D.C. Water Resources Research Institute
Annual Technical Report
FY 2011

Introduction

This report summarizes the activities of the District of Columbia (DC) Water Resources Research Institute (the Institute) for the period March 1, 2011 through February 28, 2012. The Institute is one of a network of 54 such entities at land-grant universities in the nation which constitutes a federal/state partnership in research, information transfer and education regarding water related issues. The Institute provides DC with interdisciplinary research support to identify city water and environmental resources and problems and contribute to their solution. The Institute continues to increase its internal collaborations and partnerships among Departments at the University of the District of Columbia to provide relevant water resources research results and transfer information to assist policy makers and residents in the District of Columbia. Through its Seed Grant Program, the Institute coordinates and facilitates water resources-related research projects awarded to faculty members from the consortium of universities in the District. The consortium universities include the University System of the District of Columbia, Howard University, George Washington University, the Catholic University, Georgetown University, George Mason University, and American University. Over 200 seed grant projects have been completed and reports published by the Institute.

The opportunity to train students through development and implementation of practical applications of water science in Biological, Environmental, Urban Development and Engineering Programs is a major accomplishment of the Institute. More than 200 students trained by the Institute also interact with employers at federal and local agencies to prepare for future job opportunities. The seed grant program allows faculty members access to new technologies and equipment that develop their expertise in water resource management. Results of each project are reported and disseminated through published studies, technical reports, seminars, newsletters, brochures, and a website.

The Institute partners with the Cooperative Extension Service/Water Quality Education and Urban Pesticide Education Programs, the School of Engineering and Applied Science, the Biological and Environmental Department, and the Agriculture Experiment Station, to work toward becoming an unbiased monitor of surface water, groundwater and drinking water quality in the District of Columbia. In order to achieve this goal, two environmental laboratories have been developed at the University. The two new laboratories will serve the research and training needs of our faculty and students as well as provide training opportunities for water and wastewater quality operators for the local agencies of the DC Government. Through a partnership with DC Department of the Environment Toxic Waste and Hazardous Materials Branch, the Institute, in collaboration with the Cooperative Extension Service, was awarded a three-year Intra-District grant of $600,000 to upgrade our Water Quality Testing Laboratory to an Environmental Testing Laboratory capable of EPA certification in three years. A Gas Chromatograph-Mass Spectrometer (GC-MS) was purchased with the first year funds and an Inductively Coupled Plasma-mass Spectrometer (ICP-MS) with the second year's funds. The renovation of the lab is completed and a ribbon cutting ceremony conducted. Our Environmental Quality Testing Laboratory has the capacity to perform qualitative and quantitative analysis on most water, air, soil and plant diagnostic parameters.

The Environmental Simulation and Modeling Laboratory is the predictive and simulation component of our endeavor to impact efforts directed at improving the District's water resources quality and quantity. The Storm Water Management Modeling (SWMM) Software System and Worldwide Engine for Simulation and Training (WEST®) are the two modeling and simulation systems that have been acquired. The SWMM Software is an urban stormwater management tool used to analyze and design existing and future drainage systems. The capabilities of these software systems include assessment of urban area storm water runoff quantity and quality, design of storm water quantity and quality control systems, modeling of urban drainage systems including storm sewer systems and combined sewer systems, and evaluation of the performance of Best Management Practices such as Low Impact Developments and storm water management ponds. Other analytical software such as GIS Arc Info 9.3 and Statistical Analysis System for statistical analysis has also

been added. The WEST® software offers a user-friendly platform for the modeling and simulation of urban wastewater treatment plants, fermentation processes of river watersheds, catchments, and ecological systems. This software is a useful tool for design and comparison of varied plant configurations and water quality management plans; existing process evaluation, optimization and cost analysis; and investigation of varied types of what-if scenarios. A rainfall simulator which simulates rainfall and runoff potential under various scenarios is in the Laboratory. We have added a wireless solar powered weather station which would collect weather data for research purposes. These testing, simulation and modeling labs will significantly enhance our capacity for training, teaching, and research to better serve the residents of the District of Columbia.

Large areas of the National Capital Region (NCR) are at risk of severe flooding from three threats: Potomac River inundations, storm surges caused by Atlantic hurricanes, and the inability of local drainage to handle torrential rainfall. This threat is not hypothetical as precursors have already been experienced. Nonetheless, current planning is inadequate to handle the scale of disaster expected to occur to downtown Washington's iconic corridor. The flood situation in the NCR parallels that in New Orleans prior to Katrina, but with even greater national embarrassment. The lack of knowledge of flood potential and the lack of preparedness against the threat is a major concern.

The National Capital Region Flood Risk Assessment Program (FRAP) is a collaborative effort of the University of Maryland, the University of the District of Columbia, and George Mason University. It brings together the expertise of these major regional universities to focus on the flood risk challenge. The DC Water Resources Research Institute and the Civil Engineering Department represent the District of Columbia in FRAP. The objectives of the FRAP are to facilitate joint research, promote the application of existing knowledge to flood risk mitigation, increase the capabilities of disaster managers, and provide practical support for the development of flood risk management professional development (FRAP Prospectus, 2010).

The new College of Agriculture, Urban Sustainability and Environmental Sciences (CAUSES) is fully functional with a Bachelor of Science and Professional Master of Science Programs in Water Resource Management. Dr. Sabine O'Hara is our new Dean and this new college will increase our capacity to train students and perform scholarly research in the future.

Research Program Introduction

The DC Water Resources Research Institute will continue to provide the District with inter-disciplinary research support to both identify and contribute to the solution of DC water resources problems. These research and educational projects provide students with essential practical skills required for future job opportunities and also allow faculty members access to new technologies and equipment that develop their expertise in water resource management. Final and progress reports for the eight projects funded are included in this technical report.

Dr. Deksissa provided a progress report on his project GIS- Based Ecosystem Service Analysis of Urban Green Infrastructure as a Tool for Attaining Water and Air Quality Objectives in the District of Columbia . Rock Creek, Anacostia and Potomac Rivers are impaired significantly due to the impact of combined sewer overflows in the District of Columbia and its surroundings. The District is now proactively considering green infrastructure, a new approach of stormwater management, which temporarily holds stormwater onsite to allow water to infiltrate, evaporate and be reused. The objective of this study is to quantify the contribution of different green infrastructure, including tree canopies, green roof and open grasslands towards improving water quality in the District of Columbia. The quantitative method includes GIS technologies with spatial analysis capability and the CITYgreen®. Using the orthophotography of 2010 with 16 cm resolution, the quantitative assessment of the storm water benefit of the green infrastructure is being analyzed for Anacostia and Rock Creek watershed. The analysis of Rock Creek watershed has been completed. The results show that green infrastructures store rain and consequently reduce storm water runoff volumes and the peak flow rate. The result of such geo-referenced analysis of ecosystem service provides valuable benefit to the District in assessing the city's green infrastructure development plan and environmental/water quality objective. In addition to stormwater benefits for meeting water quality objectives, increasing area of green infrastructure can increase carbon sequestration and reduce energy use. Hence, integrating economic value and ecological benefits of the green infrastructure is crucial for sustainable urban development. The water quality model estimates the change in the concentration of the pollutants in runoff during a typical storm event given the change in the land cover from existing trees to a no tree condition. The air pollution model estimates how many pounds of ozone, sulfur dioxide, nitrogen dioxide, and carbon monoxide are deposited in tree canopies as well as the amount of carbon sequestered. Similar special analysis and ecosystem service assessment will be determined for the DC area of Anacostia watershed. We will also organize a hands-on training workshop for the UDC faculty and staff.

Dr. Royce A. Francis shared progress on his project, Integrated Water Use Impact for DC Urban Infrastructure . The objective of this research is to identify cost-effective approaches to reduction of the water use footprint of The George Washington University (GWU). In collaboration with the GWU Office of Sustainability and the DCWRRI, we will integrate life-cycle cost analysis and life cycle impact assessment to evaluate GWU infrastructure investments intended to reduce its water use footprint. We will use the cradle-to-cradle life cycle of a selected system as the system boundary, units or monetary value of system-relevant purchases as the functional unit of analysis, and employ a synthetic framework for the combination of life-cycle impact assessment (LCIA) and life cycle cost (LCC) and risk assessment (RA) methodologies where the impact of concern is life cycle cost over the life cycle of an infrastructure project. This proposal will demonstrate the potential for a natural synergy between life-cycle cost analysis and life-cycle impact assessment, while also making methodological contributions to the practice of water footprinting. The PI and his graduate students are constructing an extended life-cycle cost analysis for the implementation of LIDs in DC. The goal is to gain insight into strategies for compensating private developers or DC Water customers for installing LID based on the distribution of costs and benefits. We are in the model building stages of this work, and expect to complete this before the end of the project.

Dr. Arash Massoudieh progress report on Pollution Source Identification in Washington DC Stormwater Using Bayesian Chemical Mass Balance Modeling indicated that the goal of the proposed research is to identify the source of major pollutants and nutrients at a highly urbanized area at the vicinity of the Anacostia River in northeast Washington DC. Bayesian Chemical Mass Balance modeling will be used. This method uses the elemental profiles of potential sources, as well as the stormwater runoff samples to infer the contribution of each source. Traffic and non-traffic related sources (e.g. street dust, wet deposition, and roof runoff) are identified and multiple samples of each is collected and analyzed for their elemental profiles. The elemental profiles of the source samples and the discharged water will be analyzed using mass spectrometry technique. Then, the Bayesian CMB method will be utilized to infer the contribution of various sources into the stormwater runoff. We have already submitted proposals to EPA and NSF proposing to apply the method at a larger scale at a larger number of discharge points in the city to the stormwater being released into the Anacostia and Potomac rivers. Due to lack of significant rain during the proposed research period, the project was delayed. The researchers have asked for a no-cost extension, which was granted, until September 2012.

Dr. Song's final report on Monitoring of Glyphosate and its Degradation Residue by Phosphorus-31 Nuclear Magnetic Resonance Spectroscopy noted that Glyphosate [N-(phosphonomethyl) glycine] is an extensively used post-emergence nonselective organophosphorus (OP) herbicide, used for the control of a wide variety of weeds. Due to its strong retention on soil components, high solubility in water and long half-life in the environment (about 47 days), glyphosate may still be detected long after application or even far from the site of application. However, because its effects on non-target organisms and overall environmental impact have not been fully investigated, questions should be addressed regarding the environmental safety, in light of its increasing use. The widespread application of glyphosate generates problems regarding environment contamination. Therefore, Knowledge about the persistency of glyphosate and its derivatives would be beneficial in the handling of contaminated dredged material, and it is essential to understand the speciation of these organophosphorous compounds to gain a better understanding of their interaction in soil and aquatic environment. Using 31P NMR, rapid and reliable detection of organophosphorus compounds is achieved in this project. We successfully obtained 31p NMR spectra for all 8 samples. There is no need of further treatment this samples such as derivatization or extraction. Preliminary data shows that the degradation starts in week 2 and the concentration of degradated species increased from week 2 to week 8. The glyphosate has very strong ability of binding to soil, and decomposed P species are released and dissolved in water.

In the National Capital Region Flood Risk Assessment: Inter-university Collaboration Initiative final report, Dr. Pradeep Behera and his colleagues from the University of Maryland and George Mason University highlighted the vulnerability of the District and its neighboring region with respect to such extreme storm events and hurricanes parallel to the flood situation in New Orleans prior to Hurricane Katrina. Because the NCR is comprised of many local jurisdictions, all of which are not contained in a single state, a lack of coordination and information sharing has resulted. In order to address the vulnerability of the District and its neighboring regions from the aforementioned natural hazards, a National Capital Region (NCR) Flood Risk Assessment Program has been proposed by three local universities. The specific objectives of this project were to collect and analyze past flooding events and associated social, environmental and economic impacts, collect meteorological records of all available stations within the NCR, and create the appropriate digital file format to conduct the statistical analysis to obtain an understanding on the extreme events. There was a lack of thorough coverage in some portions of the floodplain in order to get accurate elevations and, therefore, flood depths for some buildings surveyed. In addition, information on building use was not readily available. Due to these, a numeric value for estimated damages has not been developed. The scale of potential damages can be inferred from the number of building that would be flooded. Further research is needed to determine more accurate building flood depths and more reliable damage estimation methods for building types other than residential.

In Dr. Stephen MacAvoy's progress report on Hormone Disruption and Environmental Pollutants in Anacostia and Potomac River Fish, Washington DC , he shared that water, sediment, and fish samples have

been collected from the Anacostia River from three sites. He and his student assistant have continued geochemical analysis of the water and extracted organic compounds from the sediment and water column. They have been collecting water geochemistry data since the spring 2010 and data generated under this grant are being added to the overall database. While the examination and interpretation of our results is ongoing, preliminary analysis suggests that cations correlate heavily with each other but also nitrate. Also, nutrient concentrations at baseflow (only baseflow samples were collected) show that inorganic nitrogen concentrations are consistently on the high side of "normal" for a tidal freshwater system. Our initial results, combined with earlier WRRI-funded research, were presented at the American Geophysical Union annual meeting in December 2011. The largest laboratory work that remains is examination of fish tissues collected from six individual adults for organic contaminants that may have been taken up from the sediment/water. A six-month extension was granted on October 26, 2011 and a final report will be completed by August 28, 2012.The principal remaining task to be completed is a thorough analysis of the data. We do not foresee a large amount of field work taking place before the six-month extension expiration.

Dr. Nian Zhang provided a final report on Urban Stormwater Runoff Prediction Using Computational Intelligence Methods . The objective of this project is to develop computational intelligence methods, including recurrent neural networks, particle swarm optimization, evolutional algorithm, and the combination of these methods for runoff quantity and quality prediction. We proposed an Elman style based recurrent neural network on the water quantity prediction. A hybrid learning algorithm incorporating particle swarm optimization and evolutional algorithm was presented, which takes the complementary advantages of the two global optimization algorithms. The neural networks model was trained by particle swarm optimization and evolutional algorithm to forecast the stormwater runoff discharge. The methodology was applied to renewable energy data collected from the Zero Energy House located at the University of the District of Columbia. The excellent experimental results demonstrated that the proposed method provides a suitable prediction tool for the stormwater runoff monitoring and solar radiation prediction. In addition, we proposed a predictive model based on recurrent neural networks trained with the Levenberg-Marquardt backpropagation learning algorithm to forecast the runoff discharge using the past runoff discharge, as well as the solar radiation prediction. This computational intelligence modeling tool not only explored the impact of discharge and gage height to the long-run discharge forecast accuracy, but also investigated the solar radiation prediction. Based on the excellent experimental results including the training, validation and testing errors, error autocorrelation function analysis, regression analysis, and time series response, it showed that the proposed learning algorithm proved to be successful in training the recurrent neural network for the runoff prediction.

GIS-based Ecosystem Service Analysis of Urban Green Infrastructure as a Tool for Attaining Water and Air Quality Objectives in the District of Columbia

Basic Information

Title:	GIS-based Ecosystem Service Analysis of Urban Green Infrastructure as a Tool for Attaining Water and Air Quality Objectives in the District of Columbia
Project Number:	2011DC123B
Start Date:	3/1/2011
End Date:	2/28/2012
Funding Source:	104B
Congressional District:	DC
Research Category:	Climate and Hydrologic Processes
Focus Category:	Climatological Processes, Education, Non Point Pollution
Descriptors:	None
Principal Investigators:	Tolessa Deksissa

Publications

There are no publications.

