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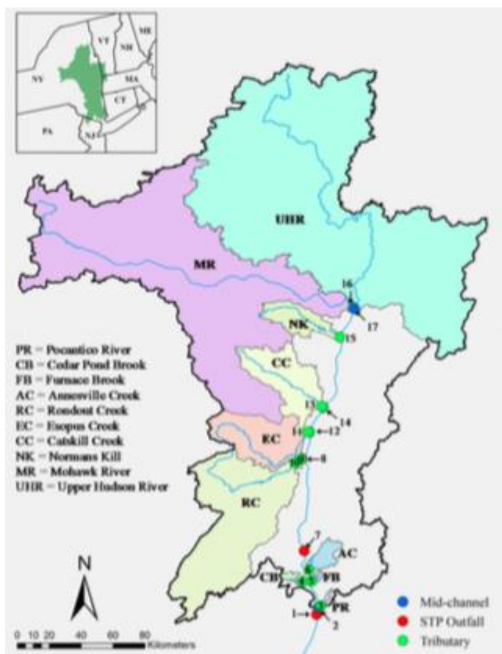
Water Resource Infrastructure in New York: Assessment, Management, & Planning – Year 5

Prepared October 24, 2017



USGS science for a changing world

NEW YORK STATE OF OPPORTUNITY | Hudson River Estuary Program

The **New York State Water Resources Institute (NYS WRI),** with funding from the **United States Geological Survey (USGS),** and the **New York State Department of Environmental Conservation (DEC) Hudson River Estuary Program (HREP)** has undertaken a coordinated research effort on water resource infrastructure in New York State, with a focus on the Hudson and Mohawk River basins.

The primary objective of this multi-year program is to bring innovative research and analysis to watershed planning and management. In particular, WRI-HREP is working to address the related topics of water infrastructure, environmental water quality, and economic vitality, especially as they pertain to land use planning and management in the Hudson and Mohawk watersheds. The WRI-HREP program coordinates individual research efforts so as to fit within the context of, and be responsive to, New York State's growing concerns about aging public infrastructure, economic constraints on public investment, and the recent requirement for State planning agencies to incorporate principals of "smart growth" as promulgated in the 2010 Smart Growth Public Infrastructure Policy Act.

In the following pages we report on progress made in **year four (2016-2017)**. Projects are discussed within the following broad themes:

1) **Infrastructure Assessment** - Water-related infrastructure including water supply and wastewater treatment facilities, distribution networks, decentralized treatment installations, dams, constructed wetlands, "green" infrastructure, etc., and their current state and effectiveness at providing water and ecosystem services regionally at reasonable cost
2) **Integrated Management & Planning** - Integration of scientific, economic, planning/governmental and/or social expertise to build comprehensive strategies for public asset and watershed management, including application of smart growth principles
3) **Environmental Monitoring** - The collection of biological, chemical, and physical data to characterize the environment, observe trends, identify threats, and inform policy decisions
4) **Novel Technology and Methods** – Development of water resource-related technologies and research methods that enhance treatment efforts or provide novel tools for monitoring and assessing water and water-based natural resources
5) **Accessibility** - Strategies to enhance citizen access to and appreciation of regional water resources

Following this summary we also include:

- A link to the full versions of final reports, which are available at our website http://wri.cals.cornell.edu/grants-funding
- Outreach efforts currently underway
- How we are adapting our efforts to support research and create effective outreach products
- A list of recently funded projects

For a copy of previous summary reports, please contact Brian Rahm (bgr4@cornell.edu), or go to https://wri.cals.cornell.edu/grants-funding

Cover images from Karin Teuffer, Damian Helbling, and Michael Twiss.

Infrastructure Assessment - Water-related infrastructure including water supply and wastewater treatment facilities, distribution networks, decentralized treatment installations, dams, constructed wetlands, "green" infrastructure, etc., and their current state and effectiveness at providing water services regionally at reasonable cost

Cross-cutting impressions

Previous research suggested that stormwater and wastewater infrastructure systems, including ditches, culverts, on-site wastewater treatment systems and "green" infrastructure, can be effective under certain conditions, but their design and management often lacks rigor, can be inconsistent, and/or is at odds with water and air quality goals. Continuing efforts on ditch and culvert networks are expanding our knowledge of how these landscape features are impacting downstream surface water quality. There is now progress in attempts to mitigate negative impacts through management practices in ditches, as well culvert replacement and right-sizing. On-going assessment of septic systems is leading to better understanding of daily and seasonal fluctuations in performance and GHG emissions.

Current research seeks mechanistic understanding of the nutrient dynamics in stormwater and wastewater infrastructure systems, such as stormwater retention basins and septic leach fields. Microbial analyses are improving our understanding of how to design these systems for maximal nutrient removal with minimal environmental impacts, like greenhouse gas emissions from nutrient transformation processes. Design is also a consideration of current research on green infrastructure, which must balance practical needs, such as providing parking area and pedestrian access, with design goals such as reducing stormwater runoff. Our understanding of how this balance changes dynamically overtime is advancing with onsite observations and historical research. Efforts to properly size culverts are being advanced with refinements to a previously-developed stream discharge model.

