005 to June 2006
Status (% Complete): 0
Project Cost: $238K
Objective and Justification:

This project is the continuation of the Catskill/Delaware reference wetlands monitoring program established with Safe Drinking Water Act Funds to compare the baseline characteristics and water quality functions of wetlands among terrene and lotic landscape positions. In Year 2, baseflow, storm water, and vegetation sampling will be completed at the 22 reference sites. A final report summarizing the findings of the monitoring program will be produced.

Implications for Watershed Management:

Results from this monitoring program will enable the NYCDEP to compare water quality functions of terrene and lotic wetland types. Analysis of water quality and vegetation data from wetlands among various landscape positions will also provide a framework for the development of wetland assessment methodologies to guide both regulatory and non-regulatory wetland protection programs.

Problems Encountered: None

3.2 Watershed Monitoring, Modeling, and GIS

3.2.1 Occurrence and Transport of *Giardia* and *Cryptosporidium* within the New York City Watershed – Year 2

Manager: Patrick O'Brien
Start & Completion Date: March 2006 to August 2007
Status (% Complete): 0
Project Cost: $200K
Objective and Justification:

The objectives of this study are to move from the synoptic, watershed wide, sampling approach utilized in Year 1 to a more focused reservoir, sub-basin and site specific approach to investigating the occurrence and transport of *Giardia* and *Cryptosporidium* (oo)cysts.

Objective 1: Targeted sampling program follow-up. Year 1 data will be analyzed to determine sites of concern based upon the frequency and magnitude of high *Giardia* and or *Cryptosporidium* elevations. These sites will be sampled on a fixed frequency basis, as well as part of a targeted upstream-downstream basis in response to elevations, in order to isolate and determine sources.

Objective 2: Role of reservoirs. While Year 1 sampling focused only on streams within the watershed, Year 2 will integrate in-reservoir sampling at one or more terminal basins in an effort to track pathogen occurrence from their land-based sources through reservoir effluents.

Implications for Watershed Management:

Data collected will provide information on transport from headwaters, into a reservoir, through the effluents. This information is needed for both watershed and risk management purposes.

Problems Encountered:

Since Year 2 is dependent on the results of Year 1, the extensive delays in Year 1 has affected the start of this study.

3.2.2 Distribution and Seasonality of Haloacetic Acids (HAA) Sources in the CAT/DEL System

Manager: Gerard Marzec

Start & Completion Date: SDWA proposal: pending approval of funding - April 2006

Status (% Complete):0

Project Cost: $150,000 (Projected)

Objective and Justification:

The City of New York's reservoirs provides high quality drinking water that may exceed future SDWA standards for HAAs. This study is designed to assess the temporal and spatial distribution of the precursor sources of HAAs (HAA Formation Potential), and to incorporate a monitoring system that enables the City to better manage the reservoir to minimize disinfection by-products (DBP) precursors in the water withdrawn for distribution. The objectives include:

1) Determining the seasonality and spatial distribution of HAAFP;
2) Determining whether or not the tributaries are major sources of HAAFP, or if the reservoir sources are predominant;
3) Determining the viability of using DA_{272} to assess HAAFP for temporal and spatial relationships. DA_{272} is the difference between the absorption at 272 nm of the raw water sample and the absorption at 272 nm of a sample that has been chlorinated and incubated for a set

time. These two readings should correlate very well and we hope to use DA_{272} to predict when DBPs may be elevated in the distribution system. In this regard, this measurement should be considered a tool for long-term use;

4) Establishing a system for continuous monitoring of DA_{272} to enable some management for HAAs;

5) Tying reservoir concentrations and temporal-spatial distributions to the current distribution system study.

Implications for Watershed Management:

1) This study will improve our knowledge of HAAFP sources and will compliment our previous understanding of THMFP sources;

2) This study will assess how easy the method is in being a predictive tool for DBPs. This method allows for an almost immediate determination of DBP formation potential as compared to other methods that take up to a week. By monitoring DA_{272} on a long-term basis, trends could be determined and management decisions could be made quickly to avoid sudden potential increases in HAAFPs or other DBP precursors .

Problems Encountered: None

3.2.3 EOH Reservoir Bathymetry

Manager: Gerard Marzec

Start & Completion Date: September 2005 to May 2007

Status (% Complete): 0

Project Cost: $280K

Objective and Justification:

The purpose of this contract is to produce accurate bathymetric data and detailed physical and chemical characterization of bottom sediments for 11 reservoirs in NYC's Croton System. The bathymetry and sediment classification information generated from this contract will be utilized by DEP managers to develop new hypsographic curves relating volume to reservoir elevation, by DEP limnologists in assessing reservoir processes and the identification of appropriate monitoring stations, and by outside consultants in the development of the hydrodynamic component for various modeling efforts.

Reservoir geometry can have a major influence on its eutrophication and hydrology, thus detailed digital maps of the reservoirs, which indicate bathymetric contours, bottom profiles, and shoreline features, are essential for understanding reservoir processes. The reservoirs of the Croton System range in age between 87 and 128 years, and the bathymetric features may have changed since original construction. The development of new bathymetric contour maps will greatly enhance the DEP's Geographic Information System database, and will improve the hypsographic relationships currently used by water supply managers. The current contract will, therefore, help to create methodologically uniform, updated information for selected reservoirs.

Bottom sediment mapping and characterization is important in defining the area, types, and amounts of sediment in each reservoir. This contract will investigate numerous sediment analytes (e.g., particle size distribution, organic content, nutrient and metals content). From this information, such issues as sediment sources (e.g., external vs. internal, biologic vs. inorganic) and relationships to overlying water quality can be determined. This preliminary information is crucial in determining and modeling the type and extent of water quality problems that are present in Croton System reservoirs.

This project must be handled through a contract because DEP does not have the personnel, expertise, or equipment to provide this type of service in a timely manner.

Implications for Watershed Management:

In summary, this contract will provide reservoir bathymetric and sediment data to improve water supply hypsographic information, enhance limnological water quality monitoring, and support reservoir hydrodynamic and eutrophication modeling efforts, in order to accurately assess the sources and fate of pollution in the Croton watershed of the City's drinking water supply.

Problems Encountered: None

3.2.4 Development of a Sediment-Nutrient Sub-model for EOH Reservoirs

Manager: Don Pierson and Todd Echelman
Start & Completion Date: pending contract registration
Status (% Complete): 0
Project Cost: $70K
Objective and Justification:

The nutrient/phytoplankton models completed for the WOH reservoirs do not have sediment sub-models to quantify material exchange between the water column and underlying sediments. This added model complexity was unnecessary for those systems, as comprehensive monitoring established there was not substantial release of phosphorus (P) from the sediments of these reservoirs. While anoxia was encountered (e.g., Cannonsville), the redox potential does not drop low enough to mobilize solid phase iron (Fe) – P associations. In the EOH system, particularly the New Croton reservoir, major sediment releases of manganese (Mn), Fe, P, and color were documented in summer in multiple years. Therefore, water quality models in the EOH system should have a mechanistic sediment sub-model that predicts sediment-water exchange in response to redox (predicted) conditions and deposition inputs of decomposable organic material (e.g., phytoplankton). The model would have the capability of predicting changes in sediment feedback from changes in the productivity of the overlying water column, and other ambient conditions. It would require the addition of at least one more model state variable (Fe), and probably also a second state variable for Mn.

In this project a sediment sub-model will be developed, setup, and initially tested (focusing on near bottom water column). This will be done within the one-dimensional hydrodynamic/hydrothermal model framework to eliminate hydrodynamic complexities and keep run times short. This is consistent with the approach adopted in earlier model development and upgrades for WOH reservoirs; kinetic/water quality model advancements can be extended to the two-dimensional New Croton framework and the 1D water quality model frameworks for other EOH reservoirs in a subsequent phase. This work therefore, supports a consistent sequence of model development that will allow linking EOH water quality models to the 1D and 2D hydrothermal models that will be completed in projects described above.

Implications for Watershed Management:

Future development of operational water quality models in the EOH system will require simulation of sediment – water nutrient exchange. The sub-model developed in this project will eventually be incorporated into the EOH water quality models.

Problems Encountered: None

3.2.5 Upgrade of NYCDEP Reservoir Water Quality Model(s) to Simulate Functional Groups of Phytoplankton

Manager: Don Pierson

Start & Completion Date: pending contract registration

Status (% Complete): 0

Project Cost: $270K

Objective and Justification:

This project will upgrade NYCDEP's reservoir water quality modeling capability by integrating the desired features and capabilities of the PROTECH phytoplankton model into DEP's 1D reservoir models. PROTECH is documented in a manuscript by Reynolds *et al*. [2001; "The Ecological Basis for Simulating Phytoplankton Responses to Environmental Change (PROTECH). Ecol. Model. 140:271-291], and provides predictive capabilities for phytoplankton functional groups, but does not have the other attributes presently embedded in NYCDEP's model(s).