UNIVERSITY OF THE DISTRICT OF COLUMBIA
COLLEGE OF AGRICULTURE, URBAN SUSTAINABILITY AND ENVIRONMENTAL SCIENCES

GIS-Based Ecosystem Service Analysis of Urban Green Infrastructure as a Tool for Attaining Water and Air Quality Objectives in the District of Columbia

Progress Report

Submitted to the
DISTRICT OF COLUMBIA WATER RESOURCES RESEARCH INSTITUTE

By:

Tolessa Deksissa (PI)
College of Agriculture, Urban Sustainability and Environmental Sciences, University of the District of Columbia

May 2012

GIS- Based Ecosystem Service Analysis of Urban Green Infrastructure as a Tool for Attaining Water and Air Quality Objectives in the District of Columbia: Progress Report

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1. Executive Summary

Increase of impervious area in the District of Columbia and its surroundings becomes a challenge for the attainment of water quality objectives in the region. All main rivers, including rock Creek, Anacostia and Potomac Rivers are impaired mainly due to the impact of combined sewer overflows. The decline of green area or pervious area has resulted in increased flow volume of storm water runoff that often exceeds the capacity of the existing sewer system. Consequently, a mixture of raw sewerage and storm water runoff is discharged to the receiving waters during as little as a half inch of rain. It is therefore imperative to seek for alternatives to address impact of combine sewer overflows. The District is now proactively considering green infrastructure, a new approach of storm water management, which temporarily holds storm water on site to allow water to infiltrate, evaporate and be reused. The objective of this study is to quantify the contribution of different green infrastructure, including tree canopies, green roof and open grass lands towards improving water quality in the District of Columbia. The quantitative method includes GIS technologies with spatial analysis capability and the CITYgreen®. Using the orthophotography of 2010 with 16 cm resolution, the quantitative assessment of the storm water benefit of the green infrastructure is being analyzed for Anacostia and Rock Creek watershed. The analysis of Rock Creek watershed has been completed. The results show that green infrastructures store rain and consequently reduce storm water runoff volumes and the peak flow rate. The peak flow rates are responsible for the combine sewer overflows. The analysis is conducted for both a municipal separate storm sewer system (MS4) as well as the combined sewer system. The benefit of storm water is being assessed for the Anacostia watershed. The result of such geo-referenced analysis of ecosystem service provides valuable benefit to the district in assessing the cities green infrastructure development plan and environmental/water quality objective. In addition to storm water benefits for meeting water quality objectives, increasing area of green infrastructure can increase carbon sequestration and reduce energy use. Hence, integrating economic value and ecological benefits of the green infrastructure is crucial for sustainable urban development.

2. Introduction

The District of Columbia is one of fast growing cities in the nation in which the development activities have resulted in the decline of heavy tree cover with increased impervious surface area, and frequent contaminations of surface waters by the combined sewer overflows. In green economy, to be truly sustainable, the city must balance the interests of the economy, the environment and the wellbeing of the community. The growth and stability of corporate investment is a function of ecosystem condition. However, according to the regional ecosystem

analysis conducted by the American Forest (1999), the city lost about 30% of its heavy tree cover, and the ecology is in state of decline and resulted in polluted watershed.

The cost of this declining natural system is costly to the DC residents. In the combined sewer overflows region, a mixture of storm water runoff with raw sewerage is directly discharged to the river during as low as half inch of rain. Subsequently all surface waters, including Anacostia River, Rock Creek, and Potomac River in the District are impaired, and do not meet the designated use of class A or primary contact. In order to address this issue the DC water long term control plan accounts for about 2 billion dollars (DC Water, 2000).

Many studies demonstrated that quantifying ecosystem service in terms of money helps promote sustainable growth while protecting environment (AF, 1999; AF, 2009; Wainger *et al*., 2010; Yapp *et al*., 2010; Bolund and Hunhammar, 1999; Jim and Chen 2008). The costs of ecological service can be estimated on the basis of cost associated to the absence of those ecological services or cleaning the environment. The District now recognizes that the existing natural and modified ecosystems within and outside of their existing boundaries are providing benefit that if lost would result in costs to the citizens of the District. Attaching dollar values with green infrastructures can be used a measure to reach the goal of EPA attainment levels for air and water quality (Casey Tree and Limno-tech, 2005). The District has, therefore, increased its effort to build green infrastructures as good indicators of the health of urban ecosystem, including tree planting, green roof and urban gardening. Residents are encouraged to plant trees with bigger canopy. The greater tree canopy, the less impervious surface and the higher environmental benefits in terms of storm water management. Trees provide communities many valuable services that can be measured in terms of money. These include (1) slowing stormwater runoff and reduce the peak flow, and (2) improving air quality.

Without quantitative assessment, and insentives for land owners that convince them why they have to invest on planting trees and maintain green surfaces, these services tend to be ignored by those making land uses and land management decisions. Quantifying ecosystem service requires spatially explicit values of service across landscapes that might inform land-use and management decisions. GIS based tool is needed for valuation of ecosystem service of the green infrastructure that includes not only the benefit of stormwater management, but also air quality is needed.

The goal of this study is to evaluate the ecosystem service of green infrastructure in the district of Columba. The objective of the study is three folds: (1) geo-coding the green area as well as gray area, (2) ecosystem service analysis of green surfaces, including trees, green roof, and other green surfaces, (3) calculate the effects of future land cover change on the District's EPA attainment levels for air and water quality, (4) writing a grant proposal extramural funding for further development of the project.

3. Methodologies

The most common modeling approach for ecosystem service is spatial modeling approach or Geographic Information System (GIS). In this GIS based analysis, the data collected contain both green as well as gray infrastructures. Green infrastructure includes areas covered with trees,

shrubs, green roofs and grass and gray infrastructure, whereas gray infrastructure includes areas covered by buildings, roads, utilities, and parking lots.

Using the orthophotography of 2010 with 16 cm resolution, the quantitative assessment of the storm water benefit of the green infrastructure is being analyzed for Anacostia and Rock Creek watershed. Urban Ecosystem Analyses is conducted using CITYgreen® software for ArcGIS developed by America Forest (AF 2002a). CITYgreen for ArcGIS used the raster data land cover classification from the high-resolution imagery for the analysis. In this tool three sub-models are integrated, such as stormwater runoff and water quality model, both are developed by U.S. Natural Resources Conservation (NRC). For air pollution, CITYgreen uses urban forest effects model developed by USDA Forest service.

The water quality model estimates the change in the concentration of the pollutants in runoff during a typical storm event given the change in the land cover from existing trees to a no tree condition. This model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD). Pollutant values are shown as a percentage of change.

The air pollution model estimates how many pounds of ozone, sulfur dioxide, nitrogen dioxide, and carbon monoxide are deposited in tree canopies as well as the amount of carbon sequestered. Dollar values for air pollutants are based on averaging the externality costs set by the State Public Service Commission in each state. Externality costs are the indirect costs to society, such as rising health care expenditures as a result of air pollutants' detrimental effects on human health.

Improved green infrastructure coverage decreases surface run off, increase infiltration or reduce combine sewer overflows (Figure 1). In the previous cover, 50% of water infiltrate into the ground and only 5% produce surface runoff. In impervious cover, about 55% of the rain water goes to surface runoff and only 15% could goes to shallow or deep infiltration.

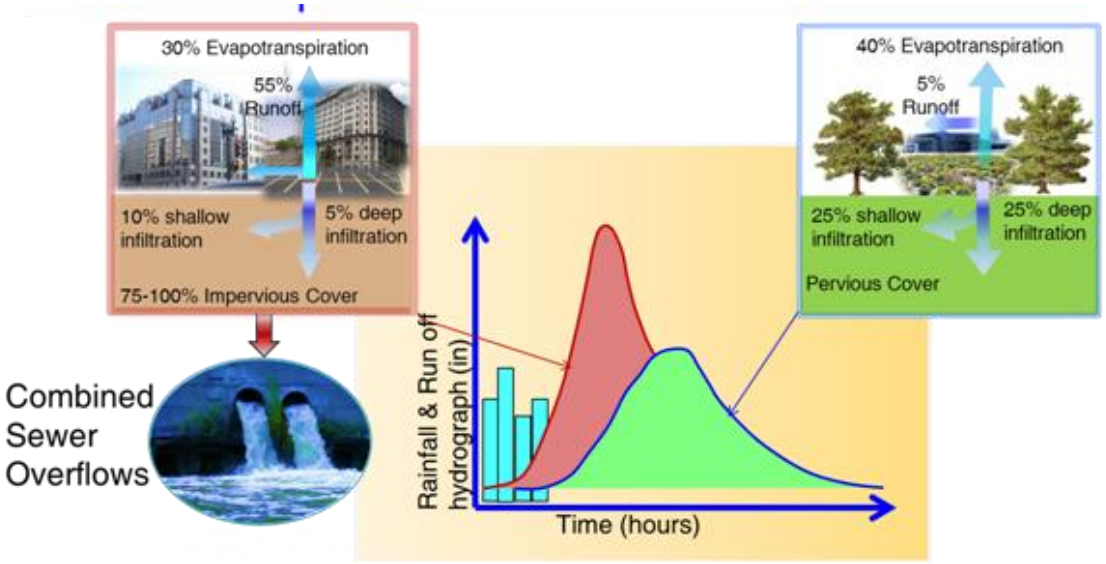


Figure 1. Conceptual representation of the effect of green infrastructure on surface runoff

3.1. Study Site map

In this study Rock Creek Park and Anacostia watershed are considered. The land cover in 2006 is demonstrated in Figure 2. About 40% of the land cover in the Rock Park is impervious surface, including transportation, buildings and pavement. About 60% of the area is covered by pervious layer, including tree canopies, grass/shrubs and bare earth. We completed the surface analysis of the Rock Creek Park, but the digitization of tree canopies in the Anacostia watershed is in progress.

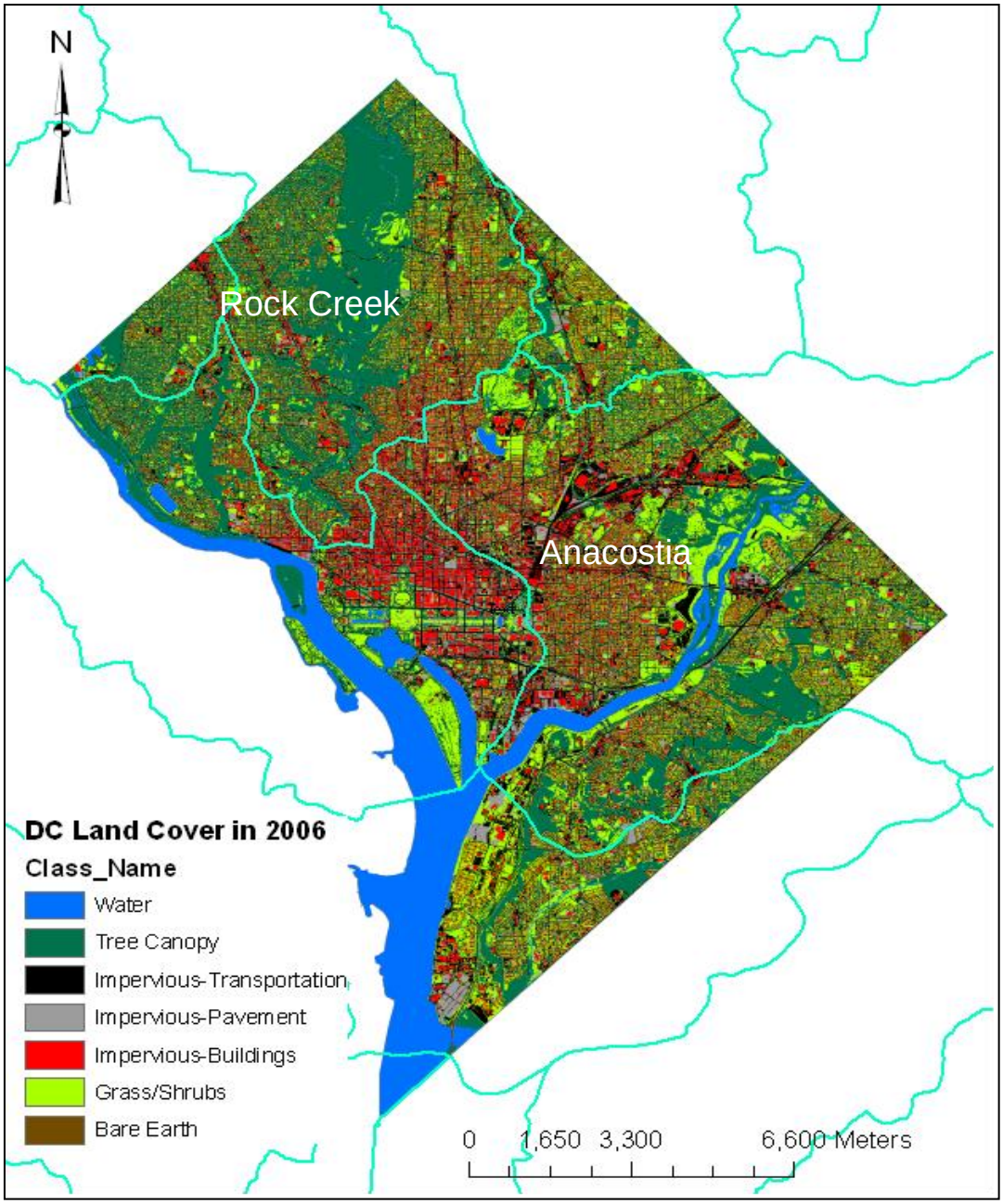


Figure 2. DC Land cover in 2006

4. Results and Discussion

4.1. Existing condition

The surface analysis result for the DC area of Rock Creek watershed is illustrated in Figure 3. The impervious surfaces area analysis indicates about 40% coverage (See Figure 4), including building and pavement. The calculated additional cubic feet storage needed is about 8 million. Total storm water value is about $16 million. The water quality condition or the contaminant loading is about 13% of Chemical Oxygen Demand, 10% of Biological Oxygen Demand and 11% phosphorus.

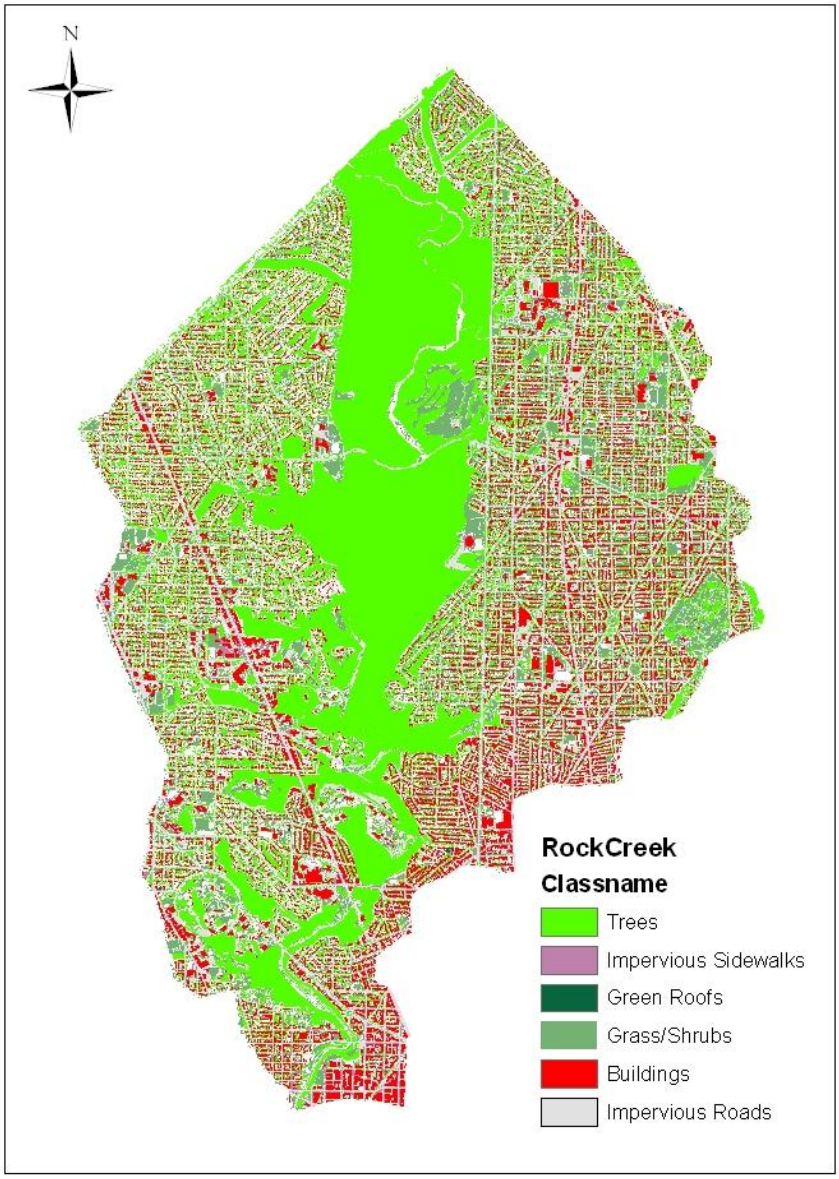
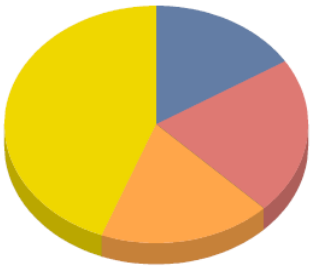


Figure 3. Analyzed Rock Creek Park

In the existing condition, trees and grass covers, including trees with impervious understory, is about 60%. The air pollution removal benefit is about 150, 000 lbs per year or it saves $0.5 million medical cost per year.