What researchers found

Project Title: **Assessing stormwater BMPs for multiple benefits**
PI: **Todd Walter** (Cornell University)
Funding Source: USGS
The nitrogen cycling dynamics of four stormwater basins, two often-saturated sites and two quick-draining sties, were monitored for approximately one year. This study paired environmental monitoring (stormwater and greenhouse gas) and microbial analyses to elucidate the mechanisms controlling nitrogen treatment. Key findings include:

- Quick-draining basins **infiltrated a larger volume of water**, leading to greater dissolved inorganic nitrogen mass reductions.
- Saturated basins had a **higher proportion of denitrification genes and potential denitrification rates.**

A flooded septic leach field (Cristina Fernandez-Baca)

Project Title: **Methane and nutrient cycling in septic leach field systems**
PI: **Ruth Richardson** (Cornell University)
Funding Source: HREP
Onsite septic systems treat approximately 25% of U.S. domestic wastewater. Despite their prevalence and continued use in new building, few studies have

attempted to characterize septic systems' air and water quality impacts. Understanding septic systems' effectiveness is vital to managing them in a way that promotes both air and water quality. Systems that are improperly sited and/or managed can cause ground and surface water contamination as well as increased greenhouse gas (GHG) emissions as compared to well-managed systems. To examine microbial populations and potential GHG and nutrient cycling within leach field soil systems, we constructed two leach field soil columns in the lab. Reactors were subjected to either flooded conditions or well-maintained conditions and compared in: (1) measured atmospheric methane (CH_4) fluxes; (2) measured CH_4 depth profile, (3) distribution and activity of key organisms involved in CH_4 cycling; (4) measured chemical oxygen demand (COD) and nutrient treatment (N, P). Overall, the columns performed more similarly in nutrient removal than in CH_4 cycling with flooded conditions significantly increasing CH_4 fluxes and overall CH_4 production. COD removal was variable and is negatively impacted by flooding while nutrient removal appears to be unaffected by flooded conditions.

- Methane emissions from flooded septic leach field soils are **significantly higher** than emissions from well- maintained systems.
- Nutrient (nitrogen and phosphorus) removal is **not affected** by flooding. COD removal does appear to be **negatively affected by long-term flooding.**
- Methane producing organisms were **more abundant** in flooded conditions.

Project Title: **Assessing the Effectiveness of Green Infrastructure**
PI: **Todd Walter** (Cornell University)
Funding Source: HREP
Although green infrastructure has become increasingly accepted as a technique to reduce runoff and improve water quality, questions remain about its effectiveness in the field. Water quantity in particular has implications for localized and riverine flooding, managing extreme storms, reducing combined sewer overflows, and improving stream ecology/ geomorphology that may be harmed by flashy runoff patterns. This study will focus on a water budget for two municipal parking lots in Kingston, NY. In fall 2016, these parking lots were redone with several green infrastructure practices (bioretention areas, pervious pavement, and dry wells), with the goal of having no runoff leave the site. This study has three components: a quantitative assessment of runoff reduction in the bioretention areas and dry wells, a qualitative assessment of design features of the overall site, and a review of the historical context of restoration within the Tannery Brook watershed. Key findings include:

- Bioretention areas and particularly dry wells appear to **reduce runoff quickly.**
- Post-construction changes to parking lot designs could have **implications for the performance of green infrastructure practices.**

The history of water management in the Tannery Brook watershed provides a **unique case study and context** for restoration practices such as green infrastructure.

Kingston parking lot and green infrastructure practices (Shawn Willis, Notice Pictures)

Project Title: **Analyzing the discrepancy between return period stream flows using the TR-55 Method and USGS recorded stream discharges**
PI: **Todd Walter** (Cornell University)
Funding Source: HREP
Stream flows calculated with the TR-55 method and obtained from USGS empirical data were compared for twenty stream gauges and their corresponding watersheds in New York State. The overall differences between the distributions of the two methods were measured using the Kolmogorov-Smirnov statistic, and 1, 10, and 100 year return period percent differences in flows. The three variables regressed against were average curve number, latitude and drainage area.

Multiple linear regression, and lasso and ridge regression showed that none of the predictor variables had significant influence on the difference between modeled and the measured values. Area and latitude have higher correlations with the raw flows for the three return period storms than curve number when analyzed individually. This was not seen in multiple regression and may be representative of a curve number influence on the discrepancy between model and empirical data. Key findings include:

- The results show that **neither curve number, nor latitude or drainage area,** heavily affects the discrepancy between the TR-55 model and the empirical stream flow values recorded by the USGS.
- The small quantity of watersheds analyzed is a **potential limiting factor in this analysis.**

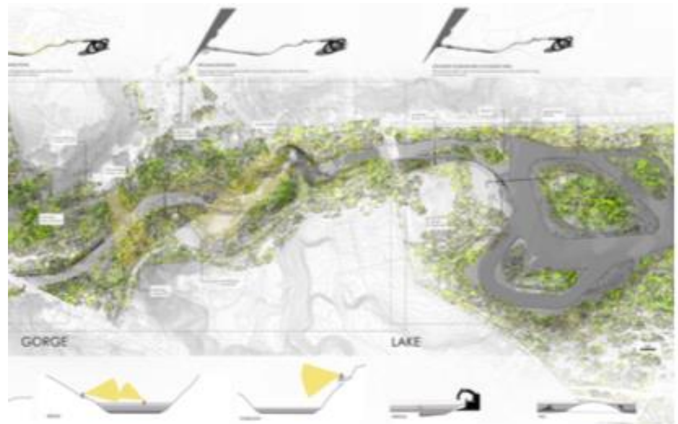
Integrated Management & Planning - Integration of scientific, economic, planning/governmental and/or social expertise to build comprehensive strategies for public asset and watershed management, including application of smart growth principles

Cross-cutting impressions

Previous research suggested that older municipalities with ageing infrastructure, combined sewer systems, and shifting urban tax bases face unique challenges to effective management of water resource assets. Decision support tools were developed, and demonstrated that the best solutions involve cooperation between municipalities, a variety of financing options, and multi-year strategic planning efforts. Additional research focused on planning and support for the removal of aquatic barriers, such as dams, in the Hudson River watershed. Removing these barriers has ecological and economic advantages and disadvantages, and initial studies provided predictions of sediment and contaminant transport, allowing stakeholders to make informed decisions regarding barrier removal.

