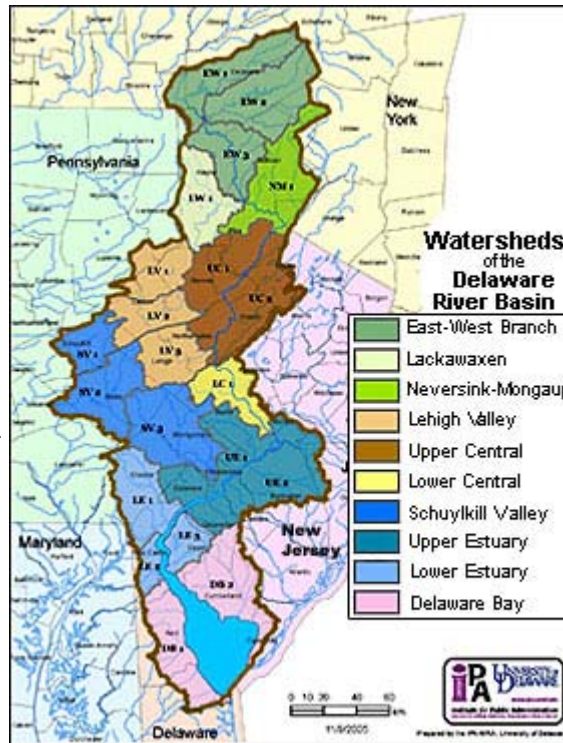# An Assessment of the Delaware River Basin

Professor Joan Ehrenfeld
Rutgers University

For the past ten months, researchers from Rutgers (the New Jersey Water Resources Research Institute), the University of Delaware (Institute for Public Administration, Water Resources Agency), Pennsylvania State University (Pennsylvania Water Resources Center), and Cornell University (New York State Water Resources Institute) have been working in collaboration with scientists from the Delaware Basin River Commission (DRBC) to develop a methodology to assess the 'health' of the Delaware River Basin.

　　　The project was initiated by the DRBC with the intent of capitalizing on the resources of the four Water Resource Institutes in the states through which the Delaware River flows. The Director of each of the four institutes is involved with the project, as well as many other partners, including the Partnership for the Delaware Estuary, the U. S. Geological Survey Water Science Center in New Jersey, and the US EPA. The project is an outgrowth of the recently-adopted Water Resources Plan for the Delaware River Basin, which requires the DRBC to periodically compile an environmental goals and indicators report defining the state of the Basin and its progress toward achieving the desired results, goals and objectives of the Basin Plan.

Watersheds of the Delaware River Basin

- East-West Branch
- Lackawaxen
- Neversink-Mongaup
- Lehigh Valley
- Upper Central
- Lower Central
- Schuylkill Valley
- Upper Estuary
- Lower Estuary
- Delaware Bay

　　　Developing a methodology for assessing such a large and varied region poses a range of challenges. First, it was necessary to divide the basin, an area of about 13, 500 sq. miles, into manageable and scientifically-defensible sub-units. The Delaware Basin covers an extraordinary variety of landscapes, ranging from the steep topography and near-wilderness status of the Catskill Forest Preserve in New York to the suburbs of Bucks County, PA and Hunterdon County, NJ, the urban areas of Philadelphia, Trenton and Camden, and the agricultural landscape and extensive fringing marshes of the estuary itself. Using an initial delineation of 5 regions developed in the Water Resources Plan, each region was further subdivided, so that 21 sub-watersheds were eventually adopted (see Figure). These basins were in part delineated on the basis of state boundaries, to facilitate the work of each partner within their home state, but were also delineated so as to promote the maximum possible homogeneity of land-use, topography, and bedrock geology; they are illustrated in the attached figure.

　　　The second challenge was to develop a list of indicator variables. The team reviewed many other environmental "report card" and assessment studies, the scientific literature on environmental indicators, and they also consulted broadly with collaborating scientists. An initial list of about 30 possible indicators of

The Director's Chair
by Joan G. Ehrenfeld, Ph.D., Director, New Jersey Water Resources Research Institute
Rutgers, The State University of New Jersey

　　　In this issue of New Jersey Flows, we highlight some of the recent research that has been funded by the NJ WRRI, as well as other notable water research taking place around New Jersey. Researchers run the gamut from undergraduate interns to senior faculty, and the topics of research are equally varied. We hope this issue illustrates the importance of research in addressing key water resource issues in our state.