Impervious Surfaces: Buildings/ structures	1,333.5	16.2%
Impervious Surfaces: Paved	1,742.8	21.2%
Low Impact Development: Green Roofs	2.1	0.0%
Shrub: Ground cover > 75%	1,506.7	18.3%
Trees: Impervious understory	3,631.8	44.2%
Total:	8,216.9	100.0%

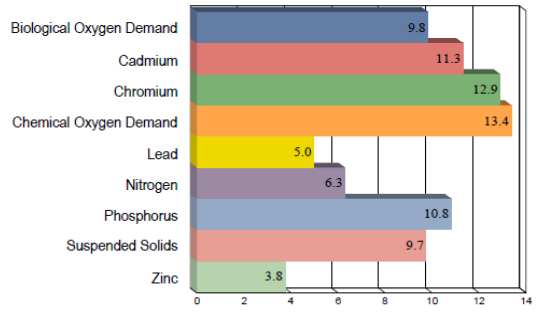
Stormwater Management

Water Quantity (Runoff Volume)

2-yr, 24-hr Rainfall in inches:	3.25
Curve Number reflecting existing conditions:	88
Curve Number of replacement land cover:	91
Dominant Soil Type: B	
Replacement land cover type: (existing condition)	
Impervious Surfaces: Buildings/ structures	
Additional cu. ft. storage needed:	**8,055,158**
Construction cost per cu. ft.:	$2.00
Total Stormwater Value:	**$16,110,317**
Annual Stormwater Value: (based on 20-year financing at 6% interest)	**$1,404,571**

Water Quality (Contaminant Loading)

Percent change in contaminant loadings



Air Pollution Removal

Nearest air quality reference city: ***Tucson***

	Lbs. Removed/yr	Dollar Value/yr.
Carbon Monoxide:	12,921	$6,341
Ozone:	148,588	$524,969
Nitrogen Dioxide:	41,992	$148,361
Particulate Matter:	122,747	$289,541
Sulfur Dioxide:	9,691	$8,363
Totals:	**335,938**	**$977,575**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Tons Stored **(Total)**:	**155,932**
Tons Sequestered **(Annually)**:	**1,214**

Figure 4. Effect of existing green infrastructure on storm water storage and water quality contaminant load reduction with tree canopy: 3,631.8 acres (44.2%)

4.2. Scenario analysis

When a 2% of the impervious building area is covered by green roof, the results are depicted in Figure 4. The benefit of this change is about 5 million ft^3 storm water storage and saving about $10 million total storm water value if a storage tank has to be built. Air quality benefit is also shows that 2% of the additional green infrastructure or green roof can further decreases air pollution related expenses. A 334 lbs/year reduction of ozone could reduce about $1000 air pollution cost per year (see Table 1).

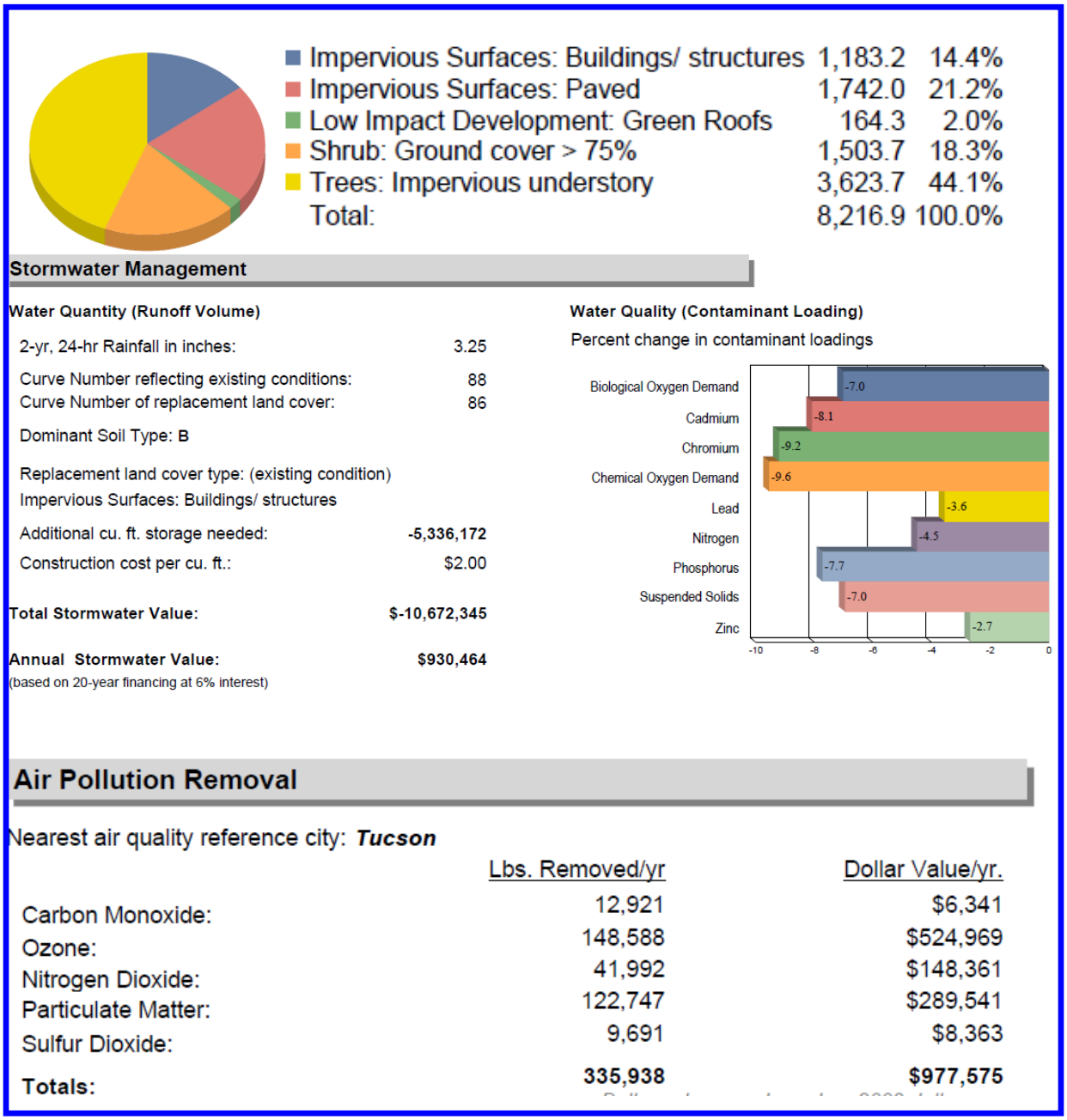


Figure 4. Effect of green roof on storm water storage and water quality contaminant load reduction

Table 1. Effect of green roof on the air quality improvement

Air quality Variables	Air pollution removal (lbs/yr)			Dollar Value/yr		
	Existing	Green Roof	Differences	Existing	Green roof	Differences
Carbon Monoxide	12,950	12,921	29	$6,355	$6,341	14
Ozone	148,922	148,588	334	$526,149	524,969	1,180
Nitrogen Dioxide	42,087	41,992	95	$148,694	148,361	333
Particulate Matter	123,023	122,747	276	$290,191	289,541	650
Sulfur Dioxide	9,712	9,691	21	$8,382	8,363	19
Total	336,693	335,938	755	$979,772	977,575	2,197

Integrating the ecosystem service in the decision making process promote environmental protection and sustainable water resources. The results of the proposed GIS based ecosystem services analysis have the following benefits:

- Quantify the stormwater, water quality and air quality ecosystem service of the existing green infrastructure of the District of Columbia.
- Calculate the effects of future land cover change before those changes are made.
- Analyze the changed of green area of the city over time, by comparing land cover maps from earlier periods, such as 10 or 20 years ago, depending on the available data.
- Assist environmental managers as a tool for mitigating carbon emission and reduce its effect on climate.
- Community awareness of ecological and economic value of green infrastructure creates incentives for the land owner to consider planting trees and urban gardening.
- Quantify the costs of parts of the green area if lost to the residence.
- Educate future scientists, including school children, and thereby improve the wellbeing of our community.

Future steps

Similar special analysis and ecosystem service assessment will be determined for the DC area of Anacostia watershed. We will also organize a hands-on training workshop for the UDC faculties and staffs.

Presentations

The finding of this study was presented at local and international conferences/seminar:

- Deksissa, T. (2011). Effect of Green Infrastructure on Urban Water Quality Restoration. Annual Conference on Water Resources, November 7-10, 2011, Albuquerque, NM.
- Deksissa, T. (2011). Sustainable Water Resources Management, 2011, Agriculture Experiment Station Seminar, CAUSES, UDC

Graduate student participation

Matthew Fialla, Rachel Perry and Toni Davidson assisted in digitizing tree canopies. Matthew digitized for Rock Creek Watershed, whereas Toni and Rachel is assisting in digitizing tree canopies in parts of the Anacostia Watershed.

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National Capital Region Flood Risk Assessment: Inter-University Collaboration Initiative

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Publications

There are no publications.

UNIVERSITY OF THE DISTRICT OF COLUMBIA
COLLEGE OF AGRICULTURE, URBAN SUSTAINABILITY AND ENVIRONMENTAL SCIENCES

National Capital Region Flood Risk Assessment: Inter-university Collaboration Initiative

Final Report

Submitted to the

DISTRICT OF COLUMBIA WATER RESOURCES RESEARCH INSTITUTE

By:

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University of the District of Columbia

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Table of Content

Abstract

It has been recognized that the downtown areas of Washington DC are at risk of severe flooding from the natural hazards such as extreme storm events and Atlantic hurricanes. The relatively flat areas of Potomac River flood plain and inadequate capacity of existing drainage system could exacerbate the flooding situation during such events resulting in disastrous impact to federal triangles, particularly to our nation's iconic treasures. Moreover, the global warming and climate change can increase the frequency of extreme events which is a major concern (IPCC, 2007). The lack of knowledge of flood potential, flood risk assessment and lack of preparedness against such natural hazard creates vulnerability to the District of Columbia and its neighboring region which is a major concern.

In order to address the vulnerability of the District and its neighboring regions from the aforementioned natural hazards, a National Capital Region (NCR) Flood Risk Assessment Program has been initiated by three local universities that include University of Maryland (UMD), University of the District of Columbia (UDC) and George Mason University (GMU). This program would facilitate inter-university collaborative research, promote the application of existing knowledge to flood risk mitigation and increase the capabilities of disaster management. This will not only assist the federal, state and District agencies, and relevant private and public entities but also train the future engineers, water resources professionals and other relevant professional communities.

As a part of the program, the District of Columbia Water Resources Research Institute (DC WRRI) which is located within the University of the District of Columbia, proposed this seed grant project to assist collaborative universities in developing the center and conduct initial studies. The faculty and student researchers from UDC, and UMD participated in conducting initial studies that included flood data inventory for the Washington Metropolitan Region and long-term precipitation analysis for Washington DC.

1. Introduction

It has been recognized that the District's location at the confluence of Potomac and Anacostia River combined with three buried waterways, broad floodplains, and relatively flat elevations, renders it highly susceptible to periodic flooding (NCPC, 2008). The downtown area of the District, including federal triangle area, was threatened by several natural hazards that include extreme storm events and Atlantic hurricanes. The examples of such natural hazards that caused disastrous impacts to the District and its neighboring region include 1936 Spring Storm event, Hurricanes Hazel, Agnes and Isabel and June 2006 extreme storm event. Hurricane Isabel which struck the North Carolina coast in 2003, even though not a direct hit to the NCR nonetheless caused over $1.1 billion (2010 USD) in damages to DC, southern Maryland, and northern Virginia.

The relatively flat areas of Potomac River flood plain and inadequate capacity of existing drainage system could exacerbate the flooding situation during such events resulting in

disastrous impact to federal triangles, particularly to our nation's iconic treasures. Moreover, the global warming and climate change can increase the frequency of extreme events which is a major concern (IPCC, 2007). The lack of knowledge of flood potential, flood risk assessment and lack of preparedness against such natural hazard creates vulnerability to the District of Columbia and its neighboring region which is a major concern.

The vulnerability of the District and its neighboring region with respect to such extreme storm events and hurricanes parallel to the flood situation in New Orleans prior to Katrina. Hurricane Katrina flooded 80 percent of the New Orleans, caused 1,300 deaths, forced an extended evacuation and relocated 100, 000 residents that resulting in an estimated monetary loss of $40 to $50 billion dollars to the city (Colton, et al., 2008). While the economic losses would not reach the level of New Orleans and life safety is less at risk, the flooding of downtown Washington's iconic corridor, the potential damage to priceless treasures of the country, the closure of the Reagan National Airport, and the disruption of business and commerce in the region would raise the issue of why there was not a coordinated flood risk management plan for the region. The existing lack of coordination is widely recognized.

In order to address the vulnerability of the District and its neighboring regions from the aforementioned natural hazards, a National Capital Region Flood Risk Assessment Program has been proposed by three local universities that include University of Maryland (UMD), University of the District of Columbia (UDC) and George Mason University (GMU). It is noted that National Capital Region (NCR) comprises of District of Columbia, Montgomery and Prince George's Counties of Maryland; Arlington, Fairfax, Loudoun, and Prince William Counties of Virginia.

2. Scope and Research Objectives

The overall goal of the program is to develop National Capital Region Flood Assessment Program Center (NCR FRAP). The specific objectives of the NCR FRAP are to:

- Facilitate effective joint research, analysis and related activities to benefit the organizations, communities and residents of the NCR;
- Expand knowledge and promote innovative application of the existing knowledge to support risk and vulnerability assessment, contingency planning and preparedness, mitigation, disaster response, and disaster recovery;
- Increase the professional knowledge and capabilities of disaster managers and responders;
- Facilitate coordination among researchers, educators, trainers, and practitioners.
- Encourage the involvement of members of the academic community in disaster related activities;
- Provide practical guidance and support for the development of flood risk and disaster management professional development and education curricula.

The specific objectives of this project are to:

- Assist the collaborating team in developing proposals for extramural funding,
- Collection and analysis of past flooding events and associated social, environmental and economic impacts,
- Collection of meteorological records particularly rainfall records of all available stations within the regions of District, Maryland and Virginia from the NOAA and NCDC web-sites,
- Understand the available data format and create the appropriate digital file format to conduct the statistical analysis to obtain an understanding on the extreme events.

3. Flood Data Inventory for the National Capital Region

Significant flood events within the NCR has, at times, prompted flood risk studies to be conducted by various agencies or interested parties. Because the NCR is comprised of many local jurisdictions, all of which are not contained in a single state, a lack of coordination and information sharing would be a natural tendency. While Maryland, Virginia, and the District may each have a comprehensive flood risk management plan and policy in place, there is more progress to be gained in coordinating across boundaries to develop a comprehensive understanding of flood risks specific to the NCR. This study aims to provide the foundation to a regional flood risk assessment for the NCR.

Defining the National Capital Region (NCR)

The National Capital Region (NCR), as defined by the National Capital Planning Act of 1952, is comprised of jurisdictions in Maryland, Virginia, and the District of Columbia. Figure 1 provides a list and a map of the jurisdictions within the NCR. The NCR covers about 2,500 square miles and is home to over 5 million residents. It is unique in the United States as the home of the Federal Government, whose many agencies employ roughly 340,000 local residents.