Project Tasks:

- Compare present NYCDEP phytoplankton identification/enumeration methodology to another widely used methodology. Paired analyses will be conducted for the monitored interval (e.g., March – November) of a selected year and reservoir. This will form the basis for any adjustments that may be needed for the long-term NYCDEP phytoplankton monitoring data.
- Test the existing PROTECH model on Cannonsville Reservoir, including assessment of the ability to predict succession and biomass of functional groups. Compare PROTECH simulations of total phytoplankton biomass with predictions from the existing NYCDEP model.
- Merge the best features of PROTECH (phytoplankton dynamics) and the existing NYCDEP model(s) (hydrodynamics and nutrient cycling) to form the upgraded reservoir water quality model(s).

- Test the upgraded model for Cannonsville Reservoir.
- Develop recommendations for applying the upgraded composite model to other NYC reservoirs.

Implications for Watershed Management:

The capability to simulate algal functional groups can provide DEP with the ability to simulate algal blooms, of groups (i.e. large colony forming cyanobacteria), which may lead to problems in drinking water use and treatment. This will enhance our modeling capability, as presently we can only simulate total algal biomass (measured as chlorophyll a).

Problems Encountered: None.

3.2.6 Numerical Weather Prediction and Forecast Products as Input Into Eutrophication Models

Manager: Don Pierson

Start & Completion Date: pending contract registration

Status (% Complete): 0

Project Cost: $10K

Objective and Justification:

There have been substantial advances in the skill of short-term (1 - 5 days), medium-range (two weeks), and longer-term (monthly to seasonal) atmospheric forecasts over the past two decades. Output from these forecasts, when used as input to hydrologic models, may improve forecasts of stream-flow and other derived parameters such as turbidity. The purpose of this project is to explore the feasibility of using the medium range [i.e. the Global Forecast System (GFS) model] and longer-term forecast products of the National Centers for Environmental Prediction (NCEP) for hydrologic predictions in the New York City watershed on time scales of up to eight weeks. This study will:

- Evaluate the systematic biases and the accuracy in predictions of precipitation and temperature over the NYC watershed domain and introduce procedures to improve raw GFS output through downscaling.
- Use the technique of model output statistics (MOS) to correct for systemic biases in the GFS output. MOS downscaling will develop empirical relations between gridpoint values of model output. Observed data will consist of historic Cooperative Observer network stations and the more recently deployed NYCDEP meteorological network.
- Produce a test “hindcast” from a chosen subset of cases of interest to NYCDEP with output including precipitation occurrence, precipitation amounts, maximum temperature, and minimum temperature for stations in the NYCDEP network.
- Develop tool to incorporate real-time NCEP output into a daily updated 8-week forecast product that can be ingested by NYCDEP hydrological models.

Implications for Watershed Management:

In order to make simulations that can support reservoir operational decision- making it is necessary to run the Nutrient Management Eutrophication Modeling System (NMEMS) up to the present and then into the future in order to make predictions of the future state of a reservoir. This project investigates the possibility of using weather forecast information to provide a data set that can be used to drive NMEMS with the best available weather predictions. Both predicted series of weather data and measures of uncertainty in the prediction will be output by the forecast processing tool developed by this project.

Problems Encountered: None

3.2.7 Development of a Regional-Scale Future Climate Scenario for New York City Drinking Water Quality Modeling

Manager: Don Pierson
Start & Completion Date: January 2005 to August 2005
Status (% Complete): 0
Project Cost: $48K
Objective and Justification:

The objective of this project is to provide DEP with consistently developed present climate and future climate data sets, which can be used to drive DEP's Nutrient Management Eutrophication Modeling System (NMEMS), in order to evaluate possible effects of climate change on reservoir water quantity and quality. Columbia University Center for Climate Systems Research (CU-CCSR) will develop these data sets:

- a control data set covering the period of 1990-1999
- a future climate data set covering the period 2050–2059

Both will contain the data necessary to drive the NMEMS (i.e. air temp precipitation wind speed etc). Data will be provided at a daily time step in a gridded 36 km x 36 km format that will encompass the entire NYC reservoir system. Data from both periods will be derived from General Climate Model (GCM) simulations available to CU-CCSR staff. The majority of the work in this contract will involve downscaling the GCM output, which out of necessity have a course spatial resolution, to the 36 km resolution, which is more appropriate for modeling the NYC reservoir system. In addition to the data, DEP will also receive reports detailing the downscaling methodology, and comparing the downscaled control period to actual meteorological measurements.

Implications for Watershed Management:

Climate change can potentially alter both the quantity and quality of water in the NYC drinking water supply. While it is easy to speculate on possible climate change effects, it is much more demanding to examine the potential effects of climate change in a quantitative framework that is consistent with DEP's present water quality modeling framework. The data provided by

this project will allow simulations with NMEMS under present and future climate conditions, so that the effects of climate change on reservoir water quantity and quality can be qualitatively assessed. This should allow the effects of multiple processes to be examined including the non-linearity and feedback effects that make simple qualitative assessment difficult.

Problems Encountered: None.

3.2.8 Croton System Reservoir Models

Manager: Don Pierson and Todd Echelman
Start & Completion Date: pending contract registration
Status (% Complete): 0
Project Cost: $100K
Objective and Justification:

This project consists of two separate tasks based on model structure. The first task will provide final verification of Croton system 1-D hydrothermal reservoir models calibrated, but not verified, under Phase I Croton system reservoir model development work (see Section 2.3.10 of 2002 report). This task will result in a group of seven models, which, are fully calibrated and verified. In the second task a two-dimensional (2D) hydrothermal models for the New Croton and Muscoot reservoirs will be setup and calibrated, building upon the preliminary 2D setups described in the project above.

Task 1: In this task one-dimensional models previously developed and calibrated for 5 EOH reservoirs will be verified. The verification process will involve comparison of model predictions of reservoir thermal structure with measured data. The verification process is important step needed to ready the models for operational use.

Task 2: In this task a two dimensional hydrothermal model for the New Croton and Muscoot reservoirs will be set up, calibrated and verified. As a result of this work operational 2D hydrothermal models of these reservoirs will be delivered to NYCDEP. The 2D model structure will be the same (based on CE Qual W2) used in 2D models in the WOH system

Implications for Watershed Management:

This project will fund the continued development and testing of reservoir hydrothermal models for the East-of-Hudson (EOH) reservoir system. The models are planned to have compatibility with the existing Catskill-Delaware reservoir models, with added functionality to accommodate Croton reservoir characteristics. The models will eventually serve as in-house management tools, and will contribute to the effective management of this reservoir system. The hydrothermal models form the foundation of fully functioning water quality models and their development is an important step in the overall development of a system of water quality models similar to those presently available for West of Hudson (WOH) reservoirs.

Problems Encountered: None.

3.2.9 Integrated Program of Measurements, Process Studies, and Modeling for the Turbidity Problem at Schoharie Reservoir and Esopus Creek

Manager: David Smith
Start & Completion Date: August 2003 to November 2006
Status (% Complete): 60
Project Cost: $2.5M
Objective and Justification:

The primary objective is to develop and test deterministic, dynamic, scientifically credible, models for temperature and turbidity for Schoharie Reservoir and Esopus Creek, (supported by the integrated programs of field measurements, sampling and laboratory analyses and process studies) that will be capable of supporting evaluation and design of rehabilitation technologies to abate the turbidity problems of these systems, and simultaneously meet specified temperature goals for Esopus Creek. A Change Order ($0.5M) is being processed to extend this contract to late 2007 and will include additional modeling elements: development and application of a probabilistic model for turbidity and temperature in Schoharie Reservoir and Esopus Creek; application of a three-dimensional model to evaluate specified management options to reduce turbidity levels reaching the Schoharie Reservoir intake(s); development, testing and application of a turbidity model for Ashokan Reservoir, and integration with the model for upstream systems to form a seamless Catskill System model; development of a near-real-time model that predicts time-of-travel and impacted depths of turbidity plumes in Schoharie Reservoir from runoff events

Implications for Watershed Management:

The Upstate Freshwater Institute, (UFI) is conducting integrated programs of field monitoring/laboratory analyses, process studies, development and testing of turbidity and temperature models, and application of models. These work elements are being used to support the evaluation and design of rehabilitation technologies for the turbidity problems in Schoharie Reservoir and Esopus Creek that will also continue to meet temperature requirements for fish populations in this creek. [This work is being conducted under contract to DEP, and requires extensive co-operation with other DEP consultants (a Joint Venture operating under a separate contract known as CAT-211 to the Bureau of Environmental Engineering. This JV is conducting engineering tasks related to the evaluation of alternatives and design of the selected technologies)]. Further, these studies will assist DEP in the operation of the Shandaken Tunnel SPDES permit. The Change Order will enable more refined and more useful modeling and will extend the study to Ashokan Reservoir.

Problems Encountered: None.