Current research continues to develop municipal capacity to manage water and scenic resources through partnerships with university student trainees, who serve as technical resources to community stakeholders. Efforts to understand the impacts of dam removal on downstream sediment and contaminant transport continue. Dam management research further expanded to consider the impact of varying flow regimes on contaminant mobilization. Combined, this work will provide an enhanced variety of options to stakeholders looking to restore more natural flow regimes to dammed water bodies.

What researchers found



Part of "Priming the Poestenskill," by Alice Sturm (MLA, Cornell 2017), a vision for redesigning the Poestenskill in South Troy as a green infrastructure corridor.

Project Title: **Troy 2028: Green infrastructure scenarios for Troy**
PI: **Brian Davis** (Cornell University)
Funding Source: HREP
This report highlights some conclusions from a 2016 study that partnered advanced graduate students in landscape architecture at Cornell University with local stakeholders to develop a wide range of implementation scenarios for multifunctional green infrastructure. The scenarios focused on key sites related to combined sewer overflows in the city. Opportunities for stormwater detention using landform and reforestation strategies were a focus, as was an interest in providing public access to the river. Opportunities for creating green infrastructure with a strong social component were identified within Troy, and conceptual proposals were put forth as part of a public exhibition and panel discussion at the Arts Center of the Capital Region. Key findings include:

- East-West streets in Troy that end at the Hudson River offer **unique opportunities** for the creation of green infrastructure that functions as a neighborhood public space.
- Existing streams can **serve as major green infrastructures** that provide ecological corridors, detain large amounts of stormwater, and create pedestrian connections across the city.
- Green infrastructure projects in Troy **cannot be based on models from large cities** that require large amounts of capital.

Project Title: **Design for climate-resilient Hudson River communities**
PI: **Johsua Cerra** (Cornell University)
Funding Source: HREP

This project investigated planning and design implications of emerging municipal climate adaptation interests by developing alternative strategies for a Hudson waterfront location in City of Hudson, New York and a riverside park and open space location in City of Kingston, NY. The project was developed in the Spring 2016 LA6020 second-year graduate design studio and the Fall 2016 LA4010 fourth-year undergraduate studio at Cornell University Department of Landscape Architecture. Each project accessed a climate-adaptive design framework to identify projected climate change hazards, risks, and potential climate adaptation opportunities for these waterfront locations. Each project team reviewed planning and policy documentation, conducted contextual analysis and site reconnaissance, interviewed stakeholders, and shared their initial design concepts with stakeholders for comment and revision. Each then developed alternative design concepts that address projected climate change risks in combination with the urban revitalization interests and needs of stakeholder interviewees for their respective waterfronts. These concepts included provision for flood-adapted landscapes and structures, waterfront park and open space, green infrastructure, contributions to urban ecosystems, and other features. Final design boards were with stakeholders at the end of the studio. The alternative design concepts developed for these locations can serve as case studies for other Hudson Valley municipalities seeking to confront climate risks to their water systems, built environment, ecosystems and community. Key findings include:

- Many Hudson River waterfront communities are subject to climate change associated risks, but few climate adaptation precedents are **scaled to the size** of these municipalities.
- **Design studio project teams** explore projected climate change impacts and potential climate adaptation options with community stakeholders.
- During this design process, **alternative design concepts (eight for Hudson and five for Kingston)** were generated to address goals for climate adaptation and urban renewal consistent with the interests of stakeholders.

Hudson River waterfront design by Rachel Liu, Samuel Parker, and Susan Rhodes, Cornell Landscape Architecture 2016 LA4010 Urban Design Studio

Project Title: **Land Use/Environmental Planning Field Workshop**
PI: **George Frantz** (Cornell University)
Funding Source: HREP

The CRP 3072/5072 Land Use & Environmental Planning field workshop in the Fall of 2016 developed draft scenic resources protection strategies for the Town of Esopus, Ulster County, and the Town of Hyde Park, Dutchess County. Student project teams were charged with developing a methodology for identifying and prioritizing scenic resources within their client municipality. Scenic resources are defined as locations or features in the landscape that are viewed, visited, and enjoyed by the public for their aesthetic quality. New York's longstanding home rule tradition of government places the protection of much of the state's scenic resources in the hands of local municipal government. This makes the protection of scenic resources in the Hudson River Valley a significant challenge, given the large number of municipalities in the region, and the wide range in terms of local government capacities to take action to protect scenic resources. Key findings include:

- Students in the Land Use & Environmental Planning field workshop provided local governments with **technical resources and guidance** in order to better protect key scenic resources.
- Each team developed a methodology for **identifying and prioritizing** scenic resources for their client community using GIS mapping. The methodologies were described in **reports and public presentations** to the client municipalities.