　　　For the latest in water research, funding announcement, events, and more visit the New Jersey Water Resources Research Institute at **http://njwrri.rutgers.edu**. We invite you to share your comments, opinions, and future NJ Flows articles by emailing njwrri@aesop.rutgers.edu. ⬥

(continued from page 1)

water quality, 11 indicators of water quantity and hydrology, 22 indicators of "living resources" (including rare or indicator species, economically important species, or highly valued species such as bald eagle), 9 indicators of aquatic habitat quality, and 19 indicators of land use and landscape structure was compiled. Lengthy discussions ensued, in which each indicator was evaluated in terms of the quality, availability, reliability, and time-series of data that were available for each one.

Eventually, a final list of 34 indicators was adopted, and for each, at least one metric and method of displaying the data to indicate trends and/or spatial information about the quality of the indicator was decided upon. For example, for water quality, the 'nitrogen' indicator will consist of a graph showing annual medians in mg L^{-1} in 5-year increments starting in 1970, with box-and-whisker plots and a line indicating the state's water quality standard, for a selected station within each sub-basin. Indicators such as stream segments that are listed under the Section 303(d) program for use attainment will be displayed on a map so that different colors (e.g., red, yellow, green) are used to indicate different levels of attainment or non-attainment.

At present, the researchers at each state Water Resource agency are collecting the data for each of the selected indicators and preparing the agreed-upon metrics. When the report is finally compiled, it will be the first synthesis of information about the status of the land and water of such a large region, and such be vital in both supporting the implementation of the Water Resources Plan for the Delaware, and in giving the public a clear idea of the 'health' of both the entire basin and each region within the basin. ♦

References
See **"Water Resources for the Delaware River Basin Plan"**, 2004, available through the Delaware River Basin Commission website (http://www.state.nj.us/drbc/basinplan.htm)

Coal & Charcoal Particles in Hudson River Sediments
& Their Roles in Binding of PAHs & PCBs

Drs. Weilin Huang & Lisa Totten
Dept. of Environmental Science, Rutgers University

The Hudson River and New York/New Jersey Harbor contain high concentrations of a wide variety of contaminants. Especially problematic are the so-called "persistent organic pollutants", a class of compounds that includes polynuclear aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). These compounds are toxic to aquatic organisms and are persistent, so they break down slowly or not at all in the Harbor. These chemicals only become a problem, however, when they are in the water column. When sequestered or "sorbed" to the sediments, they are not particularly harmful. Models of the fate of these chemicals in the Harbor are essential in helping us manage the water quality in the Harbor to ensure that the ecosystem is healthy and can support a viable food chain. These models must be able to accurately predict where the chemicals will end up, whether in the water column, where they are harmful, or sequestered in the sediments, where they are relatively safe.

Organic chemicals are bound to sediments when they sorb to the organic carbon fraction of the sediment. The mineral or inorganic fraction of sediment has very little ability to sorb and sequester contaminants. The organic fraction is not homogeneous, however, and consists of several types of materials, including decaying biological materials, coal, and charred material. To effectively model the behavior of organic contaminants in the Harbor, we need to understand how much of these different fractions exist in the sediments and how well they sorb contaminants. These are the goals of an NJWRRI-funded study we have recently completed which evaluated the role of natu-
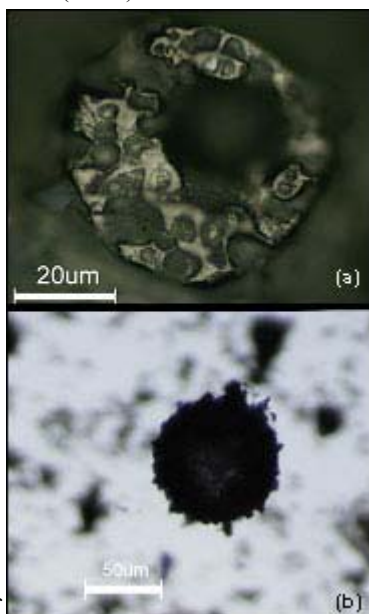

Fig. 1. Microphotographs of the isolated SOM particles (both charcoal particles) under the microscope of reflecting (a) and transmitting (b) white light mode.

rally occurring particulate organic matter in the binding of PAHs and PCBs to Hudson River sediments. We found that coal and charred organic particles are major organic materials in the sediments collected from the Hudson River and that these particulate organic materials may dominate the interactions of PAHs and PCBs with the sediments.