4. Review of Research Programs by Outside Agencies

4.1 Protection and Remediation Programs

4.1.1 Effectiveness of Whole Farm Planning and Implementation in Achieving Water Quality Improvement and Protection of New York City Water Supplies

Authors: Patricia L. Bishop, M. R. Rafferty, and J. L. Lojpersberger, Bureau of Water Assessment and Management, NYS DEC.

Dates: (Three reports delivered this year)
1 / 2004: Analysis of the sixth year of monitoring data (11/01-10/02)
8 / 2004: Analysis of the seventh year of monitoring data (11/02-10/03)
9 / 2004: Analysis of nine years of monitoring data (6/93-10/03) Before and after BMP implementation on a dairy farm in Delaware county, New York.

Executive Summary of the 9/04 report:

This report presents monitoring data from the period 6/93 – 10/03, acquired in the paired watershed study of the R Farm and Shaw Road sites. The R farm was one of the original pilot farms selected to demonstrate Whole Farm Planning (WFP) under the New York City Watershed Agricultural Program. In order to evaluate the effect of the WFP approach for water quality protection and improvement, the farm has been monitored intensively during the past 11 years. In addition, records of farm activities before and after BMP implementation have been kept. The farm and control sites were monitored for two years from June 1993 through May 1995, prior to BMP implementation at the farm in 1995-1996. Monitoring resumed in late 1996 and has continued until the present. Sampling efforts have been largely event-based.

After several years of monitoring, a former machine shed used as a shelter area for dry cows and heifers was identified as a high contributing source area. Located just upstream of the monitoring station, a cattle path led from it down a steep, eroded slope through the stream and up the opposite bank to a pasture area. In late summer of 2001, a stream crossing was constructed excluding the cows, and the banks were repaired and re-vegetated.

In January 2001, this farm was selected for participation in a pilot program of precision feeding to reduce phosphorus importation on dairy farms from purchased feed. Feeds and homegrown forages were analyzed for their protein, carbohydrate and mineral contents and the nutritional needs of the herd were determined using the *cu*NMPS (Cornell University Nutrient Management Planning System) software. Diets were adjusted and as a result, phosphorus imported onto the farm in purchased feed has been reduced by 30%. This has directly translated into a 30% reduction in phosphorus excreted by the cow.

It is expected that additional improvements to water quality will result from the new management practices described above. Thus, post-implementation sampling was extended from 5 to 9 years in order to observe the effects of these more recent farm management improvements.

Description of Data Collected:

A total of 1,326 samples were collected during the two pre BMP implementation years and 3,853 during the seven post BMP implementation years. The number of samples collected in a year generally varied directly with amount of runoff produced.

Table 4.1 shows the dates corresponding to each monitoring year and the number of samples collected during these nine years.

Table 4.1. Study periods and number of samples collected during study.

	Period	Farm	Control
Pre-1	6/1/93 – 5/31/94	468	331
Pre-2	6/1/94 - 5/31/95	315	212
Post-1	11/1/96 - 10/31/97	416	232
Post-2	11/1/97 - 10/31/98	483	262
Post-3	11/1/98 - 10/31/99	273	191
Post-4	11/1/99 - 10/31/00	403	275
Post-5	11/1/00 - 10/31/01	206	137
Post-6	11/1/01 - 10/31/02	305	162
Post-7	11/1/02 - 10/31/03	299	209

All samples are analyzed for nutrients (3 forms each of phosphorus and nitrogen), organic carbon and suspended sediment. Table 4.2 lists chemical analyses performed on samples. Streamflow volumes and nutrient and sediment loads are calculated. Pathogen sampling at both sites was conducted at least twice a month until 2002. Sampling for macro invertebrates was first conducted at both sites in July 1996 prior to completion of BMP implementation. Post-implementation bioassessment monitoring was performed once a year during the summer season through 2001 and may take place once more at the end of the study.

Table 4.2. Variables Measured During Study

Chemical Analyses	Covariates
Total phosphorus (TP)	Runoff
Total dissolved phosphorus (TDP)	Precipitation
Soluble reactive phosphorus (SRP)	
Particulate phosphorus (PP): computed as TP - TDP	
Nitrate + nitrite (NOX)	
Total ammonia ($T\text{-}NH_3$)	

Table 4.2. Variables Measured During Study

Chemical Analyses	Covariates
Total Kjeldahl nitrogen (TKN)	
Total organic carbon (TOC)	
Total suspended solids (TSS)	
pH, Alkalinity	

Conclusions:

The paired watershed study has been successful in identifying reductions in nutrient and sediment losses from an upland dairy farm in the Cannonsville Reservoir basin resulting from BMPs implemented under the Whole Farm Planning program. Greatest reductions appear to be in event loads of phosphorus, suspended sediment and ammonia. Sediment and PP reductions may be attributable to practices that lower erosion and work to keep soil particles on the farm during runoff periods. By storing manure in winter and spring, contact with saturated soil and runoff waters may contribute to reductions in event TDP losses. While some P may leave the farm in the form of manure being spread by the farmer on crop fields outside the watershed, it is likely that most reductions in P event losses are the result of retaining more P on the farm through BMPs, and, unfortunately, this could eventually lead to build-up of P in the soils.

Study Evaluation:

This is an ongoing study whose results show that between pre and post BMP implementation, a statistically significant decrease in loads was achieved at the farm site due to a suite of implemented BMPs. This work validates the effectiveness of WFP, in that a suite of BMPs can be implemented so as to mitigate water quality degradation due to loads from a dairy farm.

Study Limitations:

Unfortunately the effectiveness of each individual BMP in decreasing the total load from the farm cannot be ascertained. Additionally no insight as to the interaction between the implemented BMPs was obtained through this work. Additional studies may be required to quantitatively scale up the results of this study to the Cannonsville Reservoir scale and thus predict the impact of BMPs due to the implementation of WFP.

4.1.2 USGS Forest Health and Soil Nutrient Status

Manager: Peter Murdoch for USGS, James Porter for DEP
Start & Completion Date: 2001 - 2012 (estimated)
Status (% complete): 100 (for 2004)
Project Cost: $618K (for 2004). Project funded on an annual basis.
Objective and Justification:

The overall goal of this study is to learn to use forest harvesting to increase the retention of nutrients (mainly nitrogen and calcium) and decrease acidification and release of aluminum into surface waters in forested regions impacted by acidic deposition. As 75-80% of the West-of-Hudson water supply region is forested, this could be an extremely important tool. Specific objectives

are: 1) Determine an approximate threshold of forest harvesting intensity above which nutrient release to surface waters is increased (degrading water quality), and below which nutrient release is reduced (improving water quality); 2) Determine how the availability of calcium and nitrogen affects the growth and health of, and nutrient release from, declining sugar maple stands; 3) Use forest growth models in conjunction with the results of Objectives 1 and 2 to predict the long-term (50-100 year) consequences of the interactions of nitrogen deposition, Ca depletion, and forest harvest, with obvious implications for long-term forest health and water quality; and 4) Develop a regional map of forest condition and sensitivity to logging with regard to surface water quality impacts.

Implications for Watershed Management:

This research will help managers develop scientifically based land management plans aimed at maintaining and improving water quality. Such a tool has great significance for DEP. As part of the Watershed Agreement, the NYCDEP is spending at least $250 million on land acquisition within the watershed. Given that 75-80% of the West-of-Hudson water supply region is forested, much of the land being purchased is forested. The NYCDEP is developing management plans for all acquired lands. The NYCDEP also influences management of private forest land through the Watershed Forestry Program, in which planners develop management plans for private landowners. To date, over 250 management plans have been developed, covering over 40,000 acres. There is also the potential to influence management of state-owned lands within the watershed.

Data released in 2004 helps illustrate how different forest management practices can affect nutrient leaching from forests. Following a 33% thinning in February 2002, nitrogen concentrations in soil water increased to about 350 μmol/L, and then within a year dropped back down to reference-plot levels and have remained there. This was compared with a clearcut done several years ago, where nitrogen concentrations reached 1,400 μmol/L and have not yet completely returned to reference levels. Continuation of this project will further our understanding of the relationship between forest management, soil-site conditions, and nutrient leaching, thus making possible more scientifically-based forest management plans.

Preliminary data from the nutrient addition plots became available in 2004. It showed that addition of calcium reduced nitrogen concentrations in soil water compared to untreated reference plots, suggesting the calcium stimulated uptake of nitrogen by forest plants. This indicates that calcium is a limiting element on acid rain impacted sites such as the Neversink. This, in turn, could affect forest regeneration and growth after harvest, and thus has implications for the management of such sites. More data are required before conclusions can be drawn.

This project is also looking at a novel best management practice for dissolved nutrients. The slash left after logging has been chipped and applied to several small study plots. The hypothesis is that the high C:N ratio of the chips will drastically slow nitrification and reduce nutrient leaching from the plots. Preliminary data suggest the hypothesis may be correct, but more data are needed to confirm this.