Spillway of the Bingham Mills Dam

Project title: **Prediction of sediment remobilized by removal of the Bingham Mills Dam in the Hudson River watershed**
PI: **Weiming Wu** (Clarkson University)
Funding Source: HREP
The Bingham Mills Dam is an abandoned dam located on the Roeliff Jansen Kill, a tributary of the Lower Hudson River in New York. When in operation, it provided hydropower for nearby mills. The Bingham Mills Dam and the waterfalls are barriers for fish migrating upstream. One management option is to remove the dam. The research team surveyed the channel bathymetry upstream and downstream of the dam and collected samples to assess the sediment size compositions and the chemicals absorbed on the sediments. Then, a depth-averaged 2-D numerical model called CMS was used to simulate the sediment erosion after the dam removal. The collected data and derived results can be used for future studies on the feasibility of removing the Bingham Mills Dam and the potential impacts on the downstream stream water quality and habitats. Key findings include:

- Most reservoir sediments are sand and gravel, with **trace amounts of mercury, PCBs and pesticides.**
- The erodible sediments in the reservoir are less than 1.4 m thick, and about 9,126 m^3 in volume.
- The numerical simulation shows that most of the sediments in the reservoir can be **washed downstream with a large flood event**. The total eroded sediment is about 7,370 m^3.

Project title: **Student researcher support of adaptive management of the St Lawrence River using novel water quality monitoring methodology**
PI: **Michael Twiss** (Clarkson University)
Funding Source: USGS
Restrictive water level regulation in the Saint Lawrence River over the past 50 years has had a profound impact on ecosystem health. Currently, there are no explicit plans to determine how the restoration of more natural water level regimes in the St. Lawrence will impact water quality, although great effort has been made to develop adaptive management as the proper strategic approach. Water quality sensor arrays will be continuously operated in the Moses-Saunders hydropower dam to provide data that can relate change in water quality to changes in water levels. Mercury will be measured in water flowing through sensor arrays as well as in wetlands upstream that have the potential to release Hg with changing water level scenarios. The objective is to collect water quality data and relate this to water levels, to assess the potential for changing water levels to release Hg into the river and to produce three audience-appropriate videos to describe this important endeavor. Key findings include:

- **High resolution water quality data** was collected for the Moses-Saunders hydropower dam.
- A preliminary assessment of **legacy Hg contamination** of St. Lawrence wetlands was conducted.
- One **informative video** was produced. Two additional videos geared to a technical and K-12 audience, respectively, are in development.

Environmental Monitoring - The collection of biological, chemical, and physical data to characterize the environment, observe trends, identify threats, and inform policy decisions.

Cross-cutting impressions

Previous research suggested an urgent need to characterize the sources of contaminants within the watershed. Nutrient and bacterial pollution are of continuing importance throughout New York State, but little is known about the specific contribution from non-point and point sources such as agricultural land, sewage treatment plant outfalls, septic system leach fields, and combined sewer overflows. Monitoring for micropollutants in the Hudson River Estuary watershed was a first step towards identifying the specific organic chemical pollution present in this watershed, and its temporal and spatial distribution. However, the dynamics of other emerging contaminants, such as microplastics, remain poorly understood.

Current research focuses on defining the scope of nutrient, bacterial and emerging contaminant pollution in New York State waterbodies, and linking this pollution to potential sources as well as potential impacts. Some point sources, such as sewage treatment plant outfalls and combined sewer overflows, emerge as important sources of organic chemical and bacterial pollution, respectively. Nutrient contamination point sources and impacts continue to be elusive, with separate work looking at nutrient concentration correlated to septic system leach field density and algal density finding no correlation in either case. Temporal variation of pollutants arose as an important consideration in multiple cases. Monitoring in agricultural areas supported our understanding that these areas can be important sources of nutrient loading to a watershed, especially in the fall and winter. Ongoing microplastic sampling is advancing our understanding of how the concentration of this emerging pollutant could vary seasonally to daily with stream discharge.

What researchers found

Project title: **Tributaries and sewage outfalls: Identifying the relative contribution of sources of micropollutants in the Hudson River estuary**
PI: **Damian Helbling** (Cornell University)
Funding Source: HREP
This research aimed to improve our understanding of the sources of micropollutants in the Hudson River Estuary. We collected samples from seventeen locations along the Hudson River Estuary during May, July, and September 2016. The sample locations were selected to target sewage treatment plant (STP) outfalls and tributaries that are expected to be major sources of micropollutants in the Hudson River. The samples were analyzed to quantify the occurrence of 200 wastewater-derived micropollutants and pesticides. The data was analyzed to identify the relative contributions of various sources of micropollutants and specific outfalls or tributaries that are significant sources of micropollutants in the Hudson River Estuary, and revealed four distinct clusters of micropollutants grouped by their occurrence profiles. Rondout Creek and Normans Kill were both identified as major contributors of wastewater-derived micropollutants to the Hudson River Estuary. Rondout Creek was also identified as a major contributor of agricultural micropollutants. Our geospatial analysis revealed several associations between the spatiotemporal occurrence clusters and certain geographic catchment features including the extent of total agricultural land cover, extent of cultivated cropland land cover, number of major STP outfalls, and hydraulic distances to major STP outfalls. These data can be used to develop targeted micropollutant mitigation strategies in the Hudson River Estuary. Key findings include:

- **Sewage treatment plants** are major contributors of micropollutants in the Hudson River Estuary.
- **Agricultural land cover** and the **number of STPs** in a tributary correlate to micropollutant occurrence.
- Rondout Creek and Normans Kill contain **higher concentrations of micropollutants** than the Hudson River Estuary.