Jurisdictions

Washington DC
- •District of Columbia

Maryland
- •Montgomery County
- •Prince George's County

Virginia
- •Alexandria
- •Arlington County
- •Fairfax
- •Fairfax County
- •Falls Church
- •Loudoun County
- •Manassas
- •Manassas Park
- •Prince William County

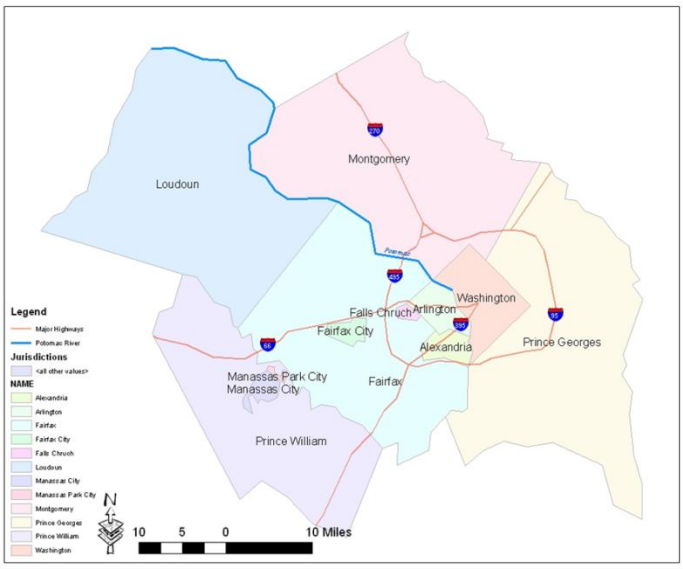

Figure 1. Jurisdictions included in the National Capital Region (NCR)

Literature and Reports

The first step to developing a comprehensive flood risk assessment of the NCR was to collect the data available and review the related studies for each jurisdiction that have already been conducted. Below is an abbreviated list of several reports that reveal how various entities within the NCR are currently addressing the subject of flood risk:

- National Capital Planning Commission (NCPC) – DC Flood Report 2008
- Hazard Mitigation Plans – (Northern VA, Montgomery County, Prince George's county, DC)
- Maryland's Vulnerability to Flood Damage – 2005
- Maryland Stormwater Management Manuals
- FEMA's Risk Mapping, Assessment, and Planning – 2011 report to Congress
- Episodic Flooding and the Cost of Sea Level Rise- 2005
- FEMA's Flood Insurance Studies (FIS) by county
- Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use – Georgetown Climate Center (2011)

In addition to the many related reports that have been issued, FEMA has also developed Flood Insurance Rate Maps (FIRMs) designating Special Flood Hazard Areas (SFHAs) for some jurisdictions within the NCR. While these maps are specifically intended to assist the National Flood Insurance Program (NFIP) determine flood insurance premiums, they have also become the basis for many planning, zoning, and development policies for local governments throughout the country.

Historical Flood Data

NOAA's National Weather Service (NWS) maintains a database of significant weather events throughout the country that is categorized by the type of event. This database was accessed to obtain a record of flood events for each county in the NCR from 1993 to present. Included in the data set was the type of flooding (coastal or pluvial), the number of deaths and injuries, and the dollar amount of economic damages reported.

The NFIP has publicly accessible statistics at the county level that data back to 1973. Included are statistics representing the number of claims made, value of payments made, policies-in-force, the value of insurance-in-force, and the value of premium-in-force.

Finally, census data was utilized so that the flood statistics could viewed on a per-capita level. This is important because the jurisdictions in the NCR vary widely in square mileage which could lead to a misrepresentation of the data.

Using these three data sets, several county level flood maps were created (see Figure 2, below).

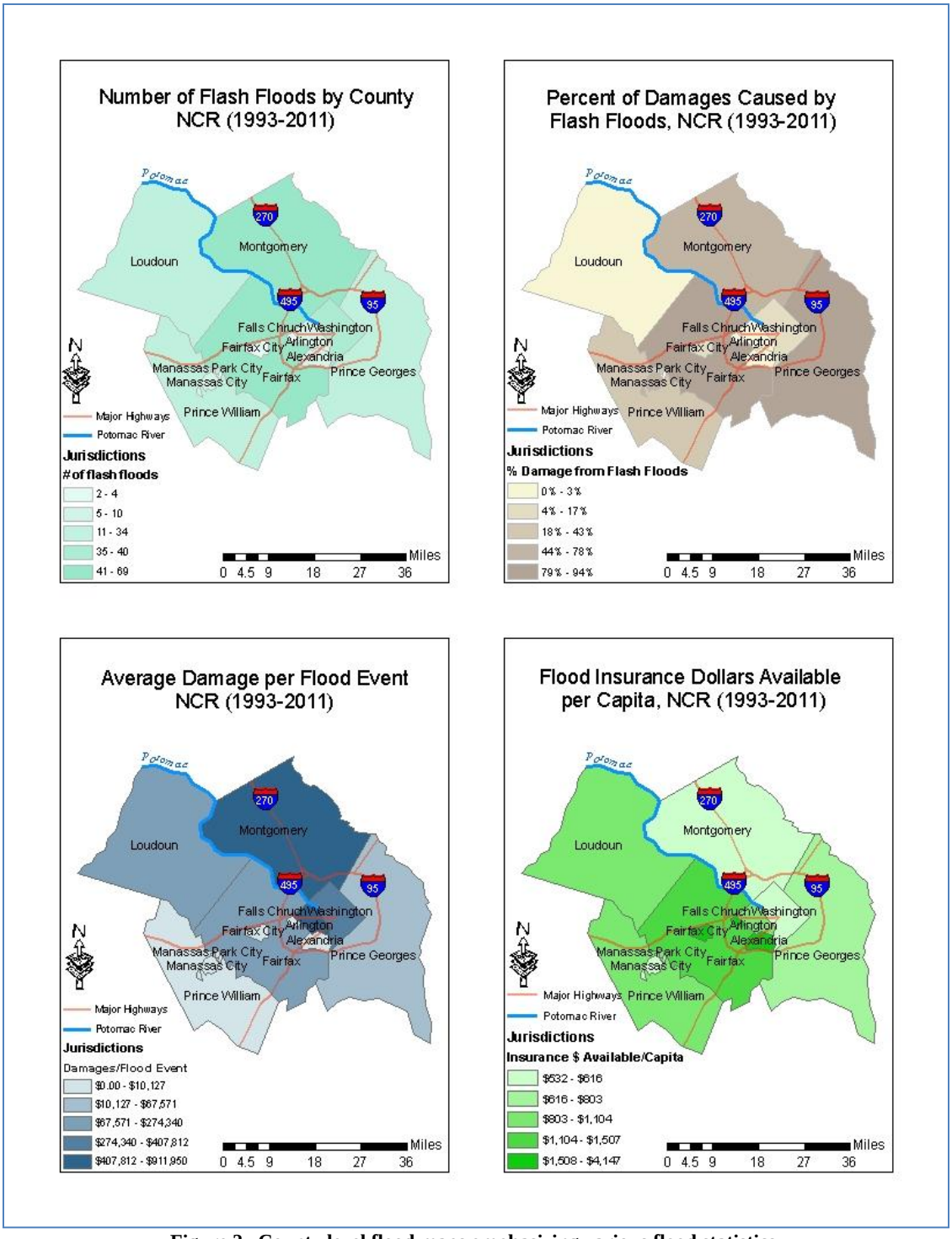

Figure 2. County level flood maps emphasizing various flood statistics.

DC Flood Damage Analysis

DC's Office of the Chief Technology Officer (OCTO) maintains an extensive, publicly accessible, database of detailed datasets pertaining to the District. Many of these data sets are conveniently available in GIS shapefile format. With this detailed data available, DC was analyzed more closely and an attempt was made to estimate flood damages that would result

from a 500-year flood event. Figure 3 displays the 100-year and 500-year floodplains, as defined by FEMA.

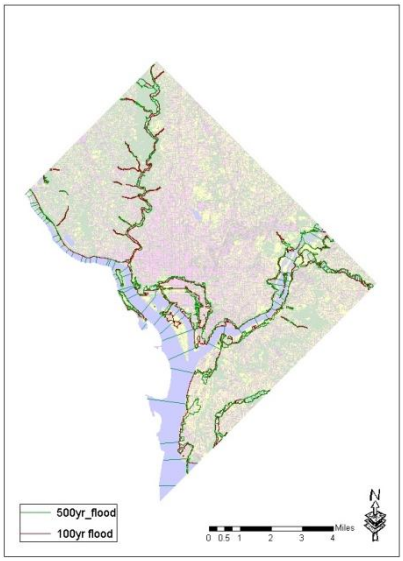

Figure 3. FEMA defined 100-yr and 500-yr floodplains in DC

Using a shapefile of mass points that contain elevations and a shapefile of polygons of all the buildings within DC, the elevations of each building were estimated by matching them to the elevation of the nearest mass point. Both layers were then clipped to the extent of the floodplain boundary. This allowed the number of buildings within the floodplain to be counted and the flood depth of each building to be calculated by subtracting the building elevations from the floodplain elevation. The results of a zoomed in portion of DC near the national mall are shown in Figure 4.

Results and Recommendations

An estimated 2,945 building are located within the 500-yr floodplain boundary. Unfortunately, the mass points did not provide thorough enough coverage in some portions of the floodplain in order to get accurate elevations and, therefore, flood depths for some buildings. This was evidenced by 322 building flood depths being reported as negative, which is irrational.

Another challenge was that information on building use was not readily available. Typically, damage estimates a based upon depth-damage curves that are carefully constructed to represent various building types and uses. Therefore, a damage curve for a residential building will be different from one for a commercial building. Commercial buildings have a wider range of possible uses and contents making accurate damage assessments more difficult. DC has the unique aspect of having many Federal Government buildings, which can be even more difficult to predict damages for.

Due to these current issues, a numeric value for estimated damages has not been developed. The scale of potential damages can be inferred from the number of building that would be flooded. Further research is needed to determine more accurate building flood depths and more reliable damage estimation methods for building types other than residential.

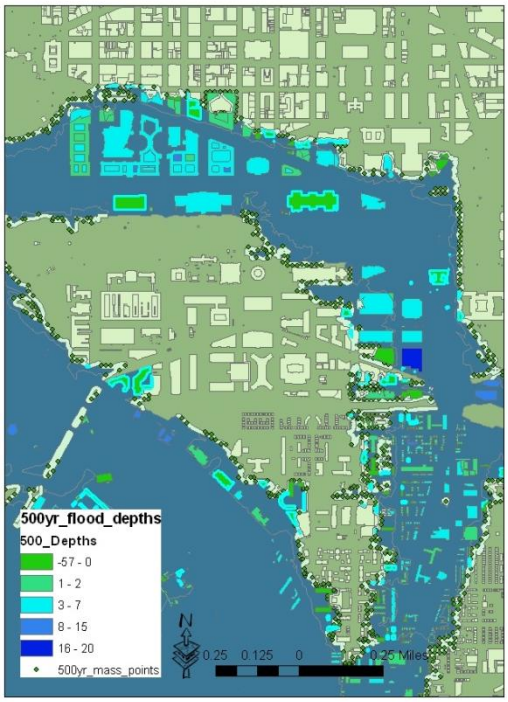

Figure 4. Buildings contained in the 500-yr floodplain with flood depths for a section of DC near the national mall.

4. Rainfall Data Analysis

In order to analyze the long-term precipitation within the region, the hourly rainfall record for Washington National (Reagan) Airport station from 1948 to 2009 was used in the analysis. From the hourly rainfall record, the maximum rainfall volume for different durations (1-hr, 2-hr, 4-hr, 12-hr, 18-hr, 24-hr, 36-hr, 48-hr and 72-hr) was obtained for each of the year. A software program was developed to obtain this information. Following table presents the values of maximum rainfall volume for each of duration and for each of the years.

Table: Maximum Rainfall Volume (inches) for various duration at the Ronald Regan Airport, Washington, DC

Year	Duration								
	1 hr	2 hr	4 hr	12 hr	18 hr	24 hr	36 hr	48 hr	72 hr
1948	1.56	1.75	1.83	2.71	3.33	3.87	4.3	4.3	4.44
1949	1.17	1.6	1.62	1.76	1.82	2.04	2.42	2.42	2.77
1950	2.62	2.73	3.61	3.86	3.86	3.86	3.86	3.86	4.61
1951	2.75	2.75	2.87	2.9	2.9	2.9	2.9	2.9	2.95
1952	2.67	2.71	2.78	3.11	3.24	3.49	3.49	4.36	4.61
1953	2.54	2.82	2.82	3.24	3.24	4.32	4.35	5.04	5.58
1954	0.82	1.03	1.16	1.68	1.73	1.73	1.73	1.73	1.73

Year	Duration								
	1 hr	2 hr	4 hr	12 hr	18 hr	24 hr	36 hr	48 hr	72 hr
1955	2.24	3.24	3.77	5.12	6.07	6.39	6.6	7.07	8.72
1956	0.96	1.11	1.26	1.9	1.9	1.96	1.99	2	2.28
1957	0.7	0.78	1.2	2.04	2.14	2.14	2.14	2.14	2.53
1958	1.89	2.04	2.49	3.47	3.56	3.56	3.99	4.24	4.24
1959	1.84	2.22	2.54	2.76	2.76	2.76	2.8	2.8	2.89
1960	1.29	1.36	1.4	2.7	2.83	2.83	3.25	3.25	3.65
1961	2.25	2.28	2.33	2.4	2.4	2.4	2.4	2.4	4.44
1962	1.24	1.27	1.27	1.51	1.68	1.68	1.7	1.72	1.75
1963	3.75	3.85	3.9	3.9	3.92	6.28	6.28	6.28	6.54
1964	1.07	1.16	1.17	1.38	1.54	1.7	1.81	2.01	2.12
1965	1.43	1.45	1.45	1.73	1.83	1.94	1.94	1.94	1.96
1966	1.69	2.07	2.44	3.53	4.07	4.15	4.28	4.29	4.31
1967	1.22	2.01	2.37	2.85	3.09	3.66	3.7	4.94	4.94
1968	1.3	1.31	1.76	2.01	2.1	2.24	2.32	2.51	2.51
1969	3.99	4.32	4.35	4.4	4.4	4.4	4.45	4.45	5.9
1970	2.61	2.66	2.76	4.69	4.69	4.69	4.69	4.69	4.69
1971	1.5	1.84	2.33	3.53	3.77	3.8	3.85	3.85	3.85
1972	2.45	3.55	4.89	6.29	7.15	7.19	7.59	7.89	8.16
1973	1.48	2.15	2.92	3.28	3.64	3.74	3.74	3.74	3.74
1974	1.57	1.58	1.71	1.84	1.93	2.13	2.27	2.28	2.28
1975	2.19	2.2	2.72	4.59	5.24	5.32	5.77	6.54	7.7
1976	1.54	1.55	1.71	2.98	4.53	5.31	5.81	5.83	5.83
1977	1.54	1.56	1.56	2.22	2.42	2.89	3.2	3.21	3.39
1978	1.94	2	2	2.08	2.32	2.41	2.82	2.84	2.84
1979	1.22	1.45	1.99	3.68	3.69	3.69	3.69	3.74	3.81
1980	1.02	1.02	1.13	1.5	1.61	1.61	1.61	1.61	1.93
1981	0.76	1.06	1.36	1.59	1.59	1.62	1.73	1.75	2.2
1982	1.2	1.2	1.35	1.69	1.8	1.86	1.87	2.52	2.75
1983	1.55	1.94	2.31	2.44	2.44	2.44	2.44	2.44	3.04
1984	0.94	1.17	1.57	1.71	1.84	2.36	2.53	2.54	2.54
1985	1.83	2	2.59	3.82	3.96	3.96	3.96	3.96	3.96
1986	1.27	1.4	1.51	2.25	2.33	2.36	2.36	2.36	2.36
1987	1.73	1.73	1.73	1.82	2.13	2.57	2.65	2.66	2.66
1988	1.33	1.33	1.33	1.53	1.79	1.79	2.38	2.38	2.51
1989	1.54	1.61	1.62	1.79	2.16	2.24	2.58	2.71	3.35
1990	1.44	1.86	2.13	2.19	2.19	2.19	2.44	2.44	2.44
1991	0.97	1	1	1.37	1.56	1.59	1.67	1.68	2.61
1992	1.08	1.08	1.2	1.62	1.83	1.84	2.25	2.31	2.42
1993	1.66	1.9	2.23	3.82	4.03	4.03	4.03	4.03	4.03