4.2 Watershed Monitoring, Modeling, and GIS

4.2.1 Water Quality Monitoring in the Source Water Areas for New York City: An Integrative Watershed Approach

Author: Stroud Water Research Center, Avondale, PA.

Date: Phase I report finalized on July 2004. Study ongoing.

The Stroud Water Research Center's monitoring program is in its fifth year, the second year of Phase II. In Phase II, Stroud located new sampling sites farther upstream in the watersheds in order to move away from the influences of wastewater treatment plant discharges and other confounding influences and isolate landscape influences on water quality.

The objectives of this monitoring program are:

1. To measure specific environmental variables that statistically relate aquatic ecosystem structure and function to land use, BMP implementation, and other watershed inputs or factors;
2. To measure chemical, physical, and biological factors that can be used to evaluate or otherwise indicate the occurrence and/or source of selected chemical and biological aquatic contaminants and;
3. To provide a baseline data set of population, community, and ecosystem-level variables along with chemical, physical, and biological indicators for: (i) assessing the current status of water quality and aquatic ecosystem structure and function in response to on-going and historical land use, BMP implementation, and other factors; and (ii) assessing future change of ecosystem and water quality in response to changes in watershed activities and condition." (Water Quality Monitoring in the Source Water Areas for New York City: An Integrative Watershed Approach A Report on Phase I of Monitoring (2000-2002), Stroud Water Research Center, July 2004, p.E-1).

Study Evaluation:

It is too soon to evaluate how DEP will use the results of this study.

4.3 Data and Methods Development

4.3.1 Mercury and Organic Chemicals in fish from the NYC Reservoir System

Manager: Jeffrey Loukmas, NYSDEC
Start & Completion Date: 2001 to March 2005
Status (% Complete): 100%
Project Cost: $310K
Objective and Justification:

The New York State Department of Environmental Conservation (NYSDEC) was awarded SDWA funding to assess contaminant levels in fish collected from NYC reservoirs. In the SDWA grant application, the NYCDEP was listed as a cooperating agency for collecting fish for this study. This project was completed in March 2005 and a paper copy report is available for distribution.

Project summary:

The 19 upstate reservoirs in New York City's water supply system all support active fisheries, but recent contaminant monitoring in five of these reservoirs detected elevated mercury concentrations in certain species of fish. The lack of fish contaminant data for the other reservoirs and the likelihood that elevated mercury levels would be found prompted this project. From 2001 - 2003, important recreational fish species from 16 reservoirs (two reservoirs, Cannonsville and Pepacton, were re-sampled because contaminant data were available for only one species from each reservoir) were examined for polychlorinated biphenyls, organochlorine pesticides, dioxins, furans, and mercury residues.

Mercury was confirmed as the primary contaminant of concern in fish tissue from the reservoir system. Mercury concentrations above the United States Food and Drug Administration (USFDA) enforcement limit of 1000 ng/g were detected in 13.6% of the samples and included seven species and 14 reservoirs. The New York State Department of Health (NYSDOH) subsequently issued human consumption advisories for six species from 11 reservoirs. Species included in the advisories were walleye (*Sander vitreus*), smallmouth bass (*Micropterus dolomieui*), largemouth bass (*Micropterus salmoides*), brown trout (*Salmo trutta*), white perch (*Morone americana*) and yellow perch (*Perca flavescens*). There are now 14 reservoirs, including all six west of the Hudson River, within the New York City system with mercury-related health advisories. Chlorinated dioxin and furan, PCB, and DDT concentrations were below USFDA or NYSDOH health criteria for all samples.

Implications for Watershed Management:

The monitoring of toxics in fish tissue provides the public with information for more informed decisions regarding the consumption of fish. This information is provided through the New York State Health Department and can be found at the website: http://www.health.state.ny.us/nysdoh/fish/fishengl.htm.

Appendix - List of Abstracts for 2005 NYC Watershed Science & Technical Conference (Fishkill), 21/22 September

1. Demonstrating multi-objective stream restoration and monitoring as part of the Esopus Creek Stream Management Plan

Dan Davis[1]; Craig Fischenich, Ph.D. P.E.[2] Gary Capella[3] ; Jake Wedemeyer[3] ; Quentin Gahan[4]

NYCDEP and Ulster County Soil and Water Conservation District (UCSWCD) with project partners, U. S. Army Corps of Engineers, USDA Natural Resource Conservation Service and FIScH Engineering, Inc., sponsored a stream restoration project in 2003 on the Esopus Creek near Phoenicia, New York. The primary goal of the project was to address erosion and failure of approximately 500 feet of the left descending stream bank that was threatening property, posing a recreation hazard and degrading water quality. Rapid retreat of the stream bank (up to 3 ft/yr laterally) exposed highly erodible clay-rich glacial deposits and was an episodic source of suspended sediment in the stream. The restoration effort comprised natural channel design (NCD) components, traditional and experimental bank stabilization techniques, and bioengineering to meet the project objectives of stabilizing the bank, returning the stream to its recent historic alignment and enhancing recreation potential. Following successful yet challenging construction conditions, NYCDEP and UCSWCD have designed a monitoring and maintenance protocol and implemented the first two years of post-construction monitoring and maintenance following impacts from several flood flows since construction. Project design, construction and ongoing monitoring will be used as a demonstration of multi-objective stream restoration to add to development of the Esopus Creek Stream Management Plan, to be completed in 2007.

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Project Manager/Geologist, Dan Davis, B.A. Geology SUNY, New Paltz, 1990. Dan is a project manager with the Stream Management Program in Kingston, NY. He is responsible for managing projects in the Esopus Creek basin as well as providing geological services for the Program throughout the WOH NYC water supply watershed.

2. Fluvial Process Research and Database Development Efforts of the NYCDEP Stream Management Program in Support of Regional Stream Restoration and Management

Sarah Miller

The concept of natural channel design (NCD) for stream restoration projects is based on the premise that morpholog-

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ical variables used to design dimension, pattern and profile can be developed from empirical models and reference stream reaches in similar valley settings. Efforts to design and evaluate restoration projects using this approach for streams of New York State have been hampered by insufficient documentation of natural variability in stream morphology, fluvial process and biology. This project sought to develop and implement a set of repeatable protocols and experimental designs to assess stability of reference sites in the Catskill Mountains, and to develop a database of associated hydraulic, geomorphic, and biologic characteristics to support regional NCD efforts. Specifically, researchers developed methods to investigate the efficacy of relations currently used in stream assessment, design, and monitoring, including defining bed-mobilizing discharge, channel geometry, bed-sediment size distribution, water velocity, relative roughness, shear stress, Shields parameter, size distribution of lateral depositional bar sediments, tracer bedload particle transport, and scour and fill depths. These findings should also provide a benchmark for aquatic habitat conditions and fish and macroinvertebrate communities in reference streams.

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3. Stream geomorphic and watershed assessment of Esopus Creek above Ashokan Reservoir

Dan Davis; Susannah Erwin (Cornell Cooperative Extension of Ulster County)

Efficient and effective stream corridor management is enhanced by optimized characterization and assessment of stream valley geomorphic and riparian condition to inform prioritization of management actions. As a FAD deliverable, NYCDEP is sponsoring development of a stream corridor management plan for the upper Esopus Creek (above Ashokan Reservoir). The Plan will summarize the resources and issues in Esopus Creek, prioritize needed action and provide recommendations for long-term stewardship. NYCDEP and Cornell Cooperative Extension of Ulster County (CCE) initiated the necessary watershed assessment and stream geomorphic characterization by implementing Phase 1 of the Vermont Agency of Natural Resources multi-phased stream geomorphic assessment protocols. Phase 1 utilizes available remotely sensed data, other mapped data, previous study results, and limited field observations to establish geomorphic-defined reaches, provisional stream classification, predictions of channel condition, adjustment process, and reach sensitivity. This effort served two purposes – initiating the actual assessment process for Esopus Creek and evaluating the efficacy of a multi-phased approach to stream corridor assessment. A Phase 1 assessment was successfully completed on the mainstem of upper Esopus Creek (26 miles), producing a comprehensive database and set of GIS projects containing detailed information on geomorphic and watershed characteristics and condition. The Phase 1 findings were evaluated by implementing Phase 2 (collection of field-based data) for three reaches. It is

clear from this exercise that a phased approach is necessary for the size of the upper Esopus Creek watershed (192 mi^2) and results will be used to optimize field assessment phases, increasing the efficiency in informing the management planning effort. While the protocols used still need further testing to determine their applicability to the goals and needs of the NYCDEP stream management planning process, they do offer a structure that can be adapted to project conditions.