The Mohawk River

Project Title: **Mohawk River water quality: Risk evaluation of combined sewer overflow and runoff events**
PI: **Carolyn Rodak** (SUNY Polytechnic Institute)
Funding Source: HREP
During the Summer of 2016 nine locations along the Mohawk River in the Utica-Rome area were sampled for general water quality parameters and microbial indicators of fecal contaminations (*E. coli* and enterococci). When compared to the 2012 RWQC, microbial counts frequently exceeded the beach action value thresholds at sample locations in Utica, NY while violations in the Rome tailwater were less common. Microbial counts correlated well with rain events, demonstrating elevated microbial counts following rain events at sampling locations directly downstream of known combined sewer overflow (CSO) locations. At one sampling location in Utica, extremely high microbial counts were ultimately attributed to a broken sewer pipe which also appears to have impacted the water quality of other sample locations up 3.5 miles downstream. These microbial counts decreased significantly once the leaking pipe was identified and repaired on July 29, 2016. The performance indicators of reliability, resilience, and vulnerability were explored as a quantitative metric for communication of the frequency, duration, and severity of contamination events. Sampling locations in Rome had high reliability and resilience indicating infrequent, short-term elevated microbial counts compared to those in Utica which had frequent, long-term, contamination events well above the recreational thresholds. Key findings include:

- Bacterial indicator counts downstream of known CSO locations demonstrated greater increases in counts **following intense rain events**.
- Elevated bacterial counts at several locations were tied to a **previously unknown leaking sewer pipe**.
- Exploration of performance indicators identified differences in the **frequency, duration, and severity** of microbial contamination between samples from Rome and Utica.

Pictometry Oblique Imagery of a septic leach field

Project title: **Evaluating septic system inputs into Sodus Bay using oblique imagery, optical brighteners, and DNA-based tracers**
PI: **Paul Richards** (SUNY Brockport)
Funding Source: USGS
Sodus Bay is an important Bay in Lake Ontario that has been heavily impacted by nonpoint source pollution. Pollution in the bay has resulted in eutrophication, algal blooms, and excessive weeds in parts of the watershed. These issues have led to several studies which have determined that nutrient contributions from developed parts of the watershed are the source of these water quality issues. Nonpoint source pollution from septic fields are an important contributor of nitrogen and phosphorous to groundwater, shorelines, streams, and lakes. It has also been implicated in bays and water bodies associated with Lake Ontario. Addressing it with watershed policy has been difficult for two reasons: 1) identifying where leach fields are hydrologically connected to water bodies is difficult to do, and 2) determining the magnitude and residence time of septic

field pollutant fluxes within watersheds is difficult. Our lack of knowledge in this issue of hydrologic connectivity greatly restricts the kind of management practices and policies we can employ to prevent nonpoint source pollution from septic systems. In this proposed study, we use the spatial information provided by Pictometry Oblique imagery to rank stream and shoreline segments in their susceptibility to septic inputs, and test this using direct water quality sampling for nitrogen, phosphorus, and optical brighteners. Optical Brighteners are minor additives of laundry detergents. Because they don't breakdown in septic systems, they have been used as evidence for the presence of septic leachate if they are detected in streams. Key findings include:

- **451 septic fields** in the watershed were mapped using Pictometry Oblique imagery.
- There was **no correlation** between nitrogen or phosphorus concentration and septic field density.
- A **weak relationship** was found between optical brightener concentration and septic field density.

Harmful Algal Bloom

Project title: **Water quality and algal community dynamics in the Finger Lakes**
PI: **Lisa Cleckner** (Hobart and William Smith Colleges)
Funding Source: USGS
Nutrient loading has resulted in the proliferation of harmful algal blooms (HABs) in freshwaters worldwide. Most HABs are composed of cyanobacteria, also known as blue-green algae, which can harm human and animal health when they produce cyanotoxins. Ubiquitous HABs represent a serious problem across waterbodies in New York State and the Finger Lakes. Studies of algal community dynamics can help illuminate factors that lead to increases in HABs. Advanced sensor technology allows for *in situ* measurements of chlorophyll differentiated by algal class. In this study, a FluoroProbe spectrofluorometer (bbe moldaenke, GmbH) was used to assess four major phytoplankton groups in the pelagic and nearshore of two Finger Lakes (i.e., Honeoye and Canandaigua Lakes). The objective of this work was to determine whether pelagic sampling reflects nearshore algal communities, and how this varies by lake trophic status. Seasonal changes in algal communities were also assessed, and water quality parameters that best explain phytoplankton succession and specifically cyanobacteria are evaluated.

- Nearshore algal communities, with the exception of two sites, **generally reflected offshore sites.**
- **Temporal trends** in algal communities were evident with increases in organisms containing phycoerythrin and phycocyanin (cryptophytes and cyanobacteria) observed in both oligotrophic and eutrophic lakes.
- Bioavailable forms of phosphorus and nitrogen were **not strongly correlated** with concentrations of total chlorophyll-a and cyanobacteria.