Year	Duration								
	1 hr	2 hr	4 hr	12 hr	18 hr	24 hr	36 hr	48 hr	72 hr
1994	1.21	1.24	1.29	1.5	1.85	2.61	2.83	3.4	3.68
1995	1.39	1.51	2.15	2.96	3.35	3.36	3.36	3.36	3.36
1996	1.47	1.53	2.08	2.55	2.57	2.57	2.57	2.57	3.37
1997	1.32	1.5	1.79	2.54	2.71	2.72	2.72	2.72	3.4
1998	0.82	0.88	1.12	1.63	1.88	2.21	2.37	2.37	2.69
1999	2	2.02	2.03	3.6	3.89	4.14	4.57	4.57	4.57
2000	1.64	1.65	1.65	1.67	1.85	2.06	2.14	2.14	2.35
2001	1.03	1.05	1.09	1.64	1.64	1.77	1.84	1.84	2.02
2002	1.71	1.78	1.82	1.92	1.93	2.02	2.04	2.36	2.36
2003	1.45	1.6	1.73	2.45	2.45	2.58	2.61	2.74	3.13
2004	2.11	2.19	2.35	2.46	2.46	2.49	3.25	3.27	3.52
2005	1.16	1.44	1.72	3.51	4.74	6.02	7.28	7.32	7.34
2006	3.34	3.9	5.89	6.33	6.75	8.48	8.97	9.72	10.48
2007	1.24	1.29	1.35	2.62	3.77	4	4	4.07	5.96
2008	1.87	2.23	2.92	3.5	3.85	3.9	3.95	3.95	6
2009	1.03	1.09	1.43	1.66	1.67	1.84	2.14	2.5	2.59

Using the measured rainfall data from Washington National (Reagan) Airport from 1948 to 2009, the annual maximum depths of rainfall were obtained for varying storm durations and for each year of record. Several probability distributions were fitted with data that included Gamma, Extreme Value and Log-gamma. The data for each duration were fitted to a log-gamma distribution that most accurately modeled the trend of the collected data. The gamma distribution density function is given by:

$$f(P) = \frac{P^{c-1} e^{-P/b}}{b^c \Gamma(c)} \qquad (1)$$

where P is the depth of rainfall (in.), b is the gamma scale parameter, and c is the gamma shape parameter. Before fitting the distribution, the logarithms of the data were taken and used to fit the b and c parameters. In order to calculate predicted values, the Weibull function was used as the exceedence probability:

$$Weibull = \frac{rank}{n+1} \qquad (2)$$

where n is the number of data points, which is 62 in this case, and the Weibull probability is a fraction. The annual maximum depths were ordered and the rank of each was used to compute the exceedence probability of each depth. To find this probability, the Weibull percentage was set equal to the integral of the log-gamma density function, as shown below:

$$F(P) = \int_0^P f(P)dP \qquad (3)$$

where F(P) is the cumulative Weibull probability. For instance, using a cumulative Weibull percentage of 99% will solve for the one percent exceedence probability, which is the 100-year storm event.

What was done for this data was to solve for log-gamma distributions for each storm duration that provided the best fit the annual maximum depths. The scale and shape parameters were determined for each rainfall duration, and predicted values were compared to the measured data. The individual frequency curves do not overlap and have realistic values, which indicates the model reasonably estimates the measured rainfall data. Table 1 shows the predicted depths for each return period and duration.

Table 2: Predicted Depths for Each Return Period and Duration

Duration (hours)	**Depth (inches) for Each Return Period (Years)**						
	2	**5**	**10**	**25**	**50**	**100**	**200**
1	1.464	2.053	2.500	3.130	3.645	4.189	4.748
2	1.631	2.289	2.785	3.481	4.048	4.645	5.259
4	1.882	2.663	3.258	4.100	4.788	5.525	6.298
12	2.467	3.459	4.203	5.240	6.083	6.982	7.936
18	2.698	3.798	4.629	5.794	6.741	7.756	8.835
24	2.878	4.110	5.049	6.373	7.454	8.610	9.825
36	3.013	4.301	5.275	6.639	7.748	8.927	10.158
48	3.111	4.472	5.504	6.951	8.126	9.368	10.647
72	3.419	4.922	6.057	7.645	8.927	10.277	11.659

The Log-gamma distribution better represent the Washington metropolitan Region.

Acknowledgement

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Monitoring of Glyphosate and its Degradation of Residue by Phosphorus-31 Nuclear Magnetic Resonance Spectroscopy

Basic Information

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Principal Investigators:	Xueqing Song

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UNIVERSITY OF THE DISTRICT OF COLUMBIA
COLLEGE OF AGRICULTURE, URBAN SUSTAINABILITY AND ENVIRONMENTAL SCIENCES

Monitoring of Glyphosate and its Degradation Residue by Phosphorus-31 Nuclear Magnetic Resonance Spectroscopy

Final Report

Submitted to the

DISTRICT OF COLUMBIA WATER RESOURCES RESEARCH INSTITUTE

By:

Dr. Xueging Song
Assistant Professor, Department of Chemistry and Physics
University of the District of Columbia

May 2012

Monitoring of Glyphosate and its degradation residue by phosphorus-31 nuclear magnetic resonance spectroscopy

Abstract:

Glyphosate [N-(phosphonomethyl) glycine] is an extensively used post-emergence nonselective organophosphorus (OP) herbicide, used for the control of a wide variety of weeds. Due to its strong retention on soil components, high solubility in water and long half-life in the environment (about 47 days), glyphosate may still be detected long after application or even far from the site of application. However, because its effects on non-target organisms and overall environmental impact have not been fully investigated, questions should be addressed regarding the environmental safety, in light of its increasing use. The widespread application of glyphosate generates problems regarding environment contamination. Therefore, Knowledge about the persistency of glyphosate and its derivatives would be beneficial in the handling of contaminated dredged material, and it is essential to understand the speciation of these organophosphorous compounds to gain a better understanding of their interaction in soil and aquatic environment. Using ^{31}P NMR, rapid and reliable detection of organophosphorus compounds is achieved in this project. We successfully obtained ^{31}p NMR spectra for all 8 samples. There is no need of further treatment this samples such as derivatization or extraction. Preliminary data shows that the degradation starts in week 2 and the concentration of degradated species increased from week 2 to week 8. The glyphosate has very strong ability of binding to soil, and decomposed P species are released and dissolved in water.

Key words: Herbicide. Glyphosate . Phosphorous-31 . NMR spectroscopy . Soil . Degradation .

Objectives

Herbicides containing glyphosate undergo decomposition mainly by microorganisms. Monitoring this process requires an application of simple, quick and cheap instrumental methods. The objectives of this project are to develop analytical method able to provide rapid, sensitive, easy and reliable detection of glyphosate and its degradation residue using NMR spectroscopy and to monitor glyphosate and its residues in soil and water samples collected from DC metropolitan area by using phosphorous-31 NMR spectroscopy.

We propose to use ^{31}P NMR spectroscopy, in an effort to eliminate the need for pre- or post-column derivatization procedures to improve both the chromatographic behavior and the detection ability by gas chromatography (GC) or high-performance liquid chromatography (HPLC). The strength of NMR spectroscopy has been in characterization of the chemical structures, and in giving information about OP-compound degradation processes in the environment, as well as OP-compound metabolism in organisms. Because NMR is also a quantitative technique, it has been applied in quality control of the OP pesticides and other agrochemicals. Finally, NMR is nondestructive, meaning that the sample can be analyzed without consuming it during the

process as happens with GC–MS or LC–MS techniques, and the sample can be stored after analysis for later studies.

Objective I: to develop analytical method able to provide rapid, sensitive, easy and reliable detection of glyphosate and its degradation residue using ^{31}P NMR spectroscopy.

Objective II: to investigate the environment speciation of glysophate and its degradation residues that are leached from using plysophate and its derivatives into DC soils and waterways and to evaluate the interactions with the soils and river sediments.

Introduction

Organophosphorus (OP) compounds are derivatives of phosphorus that have at least one organic (alkyl or aryl) group attached to the phosphorus atom either directly or indirectly by means of another element (e.g. oxygen, sulfur or nitrogen). OP compounds are in many cases highly toxic, and some of these toxic OP compounds have importance as pesticides. Pesticide is a broad term, covering a range of products that are used to control pests: insect killers (insecticides), mould and fungi killers (fungicides), weedkillers (herbicides), slug pellets (molluscicides), plant growth regulators, bird and animal repellents, and rat and mouse killers (rodenticides).

Glyphosate [*N*-(phosphonomethyl)glycine; PMG] represents a broad spectrum, non-selective amino- phosphonate-type herbicide, which has been accepted worldwide as an environmentally friendly agent for agricultural application.[1-3] It is used worldwide in the form of an aqueous solution of isopropylamine (I.P.) salt under trade names such as Roundup®, Rodeo®, Glyfonox® and Glycel®. This herbicide exhibits low toxicity to animals, however its long term influence on non-target organisms and its overall environmental fate have not been fully evaluated. Therefore, the availability of reliable and sensitive methods for the determination of PMG and its metabolites, and/or products of degradation, still presents an important topic for contemporary environmental analytical chemistry.

Glyphosate is also one of the most toxic herbicides, with many species of wild plants being damaged or killed by applications of less than 10 micrograms per plant. Glyphosate can be more damaging to wild flora than many other herbicides, as aerial spraying with glyphosate can give average drifts of 1200 to 2500 feet and ground spraying with glyphosate may cause damage to sensitive plants up to 300 feet from the field sprayed. Glyphosate use is thought to affect hedgerow trees, causing die-back, and may reduce trees' winter hardiness and resistance to fungal disease. Of nine herbicides tested for their toxicity to soil microorganisms, glyphosate was found to be the second most toxic to a range of bacteria, fungi, actinomycetes and yeasts.

Herbicides containing glyphosate undergo decomposition mainly by microorganisms. Monitoring this process requires an application of simple, quick and cheap instrumental methods. The objectives of this project are to develop analytical method able to provide rapid, sensitive, easy and reliable detection of glyphosate and its

degradation residue using NMR spectroscopy and to monitor glyphosate and its residues in soil and water samples collected from DC metropolitan area by using phosphorous-31 NMR spectroscopy.

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Objective II: to investigate the environment speciation of glysophate and its degradation residues that are leached from using plysophate and its derivatives into DC soils and waterways and to evaluate the interactions with the soils and river sediments.

Methods, procedures and facilities:

^{31}P NMR spectroscopy:

A great variety of analytical methods have been applied for determination of glyphosate. Both gas chromatography (GC) and liquid chromatography (LC) are used with various detection systems. GC analysis is performed after a derivatization procedure that converts glyphosate to a sufficiently volatile and thermally stable derivative. In LC methods derivatization procedures, producing fluorescent derivatives, are often employed to enhance the sensitivity and selectivity of detection. In many cases derivatization procedures are quite complicated and require special equipment.

Glyphosate can be measured by gas chromatography, by pyrolysis GC or by gas chromatography/mass spectrometry after derivatization by perfluoroacetylation [4], but these methods are limited by the formation of products of degradation [5]. For biological fluids, the HPLC methods are the most widely used to determine glyphosate. Methods using UV detection are not sensitive but it can be improved by derivatization [6]. Other methods have been described such as capillary electrophoresis and ion exchange chromatography using an automatic aminoacid analyser [7-9]. Recently, a GC–MS method after derivatisation using trifluoroacetamide derivatives was presented by Hori et al. [10].

The strength of NMR spectroscopy has been in characterization of the chemical structures, and by that giving information about the OP compound degradation processes in the environment as well as the OP compound metabolism in organisms. Because NMR is also a quantitative technique, it has been applied in quality control of the OP pesticides and other agrochemical products. Finally, NMR is nondestructive, meaning that the sample can be analyzed without consuming it during the process like with GC–MS or LC–MS techniques, and the sample can be stored after the analysis for later studies.

^{31}P is a spin 1/2 nucleus with 100% natural abundance, and reasonably good natural receptivity, 391 times larger than ^{13}C. The chemical shift range covered by ^{31}P-containing compounds covers more than 700 ppm, from 500 to -200, with 85% H_3PO4 used as the reference at δ 0.0 ppm. The high sensitivity of ^{31}P NMR makes the technique a reliable analytical tool similar to 19F and ^{1}H NMR. [11-12]

One of the reasons for the popularity of 31P NMR spectroscopy is the relatively good sensitivity of phosphorus. [13] Phosphorus-31, a half-spin nucleus, exists on 100% natural abundance. Its receptivity is roughly 400 times higher compared to carbon-13 on 1.1% abundance. Furthermore, the chemical shift of phosphorus is very sensitive to its chemical environment, and offers a reliable way to identify the OP compounds even in complex mixtures. The chemical shift range of phosphorus is quite broad (ca. 2000 ppm), and background signals do not usually obscure the relevant OP compound peaks like in the ^{1}H NMR analyses. Because ^{31}P is the only naturally occurring P isotope (100% natural abundance), all P species within a sample can potentially be detected by NMR spectroscopy.

Soil Sample preparation:

The soil samples were collected from two different sites in DC metropolitan area. The detailed location is shown in Figure 1. The samples were used without any further treatment.

Figure 1. The location of the site for soil collection (38.944491,-77.064672) on UDC Van Ness campus.

Dry soil sample (20 g) was placed in bottles and known concentrations of glyphosate solutions and allocated amount of water were added to provide concentration level of 10 μg g^{-1} and total volume of 100 mL. The bottles were shaken manually for uniform mixing and kept for 1 week, 2 weeks, 4 weeks and 8 weeks. Two separated layers were obtained. The top layer was collected for direct ^{31}P NMR experiment. The bottom soil layer was separated by vacuum filtration and extracted with 50 mL of demineralized water by shaking in an end-over-end shaker for 12 h at 25 ^{o}C. The extracts were centrifuged for 15 min at 2,000 rpm and the supernatant was discarded. The extracts obtained were used for ^{31}P NMR analysis (Table 1).

Table 1. Soil samples and water samples for NMR experiments

	Glyphosate in water (w)	Glyphosate in soil(s)
1 week	Sample 1w	Sample 1s
2 weeks	Sample 2w	Sample 2s
4 weeks	Sample 4w	Sample 4s
8 weeks	Sample 8w	Sample 8s

NMR experiments and Instrumentation:

D_2O and internal standard: tetramethyl silane (TMS), were purchased from Sigma–Aldrich. Glyphosate (Roundup) herbicide (Fig 2) was purchased at HomeDepot Gaithersburg store, Gaithersburg MD 20878.

Four hundred megahertz 1H NMR spectra were recorded using a Bruker Avance 400 spectrometer. 128 scans of 64K data points were acquired with a spectral width of 4800Hz(12 ppm), acquisition time of 4.09s, recycle delay of 2s and flip angle of 30◦.

Solvent suppression was achieved using the presaturation sequence. All NMR measurements were performed at ambient probe temperature (300K). Data processing was carried out with Topspin 3.1 program from Bruker.

The ^{31}PNMR measurements of soil samples were performed on an Avance 400 NMR spectrometer from Bruker operating at MHz. Five hundred microlitres of each sample was introduced into a 5 mm tube with a coaxial capillary tube containing TMS, providing an internal field-frequency lock and reference for proton chemical shifts (δ=0.00 ppm).

One-dimensional spectra were obtained with a presaturation sequence to suppress the water signal during the relaxation delay. For each sample, 128–512 transients were collected into 16K computer data points, with a spectral width of 3200 Hz and a 30° flip angle. Prior to Fourier transform, an exponential apodization function was applied to the signal, corresponding to a line broadening of 0.3 Hz. For comparison purpose, 1H and ^{31}P NMR spectra were also collected for the glyphosate solution in D_2O. ^{31}P NMR data were summarized in Table 2.