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4. GIS Overview of the Current State of Riparian Buffers in the NYC Watershed

Terry Spies - GIS Coordinator, and Ira Stern - Director, NYCDEP Watershed Lands and Community Planning

DEP's GIS system was used to inventory streams in the Catskill/Delaware portion of the New York City Watershed, categorizing stream length in terms of public or private ownership and related protection status. GIS was then used to quantitatively assess the current state of riparian buffers surrounding those streams, focusing on land ownership, protection status, regulations, and land-cover/land-use. Results for both publicly- and privately-owned lands indicate that an overall healthy riparian buffer profile exists for the Catskill/Delaware watersheds, if the current predominant land cover of forest can be maintained into the future. Recommendations on how to continue to protect and maintain riparian zones in the NYC Watershed will be presented and include significant coordination with stakeholders, outreach and incentives to private landowners, continued acquisition of easements, and further implementation of stream management plans.

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Ira Stern is Director of the Division of Watershed Lands and Community Planning for the New York City Department of Environmental Protection (DEP). He coordinates the DEP's voluntary watershed protection programs including land acquisition and management, agricultural and forestry programs, stream management and community planning. Mr. Stern's background includes experience in government, the private sector and in running non-profit organizations. He holds a Master's degree in City and Regional Planning from Pratt Institute and a Bachelor's degree

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Terry Spies is the GIS Coordinator for the New York City Department of Environmental Protection's Division of Watershed Lands and Community Planning. She earned her M.Sc. in Geography from Rutgers University in 1991, her B.A. in Geography and Certificate in Cartography from Rutgers University in 1989, and has over 16 years experience in applying GIS, Remote Sensing, and related database development and information system technologies to problems in natural resource management. She currently manages a variety of GIS projects ranging from forestry and agricultural management to community infrastructure planning to land acquisition and stewardship, all applied to water quality protection for New York City's nine million consumers.

5. Relative Importance of Turbidity Sources to the Ashokan Reservoir

D. C. Pierson, E Schneiderman, M. Zion

Turbidity levels in the Ashokan reservoir can at times reach relatively high levels (> 15 NTU), which will limit the use of the reservoir as a drinking water source. Turbidity in this reservoir is largely associated with two sources: Schoharie Reservoir releases that enter the Esopus Creek as a point source via the Shandaken Tunnel and non point source turbidity generated within the Esopus Creek watershed. Presently NYC DEP is examining ways to reduce Shandaken tunnel turbidity releases, by improving Schoharie Reservoir infrastructure, and/or by modifying reservoir release criteria. In this paper, using model simulations, we investigate the relative importance of Shandaken Tunnel turbidity and Esopus Creek non point source turbidity in influencing the Ashokan Reservoir.

A series of simulations were run from the beginning of 1993 to the end of 1999, and these were driven by measured variations in weather and reservoir operations. Watershed turbidity loads were estimated for all major tributaries to the Schoharie and Ashokan reservoirs using the GWLF model. These were then used to drive linked Schoharie - Ashokan two dimensional (CE-QUAL-W2) reservoir simulations, which predict the vertical and longitudinal distribution of turbidity in the two reservoirs. Data, saved at a daily frequency, allowed us to examine the relative importance of the two turbidity sources, over monthly to yearly time scales. How variations in weather and reservoir operations affect the relative importance of the turbidity sources, the overall level of turbidity loading, and the transport of turbidity through the west basin of Ashokan is discussed.

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tations in the US and Europe. His research interests include: mathematical modeling of environmental processes; primary production; underwater optics and remote sensing; sediment resuspension; biogeochemical cycles; surface hydrology.

6. Two-dimensional modeling of solids in Kensico Reservoir to assess processes affecting the transport and dilution of turbidity and pathogens

Todd S. Echelman

Kensico Reservoir, located in southern Westchester County of New York state, is an important component of the New York City water supply, with about 90% of the City's potable water flowing through it. With a storage capacity of about 30 billion gallons and outflows of about a billion gallons a day, the reservoir has a retention time of about one month. Transport and dilution of waters within the Reservoir are affected by the storage of the reservoir, the aqueduct flows, and meteorological conditions. Clearly, these processes affect constituents suspended in the Kensico Reservoir water column, such as solids, turbidity and pathogens. The characteristics of the suspended solids themselves also greatly affect the turbidity levels entering the New York City water supply, and recent studies show that suspended solids and turbidity levels also affect pathogen sedimentation and detection rates.

Turbidity and pathogen levels have been monitored in Kensico Reservoir for at least two decades, and in the last decade New York City began a modeling program to guide management decision-making regarding constituents of concern. This study uses a two-dimensional model (CE-QUAL-W2) to quantitatively evaluate the transport and dilution of suspended solids, under existing conditions throughout an eight-year period, from 1992 to 1999. Monthly two-day "spikes" (100 mg/l) of suspended solids are simulated from different sources (Catskill Aqueduct, Delaware Aqueduct, etc.), to assess the potential transport of turbidity and pathogen-like particles, under a variety of conditions.

Similar to initial studies (Echelman, 2004), this more systematic analysis compares transport and dilution of particles derived from different sources under both isothermal and thermally stratified conditions. Quantitatively assessments of the unit response of outlet concentrations relative to reservoir loading are performed through linear regression. Results show that Catskill Aqueduct loads, under thermally stratified conditions, produce relatively high effluent responses (EPC = 0.06 IL – 0.95), while Delaware Aqueduct loads, under isothermal conditions, produce relatively low effluent responses (EPC = 0.02 IL – 0.21), where EPC represents effluent peak concentrations, in mg/l, and IL represents influent loads, in Kg. These differences are largely derived from both the physical (bathymetric) and seasonal (thermal) conditions that characterize Kensico Reservoir. This work is intended to assist New York City water supply managers in understanding the transport of turbidity and pathogen-like particles in Kensico Reservoir.

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7. Development, Testing and Application of Models to Address Temperature and Turbidity Issues in Schoharie Reservoir

Steven W. Effler, Rakesh K. Gelda1, Emmet M. Owens1, Susan M. O'Donnell1, David M. O'Donnell1, MaryGail Perkins, David G. Smith, and Donald C. Pierson

Contemporary water quality issues for Schoharie Reservoir include the temperature (T, ºC) and turbidity (Tn, NTU) of water withdrawn that enters Esopus Creek. Several engineering alternatives are under consideration to avoid the discharge of warm or turbid water to the creek, including: (1) an in-reservoir baffle positioned to increase travel time from the primary tributary to the intake, and (2) replacement of the existing single depth intake with a multi-level facility. Credible mathematical models are required to evaluate these alternatives and guide design. The integrated program of monitoring, progress studies, and modeling that is being conducted to meet these needs is described. Key findings from the monitoring program, documentation of successful model testing, and preliminary results of model applications, are presented.

Modern monitoring techniques including the use of rapid profiling instrumentation, that supports two- and three-dimensional resolution of Tn patterns over short space and time intervals, and robotic monitoring units, that provide continuous measurements of key parameters for both the primary tributary and within the reservoir, were implemented. Conspicuous increases in reservoir Tn are reported following runoff events, associated with the entry of large quantities of terrigenous minerals form Schoharie Creek. These inputs are carried in plunging density currents, and are shown to impart distinct Tn patterns in time and space. The robotic network, that is capable of delivery data to off-site locations in near-real-time, is described and example resolved signatures of runoff event impacts are presented. This monitoring information supports modeling by specifying drivers and state variable patterns.

Documentation of successful testing of two-dimensional hydrothermal/hydrodynamic and three-dimensional hydrodynamic models for the reservoir is presented. The credibility of the two-dimensional model to simulate the seasonal thermal stratification regime and the T of withdrawn water is demonstrated for a 15 year period. Additionally, this model and the three dimensional model are demonstrated to successfully simulate the behavior of density currents in the reservoir. Finally, the successful testing of a two-dimensional Tn model for the reservoir is documented.

The tested models are being applied to evaluate the potential benefits of an in-reservoir baffle and a multi-level intake facility. The baffle alternative is being evaluated with the three-dimensional model because of the proposed configurations. The effects of three different baffle lengths on the transport of a conservative tracer from the mouth of Schoharie Creek to the intake are considered. Reduced peak concentrations and increased time of travel are predicted for the baffle configurations. A predictive framework, composed of the two-dimensional water quality (T and Tn) model linked to a heuristic optimization algorithm, is applied to identify multi-level configurations that avoid high T and minimize Tn in the reservoir withdrawal. Simulations of the effects of a multi-level intake facility on the reservoir's stratification regime are also presented.

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8. Modeling Seasonal and Inter-Annual Variability of Dissolved Phosphorus Concentrations in Direct Runoff
Mark S. Zion and Elliot M. Schneiderman

The major pathway for dissolved phosphorus to enter streams and reservoirs is via direct runoff. Rain or snowmelt washing over the ground surface carries dissolved phosphorus from the soil and transports these constituents downstream. The concentration of dissolved phosphorus in direct runoff is dependent mainly on the phosphorus concentration in the soil which, in turn, is dependent on multiple factors including the land cover and agricultural management practices such as spreading of fertilizer or manure, tillage alternatives, grazing and crop rotations.