In collaboration with Dr. Jianzhong (James) Song of Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, we employed a wet chemical procedure to fractionate and quantify different types of natural organic matter (NOM) associated with the sediments. Our results showed that particulate coal and charred materials were a few weight percent of the sediment, and constituted more than half of the total organic carbon (TOC) content in the Hudson River sediment. Humic acids, a gel-like, brown to black colored organic material derived from plant residues by microorganisms, were only a quarter or less of the TOC content. After removal of inorganic matter with acids, the coal particles and charred organic materials can be easily identified under microscope, as they are often opaque (see Figure 1). These particles have sizes of a few to about 100 micrometers, and charred particles have unique burned structures.

It is not surprising to find large quantities of coal and char particles in the Hudson River, as they are indicative of heavy utilization of biomass and fossil fuels as energy sources in industrialized regions. What interests environmental engineers is that the particulate organic matter may dominate the distribution of organic pollutants such as PCBs and PAHs between water and sediments, hence affecting the bioavailability and toxicity of sediment-bound pollutants in the aquatic systems. It is known that the sediments in the Hudson River have been contaminated

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variously with PCBs and PAHs. These sediment-bound contaminants can be released to the water column via resuspension and desorption, becoming available to living organisms and posing serious risks to the ecosystem. Our prior studies, along with those done by other research groups, have showed that coal and charcoal particles have exceptionally high capacities for PCBs and PAHs due to the hydrophobic nature of these organic particles. Moreover, the organic pollutants associated with coal and charcoal particles cannot readily desorb and are therefore not as bioavailable as those associated with inorganic mineral surfaces and gel-like humic acids, because organic pollutants bound to the interior of tightly-knit organic particles are hard to diffuse out to water. The slow release rates of bound PCBs and PAHs indeed constrain the bioavailability and lower toxicity of the sediment-bound organic pollutants. Because of the unique features displayed by the particulate organic matter for binding and inactivating organic pollutants, a group of environmental engineers at Stanford University proposed to add particulate organic carbon particles such as activated carbon to sediments in an effort to sequester PCBs and PAHs in sediments.

Our study further evaluated the possible roles of the coal and char particles in binding and sequestration of PCBs and PAHs under laboratory conditions. Experiments conducted by Mr. Yingjun Ma, a third year PhD graduate of environmental science graduate program, showed that, when associated with sediments, these organic particles had binding ca-

pacities for PAHs and PCBs 50-75% lower than freshly prepared or organic solvent cleaned coal and char particles. Nevertheless, the measured binding capacities were still one to three times greater than those of the sediments without the particulate organic matter. A possible explanation is that the Hudson River sediments contained high concentrations of organic pollutants which blocked pores and occupied binding "sites" within particulate organic matter and hence lowered binding capacities for the organic pollutants introduced newly in the laboratory. A separate experiment conducted by Samriti Sharma, another PhD graduate student of our program, indicated inorganic materials such as carbonates can also dramatically lower the binding capacities of the particulate matter for organic pollutants. These observations indicated that the role of coaly and char materials in the binding of PAHs and PCBs may be dramatically diminished after aging of the carbonaceous materials in the sediments. Our finding challenges the predictive means developed for quantitatively assessing the equilibrium sorption and desorption of organic pollutants from simple measurements of the particulate organic matter content in the sediments. Our study suggested that direct measurement of binding capacities with a representative organic pollutant probe is likely required for predicting contaminant distribution in environmental media. ♦

A Study to Link Atmospheric N Deposition with Surface & Ground Water N and Denitrification Capabilities in an Urban New Jersey Wetland

Dr. Beth Ravit, Rutgers University, working with Prof. Barbara Turpin & Prof. Sybil Seitzinger