Project title: **Nutrient monitoring in surface waters of New York's Finger Lakes region**
PI: **Todd Walter** (Cornell University)
Funding Source: USGS
Surface waters in upstate New York are often subject to contamination by nutrients as a result of point and non-point source discharges. While these impairments are notionally related to land use and resource management, the driving force behind these relationships is often unknown. In the Finger Lakes region, there are a range of streams and lakes within watersheds characterized by varying degrees of urbanization, and subject to various agricultural activities and municipal inputs (eg. wastewater treatment effluent). The aim of this project was to help develop regionally-based hypotheses for stream and lake impairments by collecting data from suspected contamination sources. Funding was also used to rain students in field and lab methodologies, and generate a broader appreciation for issues related to land use, hydrology, and management in the Finger Lakes region. Key findings include:

- In the Owasco Lake watershed, in the fall, we observed **higher phosphorus loading** from agricultural areas compared to forested areas.
- In winter, we observed the effects of **manure spreading on frozen ground** in an agriculturally-dominated watershed.

Project title: **Quantification and source identification of microplastic pollution in the Hudson River**
PI: **Todd Walter** (Cornell University)
Funding Source: HREP
Microplastic pollution in freshwater is increasingly studied in the waterways of New York State. Detrimental to organisms, both through physical mechanisms such as false satiation and through chemical mechanisms due to contaminant adsorption and particle leaching, microplastics originate from a variety of yet-to-be-quantified sources. This ongoing study aims to support the quantification and source identification of microplastic pollution in the Hudson River through investigative studies to uncover patterns in microplasic concentrations. Over the past funding cycle, we found evidence to suggest that microplastic concentrations do change in time and that the change differs between streams with wastewater treatment plant contributions and streams without, depending on the flow conditions at the time of the sampling session. Ongoing work continues to compare results found using different sampling methods, investigate the influence of dams on plastic transport in rivers, and link fish diets with fish consumption of microplastics in Hudson River estuaries. Key findings include:

- Data was collected to support **four research areas**: (1) affect of land use on microplastic concentration, (2) concentration variability between high and low flows, (3) sampling methods comparison, and (4) fish consumption of microplastics.
- There was a significantly **higher concentration of microplastics at low flows** in both streams sampled.

Microplastic sampling in action

Novel Technology and Methods – Development of water resource-related technologies and research methods that enhance treatment efforts or provide novel tools for monitoring and assessing water and water-based natural resources

Cross-cutting impressions

Previous research suggested that technological advances can serve to improve our understanding of and access to natural resources in the Hudson River Estuary and other parts of New York. A number of obstacles remain to the successful removal of organic from drinking water, especially for small public water systems. The use of chlorine-based disinfectants results in harmful by-products, which are not well-characterized, and more advanced technology can be beyond the means of small municipalities. Similarly, our understanding of the migration patterns of sturgeon, a characteristic species of the Hudson River that is listed on the US Endangered Species Act, is limited and inhibits our ability to protect this species.

Current research proposes a new technology to remove dissolved organic matter (DOM) and other contaminants during the drinking water treatment process. A new method for profiling DOM has the potential to accelerate our understanding of these molecules and their potential harmful by-products. Such technological advances are critical to improving access to potable water in rural areas. A novel pairing of two tracking technologies, one genetic and one acoustically-based, is advancing our understanding of the migratory patterns of Atlantic sturgeon.

What researchers found

Project Title: **Innovative water treatment by chitosan modified diatomaceous earth for small public water systems in rural areas**
PI: **Xinchao Wei** (SUNY Polytechnic)
Funding Source: USGS
Small public water systems (serving a population of 10,000 or less) play a vital role in providing safe drinking water to rural areas in the U.S. For example, there are ~200 public water suppliers in Oneida County, Upstate New York, but only two of them serve a population of more than 10,000. In view of the growing amounts and types of pollutants from industrial, agricultural, and residential sources, providing safe drinking water is becoming increasingly difficult for small public water systems because of their unique geographical, financial, technical and operational constraints. Therefore, there is an urgent need to develop affordable, efficient, and sustainable technologies suitable for small public water systems in rural areas to remove a cluster of contaminants (such as dissolved contaminants and DBP precursors). The objective of the proposed work is to develop an innovative sustainable drinking water treatment technology for resource-constrained small public water systems, using chitosan modified diatomaceous earth (DE) to remove a group of dissolved contaminants (natural organic matters, arsenic, and nitrate). The adsorption performance in removing the target contaminants, alone and in combination, was examined by batch adsorption tests. Key findings include:

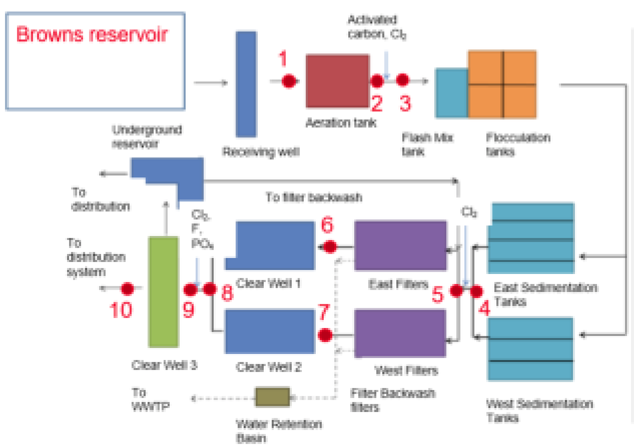
- Modified diatomaceous earth was **effective for removing organic matter and arsenic**, but did not effectively remove nitrate.