Two separate modeling strategies can be used to simulate dissolved phosphorus concentrations for direct runoff. One approach is to assign a concentration value to the direct runoff associated with land cover, land use and management practices based on observed concentrations obtained from field studies. This approach, used in the Generalized Watershed Loading Functions (GWLF) model offers simplicity, ease of use, flexibility, and the ability to directly incorporate observations into the model. As new data and studies reveal previously undetected effects of watershed processes, these effects can be readily incorporated into the model via appropriate changes in concentrations associated with direct runoff.

A second approach is to calculate phosphorus concentrations based on phosphorus soil mass balance, accounting specifically for phosphorus additions due to manure and fertilizer spreading, plant uptake, mixing due to tillage and internal soil phosphorus transformations. This approach is used in the Soil and Water Assessment Tool (SWAT) model, developed by the U.S. Department of Agriculture. The advantage of this approach is the realistic representa-

tion of the conceptual processes that control watershed chemistry, thus providing opportunities to study how manipulation of individual processes and management practices can impact watershed phosphorus loads in direct runoff.

The purpose of this study is to improve concentration values used in the GWLF model by utilizing the sensitivity of dissolved phosphorus concentrations in direct runoff due to land management options and climatic variability as they are calculated by the SWAT model. Dissolved phosphorus concentrations in direct runoff for various land management options are predicted by SWAT based on the underlying integrated theory. This permits the investigation of seasonal patterns and inter-annual variability on runoff phosphorus concentrations. The resulting intra- and inter-annual variability in phosphorus concentration is then added to the GWLF watershed model, thus improving predictive capability for watershed management scenarios.

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9. Variation in Total Phosphorus Export Coefficients for Small Catchments Based on Routine and Storm Event Monitoring

Dale L. Borchert and James D. Mayfield

From 2000 to 2004, the NYCDEP conducted an intensive monitoring program on three study catchments located within the New Croton Reservoir watershed in Westchester County, NY. The data collected were used to estimate annual total phosphorus export coefficients from the three study catchments. The export coefficients generated from this project were then compared to literature values, and discussed in terms of annual rainfall and annual runoff coefficient differences. The data affirmed the difficulty in developing a single export coefficient for a particular land use or catchment. The data also re-enforced the need to apply a range of acceptable export coefficients when modeling land use changes.

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Dale Borchert has been a District Hydrologist with the NYCDEP for the past 8 years. In this capacity, Dale has directed a team of scientists and research assistance in the collection, maintenance and analysis of streamflow and water quality data collected in the NYCDEP's East of Hudson watershed. The suburbanization of this area has led Dale's work to focus on the effects of development on water quality, as well as the effectiveness of Best Management Practices to improve water quality following land use change. Dale holds an M.S. in Environmental Science from SUNY ESF, as well as a B.A. in Geology from the University of Rochester.

James D. Mayfield is the director of the Watershed Hydrology Program, NYCDEP Division of Drinking Water Quality Control. He received his B.S. in Biology from Centre College of Kentucky and an M.S. in Biology from the University of Louisville. He began his career at NYC DEP in 1988 as the Catskill District Limnologist, where he conducted limnological surveys, performed laboratory analyses, managed data, and prepared reports. In 1990 he began supervising the program that would evolve into the Watershed Hydrology Program. This program conducts water quality monitoring in the NYC watershed at over 150 stream or release sampling locations and also maintains a meteorological network of 25 sites. The program also designs and implements special studies to address specific water quality issues or informational needs.

10. Monitoring of Pesticides and Other Toxic Compounds in NYC Watersheds

David Van Valkenburg (presenter), Charles Cutietta-Olson, and Tracy Lawrence

Sampling of NYC's water supply waterbodies for pesticides and other toxic compounds has been ongoing since 1994. This program was enhanced in 2000 with $120,000 over two years for additional laboratory analysis of samples. A sampling strategy targeting potential source areas was implemented throughout the East-of-Hudson and West-of-Hudson watersheds. While data before 1999 are limited, a review of data collected in the 1994-2004 period suggests that pesticides and other toxic compounds do not occur in water at concentrations that are a major concern for the water supply at this time. The most frequently detected compounds are the herbicide 2,4-D and the class of compounds known as polycyclic aromatic hydrocarbons (PAHs). The reservoir watersheds with the most frequent occurrence of detections are Muscoot, New Croton, and Kensico. Future monitoring will attempt to characterize ambient pesticide and toxic compounds concentrations in water and sediment on a statistical basis (i.e., a specified level of confidence of estimates of mean and 90th percentile concentrations) in order to more quantitatively identify source areas and assess the environmental and water supply risk posed by these compounds.

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Having worked at DEP for over six years, Mr. Van Valkenburg conducts monitoring and data management and analysis tasks for a variety of projects including the tributaries near the proposed "Belleayre Resort at Catskill Park" development and the Pesticide and Toxics monitoring program.

11. DEP Wetland Functional Assessment Mapping
Laurie Machung

DEP's Wetland Functional Assessment Program combines a GIS-based classification and assessment system with a monitoring program to determine baseline characteristics and water quality functions of wetlands among various hydrogeomorphic settings. The GIS portion of the work was completed in 2004 through a contract with the United States Fish and Wildlife Service (USFWS). The USFWS completed a Watershed-based Wetland Characterization and Preliminary Assessment of Wetland Functions (W-PAWF) for the Croton, Catskill, and Delaware Watersheds. For the W-PAWF, hydrogeomorphic modifiers were attached to each wetland polygon in the NWI database to support preliminary, basin-wide assessments of eight wetland functions: surface water detention, streamflow maintenance, nutrient transformation, sediment retention, shoreline stabilization, provision of fish habitat, provision of waterfowl and waterbird habitat, and provision of other wildlife habitat. A series of 13 maps was prepared for each reservoir basin to highlight wetland types that may perform these functions at significant levels. Because the W-PAWF is a preliminary evaluation based on wetland characteristics interpreted through remote sensing and best professional judgment, DEP completed an extensive field review of the wetland classifications and has implemented a monitoring program at a subset of reference wetlands located throughout the Croton, Catskill, and Delaware Watersheds. DEP's field review has resulted in a number of methodological improvements for the W-PAWF, particularly in the identification of isolated wetlands. A pilot monitoring program has been completed in the West Branch and Boyd Corner reservoir basins and is currently underway in the Catskill and Delaware Watersheds. Reference wetland monitoring data are being analyzed to assess the findings of the W-PAWF and to investigate relationships among chemistries of soil and water, plant communities and hydrogeomorphic classes.
Results of this program will enable DEP to determine baseline conditions and water quality functions of a number of wetland types and will benefit the development of both regulatory and non-regulatory wetland protection and non-point source programs.

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12. Pressure as a Potential Indicator of Interference in the Recovery of Cryptosporidium spp. oocysts in Surface Water Samples Using Method 1623
Lisa Blancero and Kerri A. Alderisio

During field filtration at several sites in the New York City watershed, an increase in pressure on the filters was noticed. Preliminary data analysis of field filter pressure and the frequency of detection of Cryptosporidium oocysts indicated a slight signal of decreased recovery at increased filter pressures. It is believed that the sediment at these sites may have had an impact on the recoveries as well as the pressure increase on the filters. This sediment, Catskill clay, is different from other matrices that the lab has seen such as the Tennessee River Sediment used in USEPA performance testing samples. As a follow up, a study was designed in the laboratory to focus on the pressure aspect of sample collection and the effects of Catskill clay. Approximately 9.5 grams of a local matrix of Catskill clay was added to deionized water in the laboratory so that a maximum filter pressure recommended by the filter manufacturer (60psi) could be attained. Three filtration units were designed to filter three different 50L carboys simultaneously, each as an independent unit. Using the Catskill clay, the laboratory created matrix samples with each having a turbidity of 240 nephelometric turbidity units. Each of these matrix samples were spiked with flow cytometer counted Cryptosporidium oocysts obtained from Wisconsin State Laboratory of Hygiene and subsequently filtered at three different pressures (10psi, 25psi and greater than 50psi). Each of the filters was processed according to USEPA Method 1623: Cryptosporidium and Giardia in Water by Filtration/IMS/FA. Initial trials showed a decrease in oocyst recoveries by an average of 13% as the pressure increased from 10 psi to 50 psi. In an effort to increase overall recoveries, 5% sodium hexametaphosphate was added to the elution step. Although overall oocyst recoveries did increase, a significant decrease in oocyst recovery still occurred as the pressure on the filters increased. It is believed that these data may indicate the importance of recording pressure while collecting samples for protozoan analysis, as well as the need to be very familiar with the matrix of a sample in order to appropriately qualify the data produced at each collection site.

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the water supply, as well as applying Microbial Source Tracking techniques to water samples for improving methods to detect and speciate pathogens for source identification.

13. Application of Pathogen Field Monitoring Data: Preliminary Modeling to Assess Transport Processes in Ashokan Reservoir

Gerry Pratt and Todd Echelman

Recent advances in computer modeling of reservoir systems have contributed to the understanding of the transport of water and suspended particles such as pathogens. Sedimentation is identified in several studies as an important process affecting pathogen detection rates in lakes and reservoirs. This exercise applies field data and theory to the modeled processes and evaluates sedimentation as predicted by computer simulations and real world situations. A two-dimensional model provides a preliminary assessment of transport of Giardia-like particles, under existing 2004 conditions in Ashokan Reservoir.