Rutgers University scientists are participating in a research program that will support wetland enhancement and restoration within the Hackensack River watershed. The 46-acre Teaneck Creek site is managed by a public-private partnership between Teaneck Creek Conservancy and Bergen County, and is located within the 1200-acre Overpeck Preserve, a Bergen County, NJ park. Teaneck Creek is a tributary of Over-peck Creek, which flows into the Hackensack River, and so improving the quality of water as it moves through this site
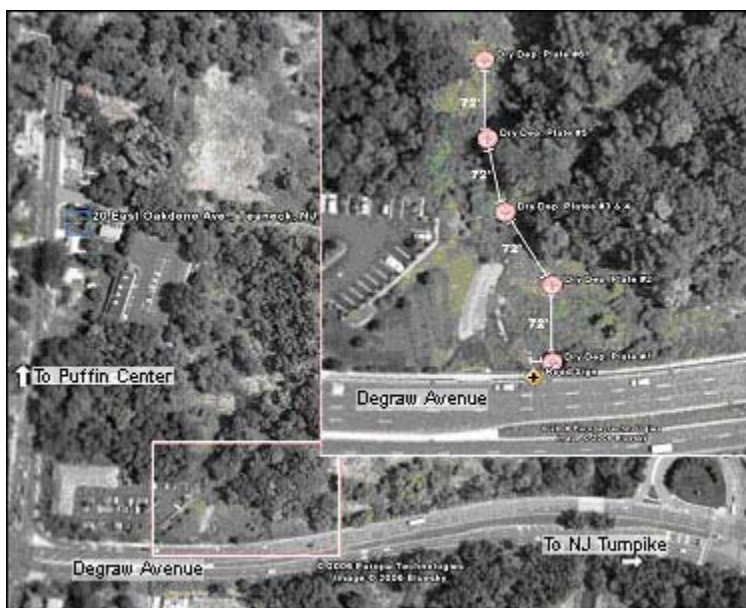
Dry deposition sampling in Teaneck Creek Conservancy

will result in higher water quality in the downstream estuary.

The restoration project is highly interdisciplinary, and includes Rutgers hydrological engineers, wetland scientists, environmental scientists, plant ecologists and USGS water specialists. One of the primary restoration goals of the project is to increase the amount of denitrification occurring in this ecosystem after creation, restoration, and enhancement of additional wetland acreage. By removing excess nitrogen (N) from surface waters before these waters enter the lower estuary, the freshwater wetlands can help protect NJ's coastal waters from algal blooms and eutrophication associated with high nutrient loads.

To establish a nitrogen budget pre- and post-restoration we needed to

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Conference Calls

AWRA Restoration Dialogue at the Bahia Mar Resort, Fort Lauderdale, FL, September 18-20, 2006. For more info, visit www.awra.org

Second Passaic River Symposium: Progress and Challenges at Montclair State University Conference Center, Montclair, NJ, October 13, 2006. For more info, visit www.csam.montclair.edu/pri/symposium2006

9th Annual Wetlands and Watersheds Workshop at the Holiday Inn on the Boardwalk, Atlantic City, NJ, October 23-26, 2006. For more info, visit www.wetlandsworkgroug.org

For more conferences, please check out **http://njwrri.rutgers.edu/events_list_page.htm**

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determine the fluxes of N compounds coming into the system via atmospheric deposition. Funding provided by the New Jersey Water Resources Research Institute allowed researchers to determine the types and amount of this atmospheric N entering the Teaneck Creek ecosystem. Atmospheric N can be found in the gaseous phase, associated with dry particles, and in precipitation. This deposition contains both inorganic (nitrate, ammonia) and organic compounds, and is a major N source in the northeastern U.S. An annual N atmospheric deposition budget was constructed based on samples collected and analyzed over four seasons (April, August, and October 2005, and January 2006).

Dry deposition samples were collected adjacent to De-Graw Ave., a major thoroughfare that forms the southern boundary of the Teaneck Creek ecosystem. This highway is also an access point for both Interstate Rt. 80 and the NJ Turnpike, which are adjacent to the site. Collectors were set up at locations ranging from 0 to 90 meters from the roadway (See Fig.). Our particulate nitrate deposition was within the range found by Lovett et al. (2000) for suburbs of NYC. When we compared our nitrate particle concentrations at the various distances from the roadway, we found inorganic N concentrations 20-50% higher at the roadside than the concentrations 100 meters further from the highway.

These results suggest that roadway-associated emissions are contributing to deposition of nitrate containing particles. It is currently thought that the method of collection we used results in collection of predominately dry particles, but does not reflect gaseous dry deposition, and so we are in the process of doing additional experiments to determine N concentrations in the gaseous phase.

Rain and snow wet deposition samples were collected from the rooftop of Thomas Jefferson middle school, which is adjacent to the northern boundary of the Teaneck Creek Conservancy. Based on USGS precipitation data for the previous year (data for the current year was not yet available), we estimate that we sampled approximately 25% of the total annual precipitation during the study year. Wet deposition of inorganic N was ten-fold greater than dry particle inorganic N deposition. In general, higher N concentrations were measured during small precipitation events and lower N concentrations were found during the high volume precipitation events. The range of nutrient concentrations measured in the wet deposition samples was similar to concentrations collected over the past five years (Seitzinger et al. 2005) at other sites in NJ (including Camden, New Brunswick, and the Pinelands). These concentrations are also within the range reported for inorganic N deposition in thirty watersheds along the East and Gulf coasts of the U.S. (Meyers et al. 2001).