Table 2. ^{31}P NMR chemical shifts for water samples and soil samples

	^{31}P chemical shift for soil samples	^{31}P chemical shift for water samples
1 week	8.13 ppm	7.62 ppm(strong) 22.20ppm(weak)
2 weeks	7.85 ppm	7.66 ppm(strong) 12.25 ppm (weak)
4 weeks	9.43 ppm	2.54 ppm (weak) 7.54 ppm(strong) 12.67 ppm (weak)
8 weeks	10.50 ppm	1.62 ppm (weak) 2.48 ppm (strong) 7.49 ppm (medium) 9.31 ppm (medium) 12.37 ppm (weak) 12.79 ppm (weak)

Results and Discussion

Proton NMR of glyphosate was able to obtained using solvent suppression technique. The most significant siginal in the proton spectrum is a doublet that was observed at 2.88 ppm. It was assigned to the CH_2–(P) protons of the glyphosate molecule. The coupling constant value $^2J(^1H\text{-}^{31}P)$ 11.6Hz is characteristic of ^1H–^{31}P magnetic interaction. The CH_2–(N) group of glyphosate gave a singlet at 3.69 ppm. Another intense doublet observed at 1.18ppm ($^2J(^1H\text{-}^1H)$ 6.5Hz) was assigned to the methyl groups of isopropylamine (I.P.). In the spectrum obtained for glyphosate, the presence of

I.P. was also indicated by the heptalet at 3.37 ppm. However, no typical PCH_2, $N\text{-}CH_2$ and isopropyl amine signals were observed for soil samples spiked with glyphosate . This indicates that the $P\text{-}CH_2$ and $N\text{-}CH_2$ bonds have been decomposed.

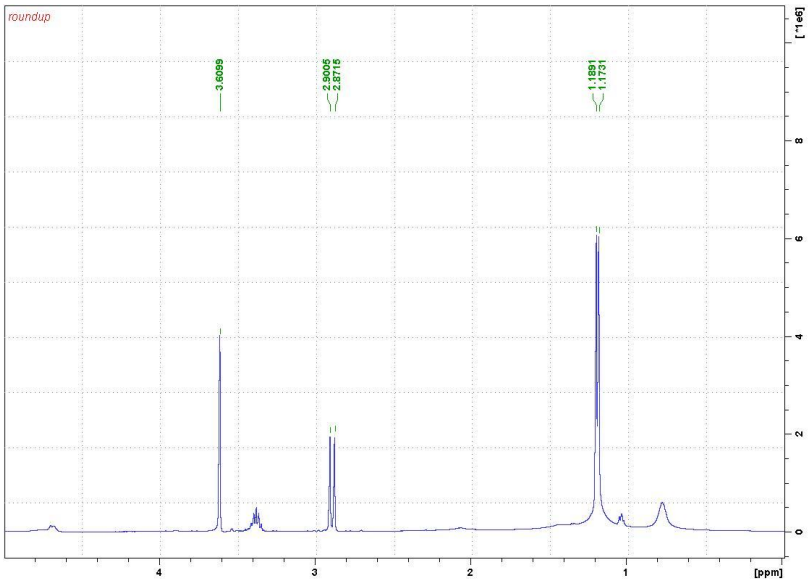


Figure 2. Proton NMR spectrum for glyphosate (1W) showing no typical signals for P-CH_2, N-CH_2 and isopropylamine group.

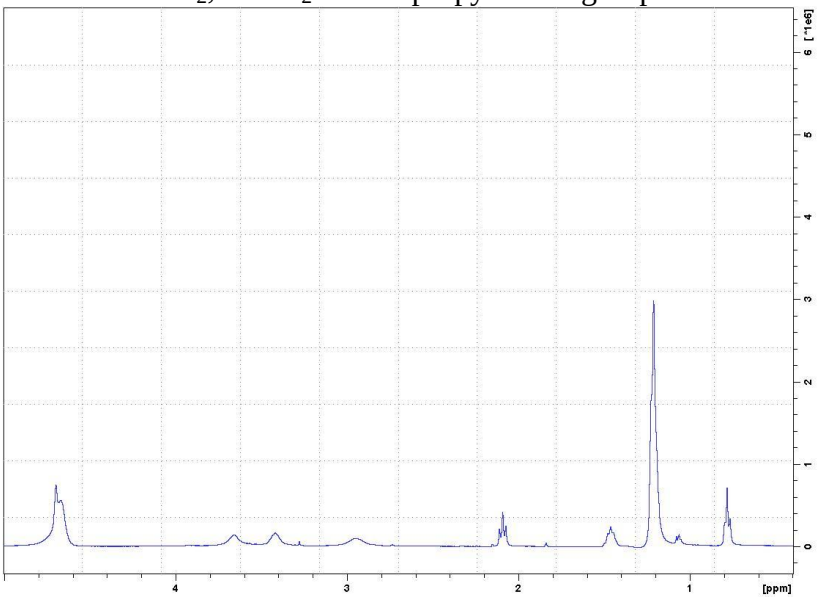


Figure 3. Proton NMR spectrum for Soil sample (showing typical signals for P-CH_2, N-CH_2 and isopropylamine group.

As shown in Figure 3, the primary environmental degradate of glyphosate in soil and water is aminomethylphosphonic acid (AMPA) through the C–N bond splitting of glyphosate. AMPA is further degraded to naturally-occurring substances such as carbon dioxide and phosphate. This means degradation of glyphosate is rapid in soil as well as in water. Glyphosate was degradated primarily by microbial metabolism in water and soil.

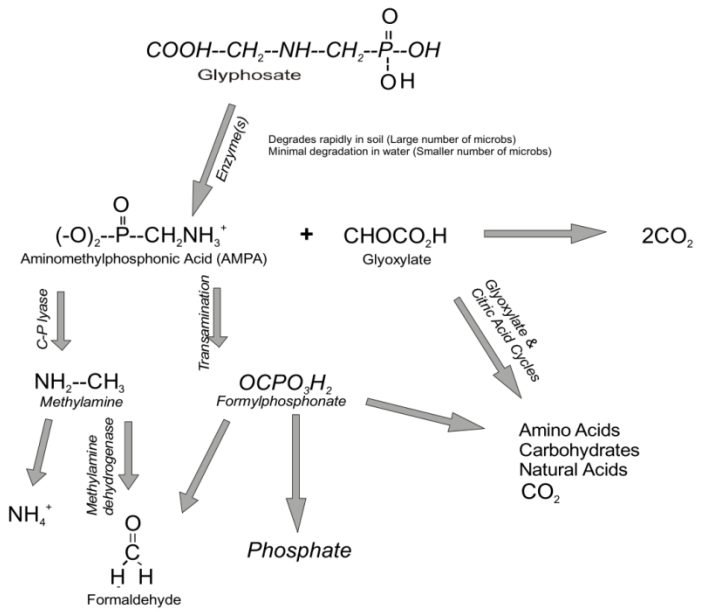


Figure 4. Glyphosate Degradation Pathway

The phosphorus NMR chemical shifts typical inorganic and organic phosphate are in the range -20ppm to +20 ppm as shown in figure 4. The P NMR chemical shift for fresh glyphosate is around 7.3 ppm clearly shown in figure 5. The typical triplet observed in the spectrum again is a sign of the existence of a P-CH_2.

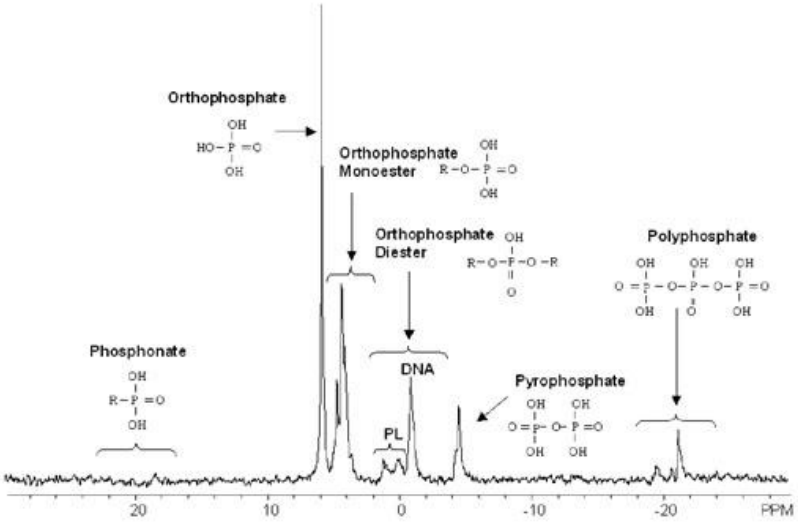
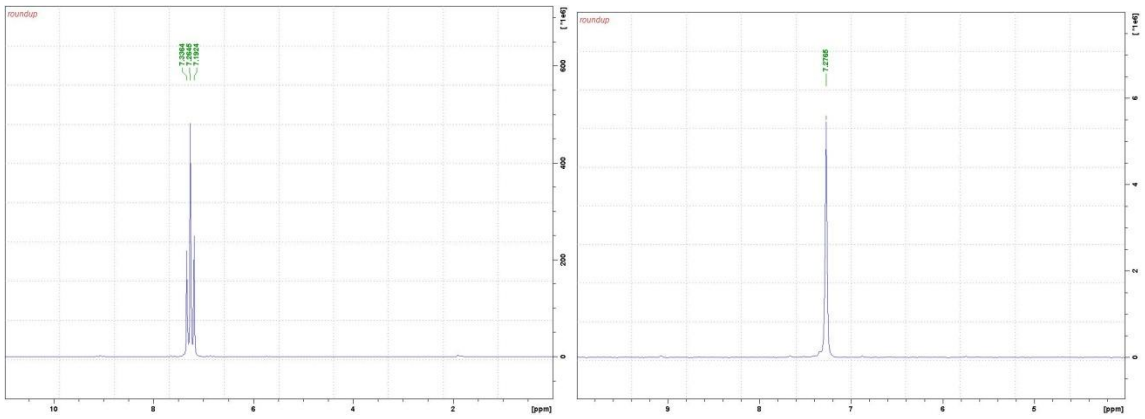


Figure 5. Typical phosphorous NMR for organic and inorganic phosphates



a **b**

Figure 6 (a) Phosphorous NMR for fresh glyphosate (triplets due to ^{31}Pcoupling with ^{13}C); (b) Phosphorous NMR for fresh glyphosate (decoupled with ^{13}C as a singlet)

The phosphorous concentration of soil sample extracts is very low, as over 10,000 scans need to be done to get a phosphorous signal. All of the four soil extracts shown a broad and weak signal in the range 7.6 ppm -10.7 ppm with very noisy baseline (Fig.6). This is a typical signal for glyphosate in water media. The Phosphorus species in all 4 soil samples (1S,2S, 4S and 8S) remained unchanged as glyphosate. This indicated that the degradation of glyphosate is very slow in soil. As we know Glyphosate is degraded primarily by microbial metabolism. Since the soil samples were collected as dry samples, the amount of microbial is very limited; the degradation is expected to be observed in longer time.

Also observed was the concentration of P in the soil extract was decreased as the spiking time increased. The phosphorous signal strength was decreased from sample 1W to 8W. As the spiking time changed from 1 week to 8 weeks, more glyphostate is decomposed to other phosphorous species. These species have less ability binding to soil and are released and dissolved in water. The only phosphorous species left in soil is glyphosate. This is in agreement with other researchers' observation: glyphosate has a very strong binding ability with soil.

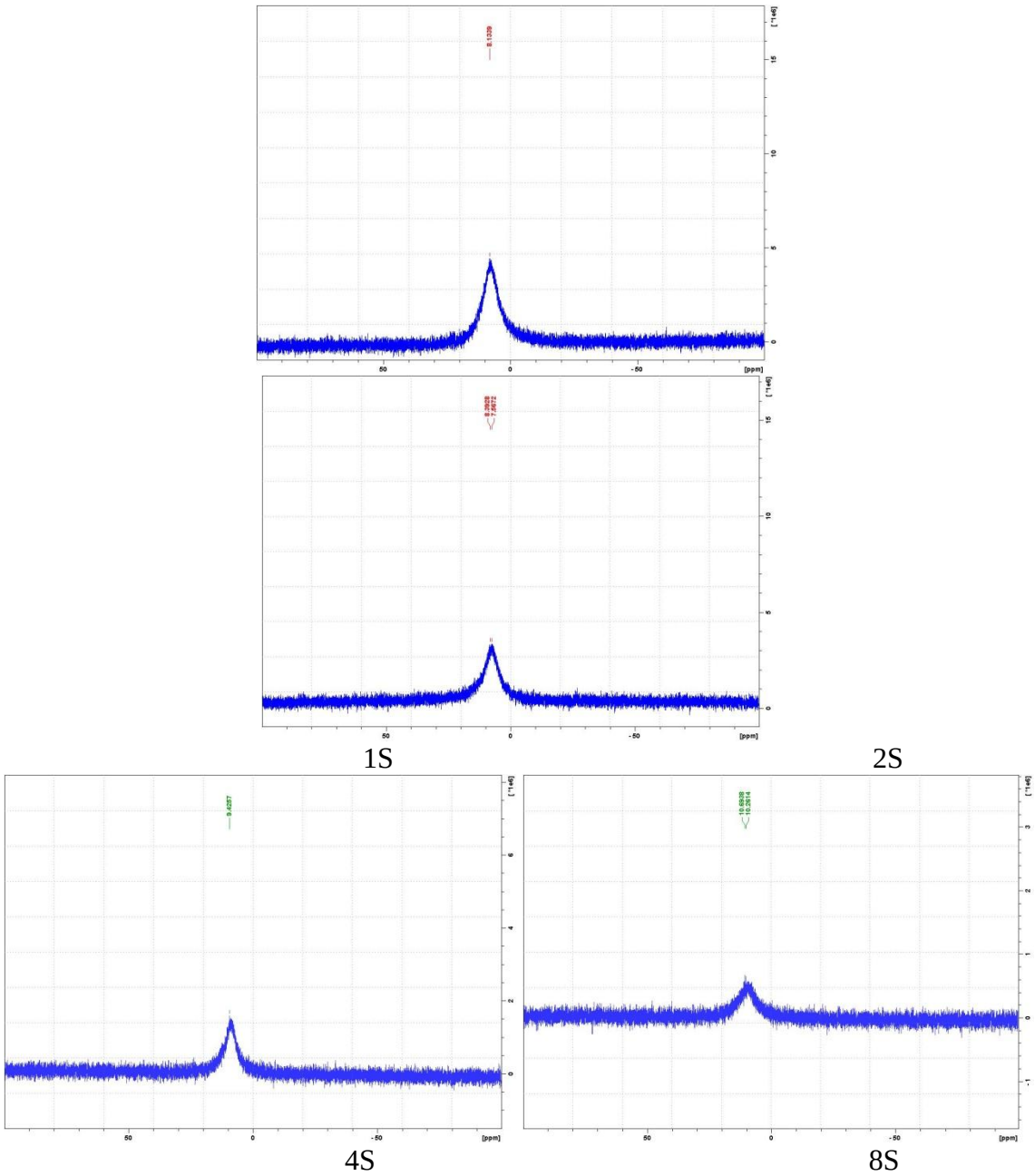


Figure 7. Phosphorous NMR spectra of soil extracts 1S, 2S, 4S and 8S.

Glyphosate binds very tightly to most soils and sediments in the environment. Studies show that the soil-binding potential of glyphosate is stronger than that of nearly any other herbicide. A ratio known as the "soil adsorption coefficient" (Koc) measures the soil-binding capacity of chemical compounds, with higher numbers meaning greater adsorption of the compound to soil. [14] This explains the low concentration of P content in soil extracts. Extended time is needed to get a P signal.

Active ingredient	K_{oc} (L/kg)
2,4-D esters	100
Atrazine	100
Alachlor	170
Metolachlor	200
Pendimethalin	5,000
Trifluralin	8,000
Glyphosate	24,000
Oxyfluorfen	100,000

While for water sample, a less noisy base line for the spectra is an indication the phosphorous concentration is comparatively higher than in the soil (Fig. 8). There are no significant concentration of other phosphorous species found in the water sample 1W, 2W and 3W other than glyphsoate, but a trend of an increased concentration of decomposed species was observed. The increase was clearly observed in the spectrum of 8W with very clear baseline and relatively high resolution of the P signals. Other than glyphosate shown in the spectrum as a minor signal around 7.5 ppm, several other phosphorous signals were also observed which clearly resulted from the decomposition of glyphosate.