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14. Drainage Basin Comparisons of Giardia spp. and Cryptosporidium spp. Occurrence within the East of Hudson District of the New York City Watershed

Patrick J. O'Brien

The East of Hudson District of the New York City Watershed is comprised of 15 separate drainage basins. Since the sources of Giardia cysts and Cryptosporidium oocysts can be from humans, domestic animals, and wildlife, the distri-

bution of (oo)cysts throughout the district is not expected to be uniform across all of basins. Additionally, between-basin differences in physical parameters such as impervious surface area, land use, waste water handling, and wildlife assemblages could affect (oo)cyst occurrence. A between basin comparison of Giardia and Cryptosporidium (oo)cyst occurrence was conducted to determine which basins of the watershed present with higher occurrences. Filtered water samples were collected from streams within each of the basins, and enumerated for occurrence, by the NYCDEP DWQC Pathogen Program as part of various research and monitoring objectives. All samples were collected and processed using USEPA Method 1623 between June 2003 and June 2005. For ease of analysis, the occurrence raw data was converted to (oo)cysts/Liter and was analyzed in that form as sample volume was not always equal. The sampling frequency at each site was not uniform; as samples were collected both monthly and quarterly for at least one year; therefore the n for each site varied between 4 and 24. The sites were pooled by basin and the mean occurrence of Giardia cysts and Cryptosporidium oocysts was calculated. A between-basin ANOVA was conducted to determine if any differences in (oo)cyst occurrence were present. Additionally, instances of high occurrence, defined as >45 Giardia cysts and > 3 Cryptosporidium oocysts in a 50-L sample were used to rank the basins by frequency of elevated counts. The results of this project will allow the NYC DEP to investigate the basin characteristics where higher occurrence was detected. Research such as this is essential to the determination of pathogen sources as well as to the establishment of effective watershed protection controls.

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15. Using the Regulatory Process to Minimize the Potential for Erosion and Sedimentation During Construction – a Case Study

Mary P. Galasso

Stormwater pollution prevention plans prepared to meet the requirements of the New York City Watershed Regulations typically include construction sequencing and erosion and sediment control plans. The detail to which these elements are addressed in the regulatory process is relative to the complexity of the project. For a municipal complex in the East of Hudson watershed, extensive cut and fill balancing was necessary to convert the site from a hilly, forested site with local wetlands and watercourses to a level municipal campus. Through DEP's regulatory review process, the details of phasing the cut and fill balances, interim grading and associated erosion control practices were established as part of the construction sequence prior to approval of the project and ensuing construction. As with any project,

modifications to the sequencing and erosion control measures were anticipated during construction.

No water quality violations were reported during construction. No work stoppages were attributed to water quality concerns. Successful implementation of the phasing, sequencing and associated erosion controls was the result of several key factors including good communication between the various stakeholders, (i.e., DEP, town officials, construction managers, contractors), adherence to the approved construction sequencing and erosion control plan, and flexibility of stakeholders in adjusting the plan as required by unforeseen circumstances. Construction is completed and all temporary measures have been removed.

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16. Applicability of Published Phosphorus Loading and Reduction Data to the Stormwater Regulatory Program in the New York City East of Hudson Watershed.
John Drake, Mary Galasso

Sources such as the National Pollutant Reduction Program Database and the International Stormwater Best Management Practices (BMP) Database have been established to provide the stormwater industry with readily accessible information as to the efficiency of stormwater treatment practices. Review of these databases and additional stormwater literature indicate that reported studies span a wide range of variables such as project scale, sampling method, sampling frequency, stormwater practice design criteria, regional and seasonal considerations. The specific applicability of available literature to stormwater management practices commonly implemented in the New York City East of Hudson watershed is examined.

Stormwater pollution prevention plans prepared to meet the requirements of the New York City Regulations regarding the effects of stormwater discharge from regulated activities must currently demonstrate, among other things, that the quality of runoff after development is not substantially altered from pre-development site conditions. This is demonstrated by comparing pre and post development estimates of constituents modeled for a defined drainage area. Generally, pollutant reduction must be demonstrated prior to discharge into the waters of the State of New York. Although project size can vary greatly, resulting drainage areas are often small in scale.

While pollutant loading and reduction data are available for many identified pollutants, phosphorus is selected for review. The selection was based both on the propensity of data reported for the constituent and mandated phosphorus limitations within the East of Hudson watershed. Published data for phosphorus loading and reduction are reviewed based on information available as to drainage area size, sample method, location and frequency, and stormwater practice type. Where the information is provided, design criteria, age of practice, and regional and seasonal variations are evaluated.

Analysis of the published data could provide relevant information regarding the efficiency of stormwater management practices commonly implemented in the NYC watershed. The applicability of the findings of this literature review to stormwater management concerns in the East of Hudson watershed is discussed.

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17. Project review of City owned facility construction projects for compliance to stormwater and erosion and sediment control standards.

M. Penny Kelly

New York City Department of Environmental Protection has a program to upgrade city water supply facilities of the Bureau of Water Supply (BWS) that are handled through Bureau of Environmental Engineering (BEE). The DEP is in the unique position of being charged with regulating activities in the watershed as well as a facility operator entrusted to deliver high quality drinking water.

Because these projects are inherently proposed in and around water, erosion and sediment controls are imperative to

avoid causing a contravention of the water quality. It is a goal of the agency that these upgrade projects are constructed in compliance with stormwater management and erosion and sediment control practices as required by the rest of the regulated community. These projects require the preparation and implementation of a stormwater pollution prevention plan, with the erosion and sediment control plan the most important component. BWS involvement in the contract process has enabled City projects to comply with New York state water quality regulations as well as our own regulations.

To achieve this goal, BWS has initiated a dialog with BEE during the contract design and into the review and approval process. Once the project is awarded, BWS maintains the dialog with the contract and observes the work, and provides input through project completion.

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18. Boat Management on NYC Water Supply Reservoirs

Jennifer Cairo

Fishing by boat, a popular recreational activity on New York City Water Supply Lands for over a century, engages an estimated 9,000 anglers and nearly 11,000 rowboats on 21 water supply reservoirs each fishing season. Rowboats used for fishing are steam-cleaned, registered and stored on Water Supply Lands to reduce the likelihood of zebra mussel introduction. On-site boat storage, the location of storage areas directly on water body shores, and intensive recreation use in these areas pose significant challenges to the management of water supply lands as well as to public recreation opportunities and, potentially, protection of water quality. Examples of specific concerns will be presented.

In early 2004 DEP Land Management staff began development and implementation of a long-term boat management strategy to address these challenges. This strategy is aimed at meeting City land management goals for protection of public health and ecosystem integrity, providing high quality recreation benefits, advancing understanding and knowledge of recreation opportunities and water supply protection, and promoting effective City land ownership. Management options being incorporated under this strategy will be discussed including:

- Consistent removal of abandoned boats from Water Supply Lands;
- Consolidation of boat administration and extended registration duration;

- Revision of recreational rules and regulations to improve boat management and fishing access;
- Improving public access to the Water Supply's outstanding deep water fishing opportunities;
- Integrating boat permit and natural resource information;
- Evaluating and improving boat storage area designation and management, and public access to storage areas;
- Incorporating angler use patterns, distribution, and satisfaction into public access management;
- Expanding public involvement in stewardship of boat storage areas and reservoir shores;
- Increasing communication with boat owners
- Identifying relationships between fishing by boat and water quality.

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Job Description: Develop, implement, administer, and evaluate public access and recreation policy, programs and permitting for 86,000 visitors to over 69,000 acres of New York City Water Supply Lands
Major Projects: Fishing access, hiking access, hunting access, recreation permitting administration, public recreational land use designation, public access outreach
Experience Related to Topic Being Presented: New York City Department of Environmental Protection 3 years.
Education: BS Foreign Service - Georgetown University, MS Forestry - State University of New York College of Environmental Science and Forestry, M Public Administration – Syracuse University
Previous Applicable Employment: New York State Office of Parks, Recreation and Historic Preservation

19. Characterization of New York City-owned Watershed Forests through Analysis of Remotely Sensed Forest Type Data.

Todd R. Baldwin, Seth Lapierre

Vertical color-infrared aerial photography 1:15840 (1"=1320) was obtained in early spring 2003 across the entire NYC watershed area. Photos were manually interpreted using a stereoscope, creating polygons for each stand greater than 5 acres in size which was consistent in crown closure, size, and species composition. Conversion to a controlled digital forest cover type map was accomplished through orthorectification from existing DEP orthophoto coverage, ultimately producing seamless ArcInfo. coverage for each basin.