The results of these studies will be used to calculate a model, which will link hydrology and denitrification potential in the Teaneck Creek ecosystem. It is our hope that this urban model will be of use in other NJ urban projects involving wetland systems, where the project goals include improving water quality.⬥

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The Influence of Urbanization on Watershed Nitrogen Cycling Watersheds

Bernice Rosenzweig, Princeton University working with Professor Peter Jaffe

Urban sprawl and its resulting impact on natural systems is one of the most important environmental issues facing us in the state of New Jersey. Each year, New Jersey adds approximately 16,600 acres of new development while losing 4,200 acres of forest and 2,900 acres of wetlands. In light of these trends, it is imperative that we better understand the ways that our urban land-use practices may alter ecosystem processes and to develop solutions. My research investigates nitrogen cycling in urban watersheds and the design of best management practices to prevent excess nitrogen from being transported into streams. I'm particularly interested in the role played by detention ponds, structures that have become ubiquitous throughout New Jersey in compliance with municipal storm water regulations.

Understanding the dynamics of nitrogen is important for several reasons: it can be a human health threat when present as nitrate in drinking water and nitrous oxide is a particularly potent greenhouse gas. Nitrogen is also the limiting nutrient in many estuaries and excessive nitrogen loads from anthropogenic activities has been linked to accelerated eutrophication of these systems. Well-known examples of the resulting ecological degradation include the 'dead zones' of the Gulf of Mexico and Chesapeake Bay.

Urban areas have been found to be a significant contributor to the nitrogen load being transported to estuaries by streams. Activities in these areas result in the creation of new sources of nitrogen from fertilizer application and the emission of nitrogen oxide compounds from fossil fuel combustion. Urban development is also known to have a significant impact on natural mechanisms of nitrogen retention. For example, the riparian wetlands adjacent to stream channels are known to act as 'hotspots' of nitrogen transformation processes in undisturbed watersheds, serving as a control point for nitrogen being transported to streams and subsequently to sensitive coastal systems. In many urban watersheds, natural stream channels have been replaced by storm drains or concrete culverts, completely eliminating the important biogeochemical service provided by the riparian zone. Even when no direct changes are made to stream channels, alteration of the hydrologic cycle in urban areas can have a significant impact on the ability of stream riparian zones function as hotspots of nitrogen retention: the increased runoff, rather than infiltration, of storm water in urban watersheds can result in lower water tables in riparian

zones, decoupling the flux of terrestrially derived nitrogen from the biochemically active zones near the surface and making denitrification, a nitrogen retention reaction that require anoxic conditions, unfavorable. Storm water detention ponds are engineered basins that are designed to retain excess storm water runoff that would otherwise enter streams too rapidly and result in flooding and erosion of the stream channel. Detention ponds play a well-known role in improving water quality by allowing for the settling of particulate contaminants. Very little is known about the role of detention ponds in nitrogen cycling, especially since a significant percentage of the instream nitrogen load is present in dissolved form, rather than bound to suspended particles. Like riparian wetlands, detention ponds often possess saturated soils and vegetation, features that provide the chemical and physical conditions necessary for significant quantities of nitrogen to be removed by mechanisms such as denitrification before it can enter streams. However, intermittent wetting and drying may result in the mobilization of nitrogen in the

Bernice Rosenzweig deploying a porewater sampler near the outlet of the Princeton University Campus Detention Pond. Visiting researcher, Hee Sun Moon looks on.

soils of these ponds transforming them into sources of nitrogen that can be transported to streams.

I'm currently conducting fieldwork in a detention pond located on the Princeton University Campus. I've installed flow-meters and automated water samplers at the inlet and outlet of the pond in order to obtain a continuous time series of nitrogen loads that enters and leaves the pond. I will also begin analysis of the pond soils to measure the various forms of immobilized nitrogen and rates of nitro-

gen transformation reactions. My goals for this work are to understand the key mechanisms of nitrogen fate and transport within this pond and to collect sufficient data to use as input parameters for a numerical model. This model will be used to optimize the design features of the detention pond for nitrogen retention.