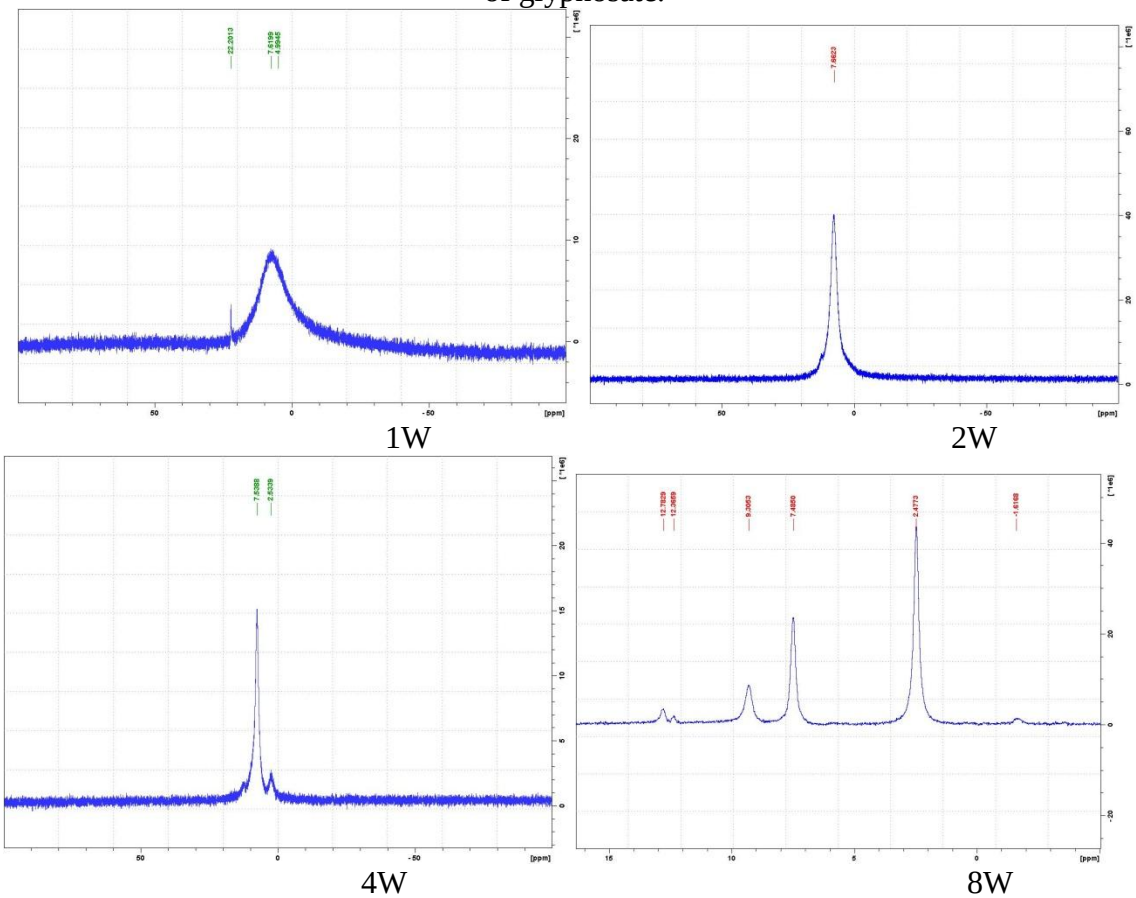


Figure 8. Phosphorous NMR spectra of soil extracts 1W, 2W, 4W and 8W.

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Urban Stormwater Runoff Prediction Using Computational Intelligence Methods

Basic Information

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UNIVERSITY OF THE DISTRICT OF COLUMBIA
COLLEGE OF AGRICULTURE, URBAN SUSTAINABILITY AND ENVIRONMENTAL SCIENCES

Urban Stormwater Runoff Prediction Using Computational Intelligence Methods

Final Report

Submitted to the

DISTRICT OF COLUMBIA WATER RESOURCES RESEARCH INSTITUTE

By:

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University of the District of Columbia
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May 2012

Table of Contents

Abstract

The objective of this project is to develop computational intelligence methods, including recurrent neural networks, particle swarm optimization, evolutional algorithm, and the combination of these methods for runoff quantity and quality prediction. We proposed an Elman style based recurrent neural network on the water quantity prediction. A hybrid learning algorithm incorporating particle swarm optimization and evolutional algorithm was presented, which takes the complementary advantages of the two global optimization algorithms. The neural networks model was trained by particle swarm optimization and evolutional algorithm to forecast the stormwater runoff discharge. The methodology was applied to renewable energy data collected from the Zero Energy House located at the University of the District of Columbia. The excellent experimental results demonstrated that the proposed method provides a suitable prediction tool for the stormwater runoff monitoring and solar radiation prediction. In addition, we proposed a predictive model based on recurrent neural networks trained with the Levenberg-Marquardt backpropagation learning algorithm to forecast the runoff discharge using the past runoff discharge, as well as the solar radiation prediction. This computational intelligence modeling tool not only explored the impact of discharge and gage height to the long-run discharge forecast accuracy, but also investigated the solar radiation prediction. Based on the excellent experimental results including the training, validation and testing errors, error autocorrelation function analysis, regression analysis, and time series response, it showed that the proposed learning algorithm proved to be successful in training the recurrent neural network for the runoff prediction.

1. Introduction

It has been recognized that urban stormwater pollution can be a large contributor to the water quality problems of many receiving waters. Depending upon the type of sewer system the stormwater runoff transports a wide spectrum of pollutants to local receiving waters through combined sewer overflows (CSOs) and/or stormwater discharges. Stormwater pollution is one of most important issues the District of Columbia faces. The downtown core of the District is serviced by combined sewer system. The development of the District over the years has increased its impervious area significantly which combines with inadequate

drainage capacity of the sewer system results in CSOs and stormwater discharges to the Anacostia River, Potomac River and Rock Creek.

To address this stormwater problem the DC Water (previously known as DC WASA) has developed a Long Term Control Plan (LTCP) which would cost several billion dollars. In order to support LTCP a continuous monitoring and modeling of the system is necessary not only to provide technical assessment but also to develop a cost-effective solution. Moreover, evaluations of runoff quantity and quality are necessary to assess the problem and to assess the performance of proposed best management practices.

Forecasting of runoff quantity and quality benefit substantially from the progress of computational intelligence techniques, particularly neural networks. Computational intelligence relies on heuristic algorithms such as in fuzzy systems, neural networks, and evolutionary computation [1]. In addition, it also embraces techniques that use swarm intelligence, chaos theory, artificial immune systems, and wavelets. Comparatively, various runoff forecast models based on neural networks perform much better in accuracy than many conventional prediction models [2]-[7]. However, a fact could not be neglected that most of such existing neural networks based models have not yet satisfied researchers and engineers in forecast precision so far, and the generalization capability of these networks needs further improving. For example, most publications used the feedforward neural networks with Backpropagation algorithms. However, a critical "drawback" of the Backpropagation algorithm is the local minima problem caused by neuron saturation in the hidden layer [8]. Because of this, the algorithm cannot converge to the minimum error, and thus it cannot get accurate prediction results.

To overcome the above challenges, it is extremely important to investigate new models with the potential for higher rates of prediction. According to the time series prediction competition results in the 2006, 2008, and 2010 Artificial Neural Network & Computational Intelligence Forecasting Competitions [9][10], recurrent neural networks, wavelet neural networks, particle swarm optimization methods, and fuzzy neural networks etc. have been widely recognized as the best models for time series prediction [11]-[28]. Because time series prediction is a generalized form of runoff quality prediction, we can expect these models will also work the best

for the specific runoff quality prediction.

However, these prospective methods have never been used for the runoff quantity and quality prediction problems. Therefore, we believe that it is imperative to investigate these state-of-the-art computational intelligence methods, or the combination of these methods on the application of runoff quality prediction. On the other hand, this effort can in turn promote the progress of computational intelligence technology. Moreover, the generalization capability of these methods can be further improved by applying them to other kinds of water quality prediction, such as water quality parameter prediction (i.e. total dissolved solids, electrical conductivity, turbidity, dissolved oxygen, plumbum, and water temperature etc.) [29][30], or to the assessment of class of water quality [31].

The proposed research is intended to fill this gap by seeking broader computational intelligence solutions to the modeling and simulation of the runoff quantity and solar radiation prediction. We will focus on the best models for time series prediction including recurrent neural networks, wavelet neural networks, particle swarm optimization, fuzzy neural networks, or the combination of these methods.

2. Research Objectives

The overall goal of the proposed study is to develop computational intelligence methods including recurrent neural networks, wavelet neural networks, particle swarm optimization, fuzzy neural networks, or the combination of these methods to forecast the runoff quantity and quality in the District of Columbia. Furthermore, the outcomes of this research will be used to write a proposal to federal and state agencies to obtain funding for the development of general-purpose advanced computational intelligence methods on the stormwater quantity data as well as energy data. The specific objectives of the research include:

- Thoroughly investigating the promising recurrent neural networks, wavelet neural networks, particle swarm optimization, fuzzy neural networks methods and their accuracy on time series prediction.
- Tailor the best models, or the combination of these models to runoff prediction problem.
- Test these computational intelligence methods using the real-time runoff data.

- Perform comparisons of the proposed methods with other conventional neural networks methods on runoff prediction.

3. Research Methodology

Forecast of runoff quantity and quality benefit substantially from the progress of computational intelligence techniques, particularly neural networks. Computational intelligence relies on heuristic algorithms such as in fuzzy systems, neural networks and evolutionary computation. In addition, it also embraces techniques that use swarm intelligence, chaos theory, artificial immune systems, and wavelets. Comparatively, various runoff forecast models based on neural networks perform much better in accuracy than many conventional prediction models. However, a fact could not be neglected that most of such existing neural networks based models have not yet satisfied researchers and engineers in forecast precision so far, and the generalization capability of these networks needs further improving. For example, most publications use the feedforward neural networks with Backpropagation algorithms. However, a critical "drawback" of the Backpropagation algorithm is the local minima problem caused by neuron saturation in the hidden layer. Because of this, the algorithm cannot converge to the minimum error, and thus it cannot get accurate prediction results.

To surmount this issue, some promising nonlinear methods, such as recurrent neural network, wavelet neural network, particle swarm optimization, fuzzy neural networks, or combinations of these methods should be investigated. These methods were recognized as the best methods for the time series prediction problem in the Artificial Neural Network & Computational Intelligence Forecasting Competitions in 2006, 2008, and 2010. However, they have never been used for the runoff quality prediction problems. Since time series prediction is a generalized form of runoff prediction, we believe that we will gain success by investigate the above state-of-the-art computational intelligence methods, or developing enhanced methods which combine these methods to carry out runoff prediction with more accurate forecasting. On the other hand, this can in turn promote the development of computational intelligence techniques.

The faculty trained the students on neural networks theory and applications,

tutorials and Matlab Neural Networks toolbox. The students also learned the tutorials about all kinds of computational intelligence models and learning algorithms. The PI and the students thoroughly investigated the recurrent neural networks, particle swarm optimization, evolutional algorithm, and the combination of these methods and their accuracy on time series prediction. We then applied the best computational intelligence methods to runoff prediction problem, which is a kind of time series prediction problem. Then the faculty and the students tested these computational intelligence methods using the real-time runoff data. We also performed comparisons of the proposed methods with other conventional neural networks methods on runoff prediction. Specifically, we first proposed an Elman style based recurrent neural network on the water quantity prediction. A hybrid learning algorithm incorporating particle swarm optimization and evolutional algorithm was presented, which takes the complementary advantages of the two global optimization algorithms. The neural networks model was trained by particle swarm optimization and evolutional algorithm to forecast the stormwater runoff discharge. The USGS real-time water data at Four Mile Run station at Alexandria, VA were used as time series input. The excellent experimental results demonstrated that the proposed method provides a suitable prediction tool for the stormwater runoff monitoring. Second, we proposed a predictive model based on recurrent neural networks trained with the Levenberg-Marquardt backpropagation learning algorithm to forecast the runoff discharge using the past runoff discharge. This computational intelligence modeling tool explored the impact of discharge and gage height to the long-run discharge forecast accuracy. Based on the excellent experimental results including the training, validation and testing errors, error autocorrelation function analysis, regression analysis, and time series response, it showed that the proposed learning algorithm proved to be successful in training the recurrent neural network for the runoff prediction and solar radiation prediction. In addition, we also applied the above methods to the solar radiation prediction application which is attached in Appendix.

In order to test the above methodology, the Real-time solar energy data and solar radiation data was collected from the Zero Energy Center located at the University of the District of Columbia campus. This station supported by the NSF funding plays an extremely important role in recording real-time solar data and wind data in the District of Columbia. While the Renewable Resource Data Center at the National

Renewable Energy Laboratory (NREL) only provides solar data till year 2005, this station can provide solar data for the District of Columbia from Year 2006 till present.

The Zero Energy Center is capable of delivering 4.5KW nominal renewable energy power. It consists of a solar tracking photovoltaic (PV) array and a Whisper H80 wind turbine to monitor, and record solar radiation data and weather data.

4. Analysis & Results

4.1 Number of Hidden Neurons and Delays

Increasing the number of neurons and the number of delays requires more computation, and this has a tendency to overfit the data when the numbers are set too high, but it allows the network to solve more complicated problems. We continuously increase both the number of neurons in the hidden layer and the number of delays in the tapped delay lines until the network performed well in terms of the mean square error (MSE) and the error autocorrelation function. After several trials, the best number of hidden neurons is determined to be 40, and the best number of delays in the tapped delay lines is 3.

4.2 Mean Squared Error

The mean squared error is the mean squared normalized error performance function. The error is the difference between the output and the target.

Validation vectors are used to stop training early if the network performance on the validation vectors fails to improve or remains the same, as indicated by an increase in the mean square error of the validation samples. Test vectors are used as a further check that the network is generalizing well, but do not have any effect on training.
The best validation performance is 0.18874 at epoch 4 when the inputs are solar energy and solar radiation, as shown in Fig. 1. It demonstrates that training, validation and testing errors decreased to 1.81215e-1, 1.88740e-1, and 1.97490e-1, respectively until iteration 4. It does not appear that any overfitting has occurred, since neither testing or validation error increased before iteration 4.

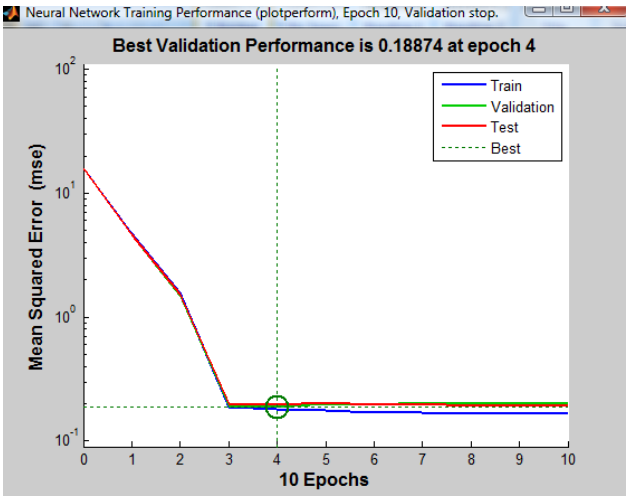

Fig. 1. The best validation performance is 0.18874 at epoch 4 when the inputs are solar energy and solar radiation.

4.3 Error Autocorrelation Function

The error autocorrelation function is used to validate the network performance. The error autocorrelation function is demonstrated in Fig. 2. It describes how the prediction errors are related in time. For a perfect prediction model, there should only be one nonzero value of the autocorrelation function, and it should occur at zero lag, i.e. this is the mean square error. This would mean that the prediction errors were completely uncorrelated with each other (white noise). If there was significant correlation in the prediction errors, then it should be possible to improve the prediction by increasing the number of delays in the tapped delay lines. In Fig. 2, the correlations, except for the one at zero lag, fall approximately within the 95% confidence limits around zero, so the model seems to be adequate.