Data provided in attribute tables includes general vegetation type, distinguishes evergreen from deciduous, natural or planted, classifies by crown closure percent and height class and distinguishes the primary, secondary and tertiary species. Analysis of attribute data has allowed characterization of overall City-owned watershed forestland by these various attributes as well as the ability to distinguish differences by basin, MOA lands verses pre-MOA lands and begin to identify potentially high-risk forest conditions.

This tool has served as a basis for further refinement of current watershed forest management strategies, improving planning and decision-making City land.

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has been a professional forester since 1983 when he graduated from the University of Vermont, School of Natural Resources.

Prior to his employment as a NYC DEP watershed forester, Seth LaPierre worked as a forest technician for SUNY Research Foundation conducting forest inventory and pest monitoring on NYC lands. Additionally, Seth is a graduate of SUNY-ESF where he also worked as a research assistant for the American chestnut restoration project and studying parcelization of private forestland in the New York City Watershed.

20. Deer Impact Management Strategy for the NYC Water Supply

Paul Lenz

City-owned water supply land in the New York City (NYC) watershed currently exceeds 85,000 terrestrial acres. Forest inventory data gathered in the last several years indicates that most City-owned water supply lands are negatively impacted by white-tailed deer (*Odocoileus virginianus*). Impact by deer on these lands has been documented through evidence of over-browsing, limited forest regeneration, and exclusion of species. Continuous elimination of forest regeneration by deer is considered a significant threat to the goal of a diverse, resistant and resilient forest ecosystem.

Forests have long been recognized as important sources of clean and abundant water. Concern over impacts from deer to forest regeneration and health, watershed recreation, ecosystem integrity, and water quality has prompted the development of Deer Impact Management Strategy (DIMS). This document provides background information on deer dynamics, studies involving deer and forest resources, current deer management activities, and a discussion of a strategy for dealing with the impacts of deer on City-owned land. The document also reviews current literature, studies and management programs, identifies land management goals for DEP that relate to water quality, forestry, recreation, and provides detailed recommendations to help meet the land management goals of the Bureau of Water Supply. This presentation is a synopsis of the document, the strategy, management activities completed thus far, and details on short and long term goals.

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21. NYC Watershed DEP Conservation Easement Program

Paul Lenz

The City has purchased 35 Conservation Easements (CE's) from willing sellers totaling 5100 acres in the NYC watershed since the since the signing of the 1997 Memorandum of Agreement (MOA) in 1997. Add to this an additional 2200 acres in DEP CE's expected to close by the end of 2005, and an additional 35 properties totaling almost 7000 acres held in farm easements by the Watershed Agricultural Council, and there are over 14, 000 acres protected.

When NYC purchases a CE, they are buying a "bundle of rights." In the case of NYC, these rights are primarily the development rights associated with a piece of property and the landowner has agreed not to conduct certain activities on the property encumbered by the CE. This may include subdivision, land disturbance, certain types of vegetation disturbance, and certain construction activities. However, the CE also allows certain other activities to occur and these may include hunting, fishing, farming, keeping livestock, building ponds, and forestry. The CE is designed to insure long-term water quality protection while also allowing the landowner flexibility to realize economic benefits as well as obtain their property management goals.

As part of the MOA and FAD, NYC is required to regularly inspect existing CE's. Currently, the Land Management Program within NYC Department of Environmental Protection (DEP) is responsible for this program and inspects all CE's at least twice per year. During these on-site inspections, landowners are invited to accompany CE Stewards and discuss property management issues. This provides an opportunity for the landowner and CE Steward to interact and build a positive working relationship. The DEP Stewardship Program is becoming increasingly proactive in assisting landowners in protecting water quality while allowing landowners to perform various activities on their land. The Stewardship Program has published a comprehensive "Water Quality Recommendations for Conducting Activities on Lands Protected by a NYCDEP Conservation Easement," sent a CE newsletter to CE landowners, and designated DEP staff as Conservation Easement Stewards to work with landowners. As part of the CE acquisition phase, Land Management staff collects significant amounts of baseline documentation. This consists of on the ground photographs with GPS locations, a baseline documentation map showing natural resource and property features, an aerial photograph, and a survey. These items are checked during each inspection.

The focus of this presentation is to inform participants about the types of natural resources that have been protected by CE's, describe the DEP Stewardship Program, explain how lands are inspected and monitored, discuss how activities are approved, and highlight the Watershed Land Information System (WaLIS) that is used to track NYC DEP CE's.

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22. Management of New York City's Water Supply Lands and Conservation Easements: An Integrated Approach

John R. Potter

The New York City Bureau of Water Supply takes an integrated approach towards management of its water supply lands and conservation easements. This holding now exceed 125,000 acres and includes nineteen reservoirs, 250 miles of streams, 2,000 acres of wetlands, and 7,350 acres of riparian buffers. Updated statistics on this holding are quantified and presented. The protection of these critical water supply resources on fee lands is done within the context of an overall Land Management Plan that sets goals in support of the Bureau's mandate of ensuring delivery of a sufficient quantity of high quality drinking water to consumers. These goals are presented, and examples are given in situations where there is overlap and the need for integration. Progress towards meeting the Bureau's land management goals is summarized in terms of land use planning, resource management, property management, and recreational use. An overview is given on progress with conservation easement stewardship. Upcoming challenges in all areas of City land management are outlined.

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23. The Simultaneous Detection of Intrinsic *Giardia* and *Cryptosporidium* (oo)cysts with Matrix Spike Recovery – The Good, the Bad, and the Texas Red!

Kerri A. Alderisio, Lisa A. Blancero and Debra Schwarz

A technical study was conducted to determine comparability between spiking with ColorSeed™ C&G and live *Giardia* and *Cryptosporidium* for protozoan matrix spike analysis. Since ColorSeed has not yet been approved for use with USEPA Method 1623, the initial objective was to validate ColorSeed while comparing it to the routine live spiking procedure used by the New York City Department of Environmental Protection's Pathogen Laboratory. The

tricky part was getting it to work in our matrices. ColorSeed C&G is a promising tool for performing quality control measurements of (oo)cysts within one field sample. The red fluorescent (oo)cysts are identified as ColorSeed spike material during microscopic examination and are used to determine the percent recovery of the spiked organisms from the matrix. The organisms that do not fluoresce red, but do fit the requirements outlined by USEPA Method 1623 for identifying *Giardia* and *Cryptosporidium*, are counted as intrinsic organisms that originated from the environment. Upon examination of the first samples, it was evident that the fluorescein isothiocyanate (FITC) fluorescence was fading from the *Cryptosporidium* oocysts much more quickly with the ColorSeed spiked samples compared to DEP's routine spiked samples. Also, generally, ColorSeed samples processed entirely through Method 1623 resulted in *Giardia* cysts that appeared damaged when compared to samples analyzed with the live spike material. Oddly, these same distorted organisms had some variety of brilliant fluorescent red color when observed under the Texas Red filter, confirming that they were ColorSeed organisms. Conversely, analysts also recorded some ColorSeed cysts that were identified as *Giardia* under FITC when spiked into deionized water, but when further examined under a Texas Red filter, appeared a very dull red. Once the procedural areas of concern were identified, and method changes were introduced, improvements were observed in all of the aspects noted during the preliminary testing. Changing the stain improved FITC fluorescence, changing the Method 1623 elution buffer stopped the damage occurring to the cyst morphology, and as a result, the Texas Red fluorescence improved greatly. The percent recovery of the *Giardia* cysts also improved and became much more comparable to the recoveries seen with the routine method. Adaptations discovered during this experimentation have allowed for the potential to eliminate the need for a second sample to be collected and analyzed with each field sample when matrix spike recovery is required on non-regulatory samples. The result is an overall time saving procedure that does not compromise the recovery of (oo)cysts in matrices seen in the New York City Watershed.

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24. Continuous Water Quality Monitoring and Remote Data Transmission for the New York City East of Hudson Water Supply System

Wayne Geriak, P.E., Douglas Gronager

The overall size and geographical area encompassed by the New York City East of Hudson (EOH) Water Supply presents various challenges when attempting to design, build and maintain a continuous water quality monitoring and telemetry network. The large volume of water that is utilized by the City of New York and other communities connected to the aqueduct system must be monitored at strategic locations on a twenty four (24) hour, seven (7) day a week basis to insure the safety and health of the consumers and that regulatory mandates are met. The large geographical region encompassed by the East of Hudson Water supply system requires a variety of data acquisition schemes that are needed to provide "real-time" water quality data to Management and Operations so that the overall system can be utilized to optimize water quality and water quantity delivered by the system. Some of the topics of the discussion are:

1. Determining site selection and parameters of interest
2. Selection of water quality and telemetry equipment and vendors
3. Redundant systems to insure data continuity
4. Telemetry system design
5. Data Acquisition and Storage

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Mr. Gronager holds an Associate Degree from Westchester Community College in Environmental Science in addition to his military experience in communications. Mr. Gronager is currently developing a web-based application of the PC-RM database in addition to his overall network responsibilities.