Along with understanding nitrogen cycling processes within a single detention pond, I would also like to better understand the role of detention ponds in nitrogen cycling on the watershed-scale. I have begun field monitoring in the Harry's Brook Watershed in Princeton, New Jersey. I chose this watershed as my study site because of the great deal of diversity in development history within its relatively small area ($6.5 km^2$). It contains an urban core which is completely drained by a system of storm sewers, a forested subwatershed which will serve as a control catchment for the study, a region of "new" residential and commercial development containing stormwater detention ponds, and areas of "old" residential and commercial development in which no stormwater detention ponds are present. We have collected streamwater samples from 25 sites within this watershed at regular intervals during low-flow conditions and at key locations during 8 storm events. Our research to date has shown that instream nitrogen loads are greater in the urbanized branches of the watershed however, continued research is necessary in order to come to conclusions on the large-scale role played by the detention ponds.◊

Regional Planning Comes of Age

Regional Planning Comes of Age: A groundbreaking conference exploring the promise and practice of regional land use planning in the Mid-Atlantic and Northeast states, on the 25th Anniversary of the Pinelands Comprehensive Management Plan.

September 28-29, 2006 at the Hyatt Regency in New Brunswick, New Jersey

The conference will include plenary addresses and seminars on regional land use planning aimed at preserving natural and historic resources while strengthening communities in our dynamic and growing part of the country. Hon. Bruce Babbitt, Robert Yaro, and Doug Foy will deliver plenary addresses.

Seminars will address topics such as transfer of development rights, growth management tools, protecting water resources through regional planning, economic impacts of regional planning, using regional planning to preserve historic and cultural resources, cooperative planning across political boundaries, and regional zoning and land use regulation.

Seminars will also explore outstanding and developing examples of regional planning, such as the New Jersey Pinelands, the Adirondacks Park, the Long Island Pine Barrens, the Cape Cod Commission, Chesapeake Bay watershed initiatives and much more.

Visit http://www.regionalplanningcomesofage.org/conference/ for more info and registration.

NJ DEP : Completed and Current Water Research

By Suzanne Shannon
New Jersey Department of Environmental Protection
Division of Science, Research and Technology Water Research

◗ Completed Water Research

Forecasting Algal Blooms at a Surface Water System with Artificial Neural Networks. *Tom Atherholt, Ph.D., DSRT. Emery A. Coppola, Jr., Ph.D.; Adorable B. Jacinto, B.S.; Scott Lohbauer; Mary Poulton, Ph.D.; Ferenc Szidarvoszky, Ph.D.*

Algal blooms (AB) in potable water supplies are increasingly prevalent and cause serious water quality problem around the world. AB events can cause taste and odor problems, damage the environment, and some algal classes, like blue-green algae, may release toxins that can cause human illness or even death. There is a need to develop models that can accurately forecast algal bloom events on the basis of predictive physical, meteorological, chemical and biological information. Such forecasting models can provide valuable lead-time for water treatment systems to implement measures to minimize the consequences of the AB event, if not actually prevent it. Given the multitude, interplay, and complexity of the various controlling environmental factors, modeling and forecasting AB is a daunting challenge. This research focused on the feasibility of using artificial neural network (ANN) technology as an accurate, real-time modeling and forecasting tool. Previously collected data from a NJ water utility served as the test case. AB forecasting periods included one week and two weeks prior to the event. Despite a less than ideal number of historical AB events, the high predictive accuracy achieved in this study indicates that with sufficient data, both in terms of the number of historical AB events and availability of important predictor data, ANNs can serve as reliable, accurate, real-time AB forecasting tools.
http://www.state.nj.us/dep/dsr/wq/wq.htm

Susceptibility of Potable Water Distribution Systems to Negative Pressure Transients. *Thomas Atherholt, DSRT. Kala K. Fleming, Joseph P. Dugandzic, Mark W. LeChevallier, Rich W. Gullick*

The operating conditions of a drinking water distribution system (the network of underground pipes through which water is delivered from a drinking water treatment plant to customers) are rarely at a steady state. Each day, due to constantly changing demand, water pumps start up or switch off and valves open and close, resulting in rapid flow changes. Previous research has established that pressure waves generated by these disturbances can propagate throughout the distribution system.

Low or negative pressure events create opportunities for external contamination to enter the distribution system. Leakage points in water mains, submerged air valves, cross-connections and faulty seats or joints can all serve as entry portals for external contaminants when the pressure of water surrounding a distribution system main exceeds the water pressure inside the main. Low water pressure and cross connections with non-potable water pipes are well-known risk factors for disease outbreaks.