Project Title: **Profiling labile amino acids in aquatic dissolved organic matter by higher resolution liquid chromatography-mass spectrometry**
PI: **Ludmilla Aristilde** (Cornell University)
Funding Source: HREP
Labile amino acids (AAs) represent an important source of nutrients to aquatic biota, serve as precursors to transformation products in water treatment systems, and contribute to the fluxes of carbon and nitrogen in a watershed. Therefore, the quantitation of AAs has been a long-standing focus in the characterization of dissolved organic matter (DOM) in natural and engineered water systems. We present a new method for profiling 23 AAs in aquatic DOM, including the 20 proteinogenic AAs, oxidized cysteine dimer (cystine), and two urea cycle-linked AAs (ornithine and citrulline). In addition to providing this comprehensive AA profiling, this method affords three notable advantages to current methods:

- The exclusion of a derivatization step to **simplify**

sample preparation

- No need for a two-step tandem mass spectrometry by **coupling** high-resolution liquid chromatography with a single-step high-accurate orbitrap mass spectrometry
- **Direct quantitation** of AAs using an isotope ratio-based approach



Layout of the Newburgh drinking water treatment facility

Project title: **Empirical validation of the use of genetic tags to determine the population and "Distinct Population Segment" origin of Atlantic sturgeon that were acoustically tagged off the Delaware Coast and in the Long Island Sound**
PI: **Isaac Wirgin** (NYU School of Medicine)
Funding Source: HREP

At one time, adult Atlantic sturgeon supported a signature fishery in the Hudson River and many other major rivers coastwide. Overharvest and several other anthropogenic stressors led to a reduction of abundance of almost all populations, state and federal harvest moratoriums, and subsequent listing of the species as five Distinct Population Segments under the U.S. Endangered Species Act. Although Atlantic sturgeon exhibit strong spawning fidelity to their natal rivers, subadults and adults are highly migratory for prolonged periods in coastal waters and are seasonally found in non-natal estuaries. DNA approaches are the "gold standard" to distinguish populations and to identify the river-of-origin of individuals outside of their natal estuaries. Similarly, use of acoustic telemetry has been adopted by many sturgeon researchers to better understand their complex and prolonged migratory behavior within and outside of their natal estuaries. In this study, we married the two approaches to evaluate the veracity of the DNA approaches in determining the river-of-origin of sturgeon by comparing genetic assignments to individual spawning rivers and DPS with the actual detection of acoustically tagged fish in the Hudson River and Delaware River at spawning time. Surprisingly, we found that only 84% of river-of-origin genetic assignments corresponded with the spawning river in which the fish were detected by the acoustic arrays. Key findings include:

- **River-of-origin was determined using genetic techniques** for migratory large adult Atlantic sturgeon collected off the Delaware Coast and subadults from Long Island Sound and **compared to the rivers in which these same acoustically tagged fish were detected at spawning time**.
- Correspondence was high between genetic assignments and detections in the **Hudson River**, but lower for those detected in the **Delaware River**.
- Although the reasons for this lack of correspondence between genetic assignments and detections are unknown, it may result from the behavior of adult sturgeon to **enter several spawning rivers** before and after actual spawning.

Atlantic sturgeon

Accessibility - Strategies to enhance citizen access to and appreciation of regional water resources

Cross-cutting impressions

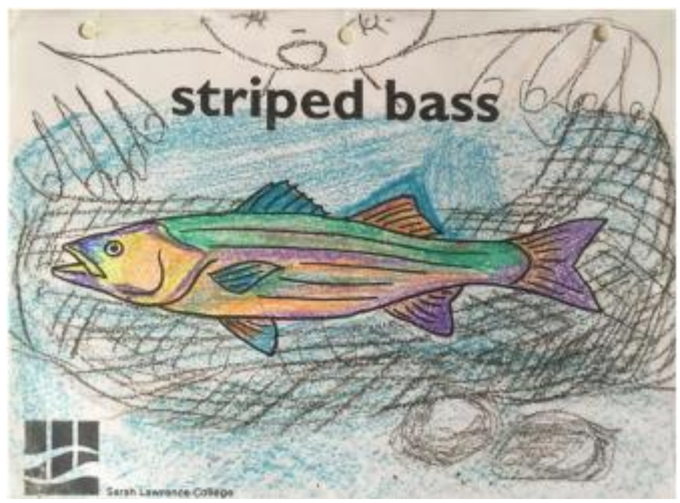
Previous research suggested not all residents of the Hudson River Estuary watershed had full access to the benefits of this natural resource. The barriers to access can vary greatly, from a lack of educational opportunity to physical barriers. In all cases, an opportunity was identified to develop programming that would overcome these obstacles and increase access to and appreciation of this local water resource.

Current research revealed the need for educational and access-based programs focused on the Hudson River. Children visiting an environmental education community center expressed their feeling that this was “the best field trip ever” and demonstrated increased environmental knowledge and empathy after the field trip. Similarly, when provided the resources required to improve beachfront access, local municipalities were eager to apply them. These cases suggest there is ample opportunity to further enhance community engagement with, and access to, the Hudson River; this model may be able to expand to other New York State water bodies in the future.