Investigating pressure transients improves the understanding of how a system will behave in response to variety of events such as power outages, routine pump shut downs, valve operations, flushing, firefighting, main breaks and other events that can create significant, rapid, temporary drops in system pressure.

This research addressed the gap that exists in understanding distribution system characteristics that are conducive to the occurrence of negative pressure transient events. These events were documented in several water systems and mitigation strategies were identified. http://www.state.nj.us/dep/dsr/dw/dw.htm

Bioassessment Integration Study: Systems Ecology Evaluation of US EPA Rapid Bioassessment Protocols in New Jersey (Macroinvertebrates, Periphyton, Fish and Habitat) *Thomas Belton, DSRT. Richard J. Horwitz and Camille Flinders, The Academy of Natural Sciences*

The purpose of this project was to analyze existing fish, macroinvertebrate, and algal data to develop new methods for integrated stream bioassessment protocols. Integrated analysis has the potential to provide several benefits. Since different indices (i.e., fish, invertebrate, alga) may be sensitive to different stressors and spatial patterns of indices can reveal scale and location of disturbances, examining and integrating multiple indices can provide more specific information on causes of impairment at different sites and possibly association of impairments among sites. Additionally, assessments are more robust by avoiding false determinations of impairment by reliance on a single index, resulting in more defensible determinations. This increased understanding can lead to more efficient monitoring protocols (e.g., using stepwise analysis to determine potentially impaired sites from limited sampling, with follow-up sampling to provide more definitive assessments) and provide managers with a more powerful tool to focus their rehabilitation efforts.
http://www.state.nj.us/dep/dsr/wq/wq.htm

◗ Current Water Research

Evaluation of Treatment Options for Domestic Potable Water Systems. *Ravi Patraju, DSRT*

Pursuant to the Private Well Testing Act, New Jersey homeowners are required to reduce certain drinking water contaminants to safe levels. Presently, there is a small amount of information on reducing levels of existing contaminants. The goal of this project is to identify treatment technologies effective in achieving the acceptable limits of the contaminants existing in the potable water. This research will concentrate on the first phase of this goal by 1) identifying the contaminants of concern in the domestic water systems, and 2) conducting a literature search to identify recommended technologies for treatment of the respective contaminants.

Development of a Headwater IBI for New Jersey Upland Streams Phase II. *Thomas Belton, DSRT*

The purpose of this research is to examine if fish populations and surrogates (such as crayfish and salamanders) in pristine and adversely impacted headwater streams in the Piedmont, Ridge and Valley, and Highlands regions of New Jersey could be used to develop and test IBIs for small river streams. Currently, protocols for the assessment of FIBIs in New Jersey have been developed for larger streams (drainage area greater than 5 square-miles) and it's unclear whether metrics of biological integrity are applicable to smaller streams because of a naturally-occurring

smaller base fauna in these systems.

Data from this research will be used to analyze potential difference in and responses of biological communities to region differences (Piedmont, Ridge and Valley, and Highlands), land use, and other environmental indicators. Results from the study will aid the NJDEP in monitoring and maintaining environmental standards in headwater streams.

Use of BME to Estimate Water Quality in Unmonitored Stream Reaches in the Coastal Plain of New Jersey (Year 2)
Gail Carter, DSRT

The focus of this work is to develop a user friendly computer interface to the BME program (a modern spatial-temporal geostatistical approach) in the ArcGIS environment so the BME methods developed earlier are available to scientists for all water bodies. The research will provide an efficient and user friendly ArcGIS interface to the best spatiotemporal estimation method available for modern Geostatistics. The method implemented will greatly enhance the ability to estimate water quality along unmonitored reaches using a wide variety of available physical knowledge (flow and transport equations, monitoring data, measurement errors), and to rigorously account for uncertainties.⬥

Undergraduate Research Internships Funded Through NJWRRI

⬥ **Dr. William J. Cromartie, Associate Professor, Environmental Studies, Richard Stockton College of New Jersey with intern Lauren Keltos** *"Assessing Subwatersheds within the Great Egg Harbor River Basin"*

This project focused on studying two sub-watersheds (HUC-14) within the Great Egg Harbor watershed area. Dr. Cromartie and Lauren Keltos sampled Gravelly Run and Upper Babcock Creek for pH, specific conductance, temperature, redox potential, and abundance of aquatic macroinvertebrates. The student researcher has organized a geodatabase to organize the data collected by the research project as well as data from other subwatersheds. The results are being prepared for publication, and the database will soon be online for use by scientists, state and local planners, and citizens.

⬥ **Dr. John Hasse, Department of Geography and Anthropology, Rowan University with undergraduate intern Donna Moffett:** *"Evaluating Water Quality Relationships to Urbanization Patterns in Gloucester County, New Jersey"*

Dr. Hasse and Ms. Moffett conducted research in evaluating relationships between smart growth, urban sprawl, and water quality. The researchers combined land use/land cover GIS layers available from the NJ DEP with background knowledge and information on housing density to establish the following relationships:

Sprawling Watershed — Total impervious surface = 5%; Total population = 500; Acres impervious per person = 0.2

High Density Watershed — Total impervious surface = 20%; Total population = 2,000; Acres impervious per person = 0.05

1. Watersheds with sprawled urbanization have lower percentages of total impervious surfaces which may indicate less impacted water quality. Lawns and backyards soak up the rainwater, and less contamination flows directly into the watershed.

2. However, when analyzing the data on a per capita basis (instead of using percentages) these same watersheds with sprawling urbanization have substantially larger portions of impervious surface per person.

The findings in this study raise the idea that sprawl is actually better for water quality than urban high-density growth, even though substantially more impervious surface per capita is produced overall in a sprawl environment than with high-density "smart" growth.

These two finding raise the question of what is better for water quality? Is urban living or suburban sprawl better for the overall watershed?
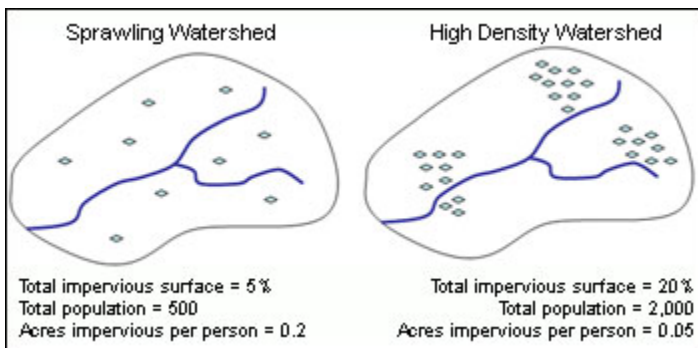
⬥ **Dr. Kenneth Lee, Dept. Civil Engineering, Rutgers University with undergraduate intern Jessica Bernardini:** *"Measuring the Viscosity of Two-phase Nonaqueous Phase Liquid-water Systems in the Presence of a Cosolvent"*

Measurements of viscosities of nonaqueous liquids are needed to support of groundwater modeling of contaminated waters. Dr. Lee is analyzing data from tests on the common groundwater contaminants perchloroethylene, benzene, and toluene with cosolvents ethanol and methanol. The research project is still under way, and is expected to provide information on the effects of nonaqueous phase liquid water systems on contaminated groundwater and the change in viscosity that occurs during the interaction of water, contaminants, and cosolvents.

⬥ **Sean X. Liu, Ph.D. Department of Food Science, Cook College with undergraduate intern Kristina Carle:** *"Biogenic Ice Nucleators in Lowering Energy Cost of Water Recovery from Impaired Waters Using CO2 Gas Hydrate Technology"*

Gas hydrate desalination is an emerging water recovery technology that could be used to reduce the cost of water recovery from impaired water resources by lowering the energy requirement. Gas hydrates can be formed at temperatures above the freezing point of water, but under elevated pressures this could be used to reduce the energy inputs for freezing desalination projects. Dr. Liu and his undergraduate based their project around pre-established techniques for forming gas hydrates: a water jet is injected into a container with carbon dioxide under pressure and ice-like gas hydrates are formed. The gas hydrates are washed, de-pressurized, and melted to produce pure water. The carbon dioxide gas is released and captured for reuse. This method of water recovery would leave behind contaminants and produce pure water.

To lessen the activation energy and reduce cost of gas hydrate desalination, Dr. Liu is investigating the use of biogenic ice nucleators. Biogenic ice nucleators are a species of bacteria that contains a protein which arranges water molecules into an ice-like lattice. This lattice is a framework on which ice forms, and acts as a catalyst for ice formation. Ice formation is similar to gas hydrate formation, and Dr. Liu is testing the feasibility of biogenic ice nucleators encouraging the formulation of gas hydrates in a desalination procedure.

Summaries written by Anna Zdepski

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