What researchers found

Project title: **The importance of field trips and cultural awareness in education: A case study of three environmental centers**
PI: **Kathleen Ruen** (Sarah Lawrence College)
Funding Source: HREP
The Center for the Urban River at Beczak is a 3900-square-foot environmental education and research facility located on 2 acres of Hudson riverfront park in downtown Yonkers. It is operated by Sarah Lawrence College in cooperation with the Hudson River Valley Environmental Education Institute. The objective of this study was to extend the research done last year to measure the effects of a field trip to CURB on students' environmental empathy, environmental engagement, interest in CURB, and cultural awareness. This was achieved with qualitative and quantitative measures, including a multi-case study (Bogden & Biklen, 1998) and a quantitative survey. The qualitative multi-case study in the field of participatory action research (Denzin & Lincoln, 2000), included note-taking and observation of students attending CURB programs. Key findings include:

- Current research indicates that field trips play a **positive role in childhood education**.
- Few or no studies have measured the **change in attitudes toward the environment** after one or more field trip visits to an interactive environmental center using qualitative and quantitative methodologies.
- In this particular case, field trips produced **environmental engagement, environmental empathy, interest in educational organizations, and overall cultural and community awareness**. Similar results were found at two other environmental centers.



Student-created image from a Center for the Urban River at Beczak field trip

Project title: **Hudson Estuary accessibility project**
PI: **Nordica Holochuck** (New York Sea Grant)
Funding Source: HREP
In cooperation with the New York State Water Resources Institute and New York State Department of Environmental Conservation, New York Sea Grant and the Yang-Tan Institute have been providing accessibility information to Hudson Estuary region's outdoor recreation stakeholders beginning with an inventory/assessment of boat launch sites in 2014 and

2015. The project progress in 2016 focused on addressing the "knowing-doing" gap. We focused on helping Hudson Estuary sites to better understand their obligation to accessibility improvements and developing a best practice guide for developing a guide for kayak and canoe (paddlesport) launches along the Hudson Estuary. Key findings include:

- Once people know where these resources are, they are happy to apply them as best as they can. Our role was to **"connect the dots"** between people in local government agencies and the best available guidance on unique outdoor recreation accessibility sites/elements.
- One of the challenges encountered is that there are **no clear-cut guidelines to achieving access outdoors** under the 2010 ADA Standards, as there is for typical sites and facilities.
- A tidal-freshwater estuary, the Hudson's unique characteristics pose challenges for recreational boat users of all abilities. **Developing a Hudson-focused guidebook** for accessibility standards is a priority going forward.

Accessible non-motorized boat launch

Full versions of final reports are available at http://wri.cals.cornell.edu/grants-funding

Outreach – How do we communicate our work?
For a complete listing of outreach activities performed by WRI and HREP staff, please see our website at http://wri.cals.cornell.edu/news

2017-2018 – Funded projects for the next year
Funded projects fall within two administrative categories. Competitive research involves investigators from institutions across the state who responded to a formal request for proposals. These researchers will work largely independently, but can be contacted regarding opportunities for cooperation and outreach. Coordinated research involves Cornell faculty who have agreed to meet quarterly to facilitate discussion and synergy among individuals, as well as with staff from WRI, HREP and the Mohawk River Basin Program.

Competitive Projects

Project Title: **Linking land use and climate dynamics to ecological responses of amphibians and reptiles within New York State watersheds: An integrative approach using citizen science** (James Gibbs – SUNY ESF)

Project Title: **Community engagement through water quality monitoring along the Mohawk River 2017: Year three of a longitudinal study** (Neil Law – SUNY Cobleskill)

Project Title: **Bacterial and viral source tracking in the Pocantico and Sparkill watersheds** (Bernadette Connors – Dominican College)

Project Title: **Geospatial assessment of riparian zones: A case study in the Hudson River Estuary – Stockport Creek Watershed** (Lindi Quanckenbush – SUNY ESF)

Coordinated Projects

Project Title: **Design for Climate-resilient Hudson River Communities** (Josh Cerra - Cornell University; Landscape Architecture)

Project Title: **Hudson tributary dam removal** (Pat Sullivan – Cornell University; Natural Resources)

Project Title: **Tracking Molecular Transformations of Organic Matter in Water Treatment Processes** (Ludmilla Arstilde - Cornell University; Biological and Environmental Engineering)

Project Title: **Support for Land Use/Environmental Planning Field Workshop** (George Frantz - Cornell University; City & Regional Planning)

Project Title: **Using multivariate analysis and USGS stream gage data to improve source tracking of micropollutants in the Hudson River Estuary** (Damian Helbling - Cornell University; Civil & Environmental Engineering)

Project Title: **The Socioeconomic Implications of Changing Flood Risk in the Hudson/Mohawk Watersheds** (David Kay - Cornell University; Community and Regional Development Institute)

Project Title: **Identifying sources of pollution and risks of waterborne pathogens in the Hudson River Watershed** (Ruth Richardson - Cornell University; Civil & Environmental Engineering)

Project Title: **Characterizing microplastics in surface water** (Todd Walter - Cornell University; Biological & Environmental Engineering)

Project Title: **Culvert assessment and modeling** (Todd Walter - Cornell University; Biological & Environmental Engineering)

Project Title: **Assessing the effectiveness of green infrastructure** (Todd Walter - Cornell University; Biological & Environmental Engineering)

For more information on these efforts please contact Brian Rahm (bgr4@cornell.edu).

For more information on the HREP Action Agenda, please see: http://www.dec.ny.gov/lands/5104.html