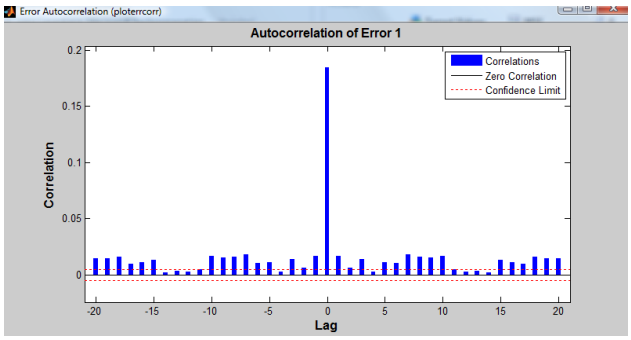

Fig. 2. Error autocorrelation function when the inputs are solar energy and solar radiation. It describes how the prediction errors are related in time.

4.4 Regression Analysis

The following regression plots as shown in Fig. 3 display the network outputs with respect to targets for training, validation, and test sets. The three axes represent the training, validation and testing data. The dashed line in each axis represents the perfect result – outputs = targets. The solid line represents the best fit linear regression line between outputs and targets. The R value is an indication of the relationship between the outputs and targets. If R=1, this indicates that there is an exact linear relationship between outputs and targets. If R is close to zero, then there is no linear relationship between outputs and targets.

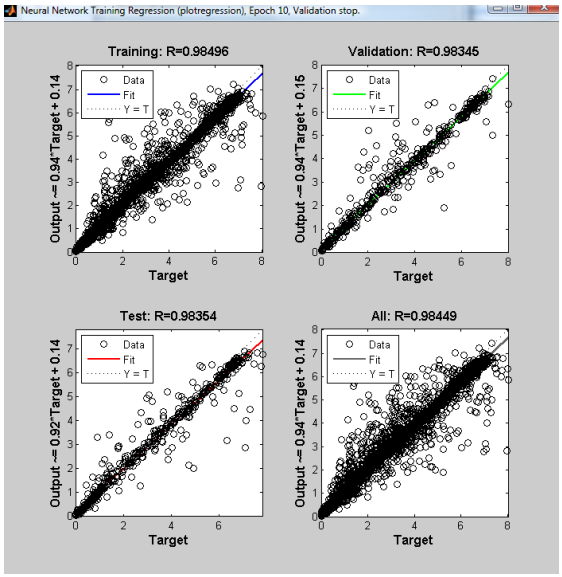

Fig. 3. Regression analysis of the network outputs with respect to targets for training, validation, and test sets.

For a perfect fit, the data should fall along a 45 degree line, where the network outputs are equal to the targets. For this problem, the fit is reasonably good for all data sets, with the overall R values as high as 0.98449.

4.5 Time Series Response

Fig. 4 shows the time series response when the solar energy and previous solar radiation are the inputs, and the solar radiation is the target. The top plot displays the outputs and targets versus time. For each selected time point for training, testing and validation, all the training targets, training outputs, validation targets, validation outputs, test targets, and test outputs are plotted. The bottom plot shows the error versus time. At those selected time point for training, testing and validation, the errors for training target, validation target, and test target are plotted. The solid line is used to measure the magnitude of errors.

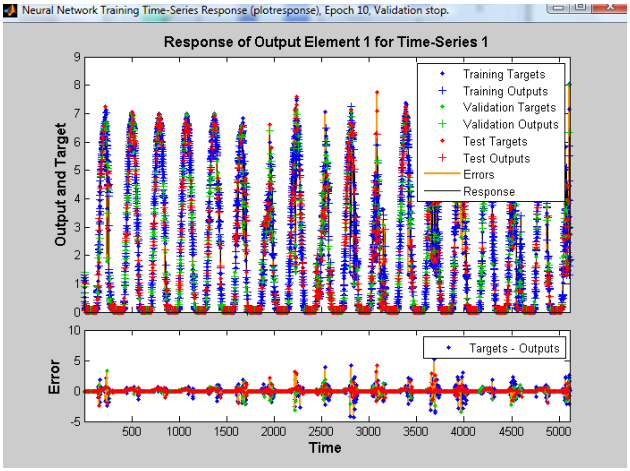

Fig. 4. The time series response when the solar energy and previous solar radiation are the inputs.

5. Research Outcome

The following research paper was published and presented, whose results are from this project (Attached in Appendix A).

Nian Zhang and Pradeep Behera, "Solar Radiation Prediction Based on Recurrent Neural Networks Trained by Levenberg-Marquardt Backpropagation Learning Algorithm," The Third IEEE PES Conference on Innovative Smart Grid Technologies (ISGT 2012), Washington, D. C., January 16-20, 2012.

6. Acknowledgement

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8. Appendix A

SOLAR RADIATION PREDICTION BASED ON RECURRENT NEURAL NETWORKS TRAINED BY LEVENBERG-MARQUARDT BACKPROPAGATION LEARNING ALGORITHM

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ABSTRACT
In response to the growing concern over the use of fossil fuels, renewable energy industries have been significant economic drivers in many parts of the United States. In the recent years there is a strong growth in solar power generation industries that requires prediction of solar energy to develop highly efficient stand-alone photovoltaic systems as well as hybrid power systems. In order to accomplish the goal, we propose a predictive model that is based on recurrent neural networks trained with the Levenberg-Marquardt backpropagation learning algorithm to forecast the solar radiation using the past solar radiation and solar energy. This computational intelligence modeling tool explored the impact of solar radiation and solar energy in forecasting reliable long-run solar energy . Based on the excellent experimental results including the mean squared error analysis, error autocorrelation function analysis, regression analysis, and time series response, it demonstrated that the proposed neural network structure and the learning algorithm could be very useful in training the recurrent neural network for the solar radiation prediction.

KEY WORDS
Solar radiation prediction, time series prediction, neural networks, backpropagation learning algorithm.

1. Introduction

Global demand for energy is increasing at a breathtaking rate, requiring significant investment in new power generation capacity and grid infrastructure. Depending on the efficiency measures implemented, by 2030 world energy needs are predicated to be between 30 and 60% higher than current levels. To meet the energy demand the International Energy Agency (IEA) has estimated the new energy capacity needs of approximately 4,800 GW before 2030, which requires an investment of almost US$ 4 trillion [1].

The global conventional energy supply is based on fossil fuel – oil, coal and natural gas. However, these energy sources are not renewable and the world's reserve of oil is dwindling and commodity prices are at their most volatile. The current rate of crude oil consumption is not sustainable. It is expected that most oil reserves will be depleted between 2040 and 2060 [2].

The burning of fossil fuels produces around 21.3 billion tons of carbon dioxide per year [3], which is twice the amount that can be absorbed by natural processes causing global warming. Global warming may cause several major adverse effects such as desertification, ocean acidification, a rise in sea levels, and the increasing occurrence of highly destructive weather-related extreme events. The burning of fossil fuels also emits carbon monoxide, sulfur dioxide and lead, which pollute the air, contaminate water and soil, and create unhealthy environment for humans. The adverse effects of fossil fuels are becoming increasingly socially unacceptable, economically unaffordable, and environmentally unsustainable

In response to the growing concern over the use of fossil fuels, renewable energy industries are becoming significant economic drivers in many parts of US. A newly released report [4] from the American Solar Energy Society (ASES) provided the following conclusions: a) Renewable energy and energy efficiency (RE&EE) in the US provided 8.5 million jobs and created a revenue of $972 billion in 2006, and more than 9 million jobs and $1,045 billion in revenue in 2007; b) The RE&EE industries grew more than three times as fast as the U.S. economy in 2007; and c) In terms of revenue growth, the hottest RE&EE sectors are solar thermal, solar photovoltaics, biofuels, fuel cells, and green building. The ASES report also includes three forecast scenarios for growth in the RE&EE industries in the US. By 2030, the base, moderate and advance scenarios forecast more than 16 million jobs and $1,966 billion in revenue, 19.5 million jobs and $2,248 billion in revenue, and 37 million jobs and $4,294 billion in annual revenue, respectively.

Due to strong increase of solar power generation, the predictions of solar energy are critical in terms of importance. Photovoltaic and solar thermal are the main sources of electricity generation from solar energy. The accurate predictions of the solar radiation evolution enable efficient sizing and improved performance of stand-alone photovoltaic systems [5], and of hybrid power systems [6][7].

Many research studies have been performed to forecast the solar radiation in recent years. They benefit substantially from the progress of computational intelligence techniques [8]. The techniques include wavelet neural network [9][10], support vector machine [11], recurrent neural network [12], echo state network [13], adaptive neural fuzzy inference systems (ANFIS) [14], and radial basis function (RBF) neural network [15], and other kinds of neural networks [16][17][18][19]. In comparison with the conventional statistical approach [20], neural networks based forecast models perform much better in terms of forecast accuracy. However, a fact could not be neglected that most of the existing computational intelligence based models have not yet satisfied researchers in forecast precision, and the generalization capability of these networks needs further improving. In addition, none of the above computational intelligence methods is used for the solar radiation prediction in the District of Columbia and the suburbs.

To resolve the above problems, it is extremely important to investigate state-of-the-art computational intelligence techniques that have potential for improving the forecasting of solar radiation. Based on the fact that neural networks [21], genetic regulatory network [22], echo state network [23], particle swarm optimization [24][25], and other computational intelligence methods [26][27] have very successfully applications on the time series prediction problems, and because time series prediction is a generalized form of solar radiation prediction, we expect these methods will also work the best for the solar radiation prediction problem.

This paper is organized as follows. In Section 2, the background of the Zero Energy Center located at the University of the District of Columbia campus Washington DC. is presented. The solar radiation and solar energy data from the center are presented. In Section 3, the neural network structure and the recurrent neural network based learning algorithm for solar radiation prediction is presented. In Section 4, experimental results including the best number of neurons and delays, mean squared error, error autocorrelation function, regression analysis, and time series response are demonstrated. In Section 5, the summary and conclusions are provided.

2. Background

2.1 Zero Energy Center at University of the District of Columbia, Washington D. C.

Real-time solar energy data and solar radiation data are obtained from the Zero Energy Center located at the University of the District of Columbia campus . This station supported by the NSF funding plays an extremely important role in recording real-time solar data and wind data in the District of Columbia. While the Renewable Resource Data Center at the National Renewable Energy Laboratory (NREL) only provides solar data till year 2005, this station can provide solar data for the District of Columbia from Year 2006 till present.

The Zero Energy Center is capable of delivering 4.5KW nominal renewable energy power. It consists of a solar tracking photovoltaic (PV) array and a Whisper H80 wind turbine to monitor, and record solar radiation data and weather data, as shown in Fig. 1. The Solar Panel array with Solar Tracker is shown in Fig. 2.

Fig. 1. Zero Energy House

Fig. 2. Solar Panel Array

2.2 Solar Radiation Data

The solar energy data and the solar radiation data were retrieved from the Zero Energy Center between June 27, 2011 and July 15, 2011. The solar energy data is plotted in Fig. 3. The solar radiation data is plotted in Fig. 4.

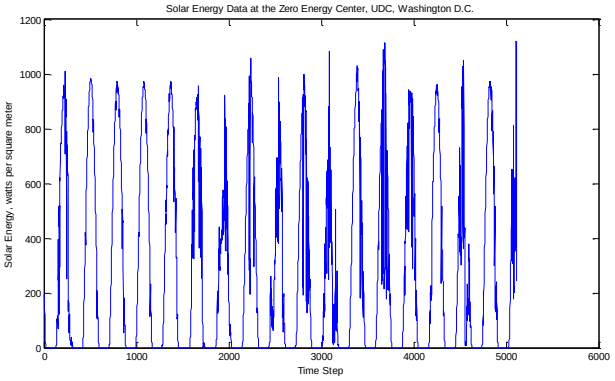


Fig. 3. The solar energy data collected at the Zero Energy Center at the University of the District of Columbia at Washington D. C. between June 27, 2011 and July 15, 2011.

Fig. 4. The solar radiation data collected at the Zero Energy Center at the University of the District of Columbia at Washington D. C. between June 27, 2011 and July 15, 2011.

Real-time data typically are recorded at 5-minute intervals, and each figure plots 5114 data. Two inputs, solar energy and previous solar radiation data each has a 5114x1 matrix, representing dynamic data, i.e. 5114 time steps of 1 element. The target, solar radiation is of the same length as the inputs, which represents 5114 time steps of 1 element dynamic data.

The entire data set was randomly divided up the 5114 time steps and 70% of the data (i.e. 3580 time steps) is used for training. They are presented to the network during training, and the network is adjusted according to its error. 15% (i.e. 767 time steps) will be used as validation data, which is used to validate if the network is generalizing and thus stop training before overfitting. The last 15% (i.e. 767 time steps) were used for testing, which have no effect on training, but provide a completely independent test of network generalization.

3. Recurrent Neural Network Based Learning Algorithm for Solar Radiation Prediction

3.1 Neural Network Architecture

A recurrent neural network based predictive models is to be developed to predict future values of solar radiation, based on the previous solar energy and solar radiation. The predictive model can be represented mathematically by predicting future values of the solar radiation time series y(t) from past values of that time series and past values of the solar energy time series x(t). This form of prediction can be written as follows:

$$y(t) = f(y(t-1),\ldots,y(t-d),x(t-1),\ldots,x(t-d))$$

The proposed neural network model is a two-layer feedforward network, with a sigmoid transfer function in the hidden layer and a linear transfer function in the output layer, as shown in Fig. 5. W is the weight matrix, and b is the bias. This network also uses tapped delay lines to store previous values of x(t) and y(t) sequences.

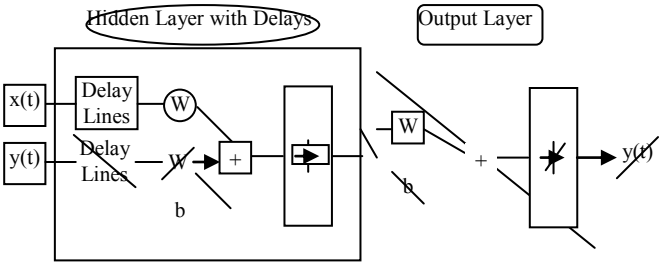
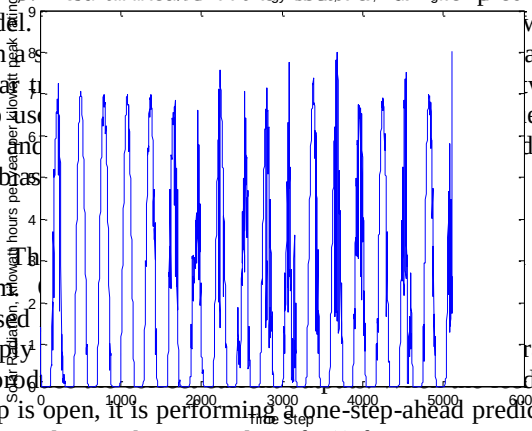


Fig. 5. Neural network architecture for the predictive model.



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loop than us to rain it dback

loop is open, it is performing a one-step-ahead prediction. It is predicting the next value of y(t) from previous values

e s l e

converted to closed loop form that the application requires.

3.2 Learning algorithm

The neural network is trained using Levenberg-Marquardt backpropagation algorithm. It is a network training function that updates weight and bias values according to Levenberg-Marquardt optimization. It is often the fastest backpropagation algorithm for training moderate-sized feedforward neural networks (up to several hundred weights), although it does require more memory than other algorithms.

Like the quasi-Newton methods, the Levenberg-Marquardt algorithm was designed to approach second-order training speed without having to compute the Hessian matrix. When the performance function has the form of a sum of squares (as is typical in training feedforward networks), then the Hessian matrix can be approximated as

$$H = J^T J$$

and the gradient can be computed as

$$g = J^T e$$

where **J** is the Jacobian matrix that contains first derivatives of the network errors with respect to the weights and biases, and **e** is a vector of network errors. The Jacobian matrix can be computed through a standard backpropagation technique that is much less complex than computing the Hessian matrix.

The Levenberg-Marquardt algorithm uses this approximation to the Hessian matrix in the following Newton-like update [28]:

$$x_{k+1} = x_k - [J^T J + \mu I]^{-1} J^T e$$

When the scalar μ is zero, this is just Newton's method, using the approximate Hessian matrix. When μ is large, this becomes gradient descent with a small step size. Newton's method is faster and more accurate near an error minimum, so the aim is to shift toward Newton's method as quickly as possible. Thus, μ is decreased after each successful step (reduction in performance function) and is increased only when a tentative step would increase the performance function. In this way, the performance function is always reduced at each iteration of the algorithm.

Training stops when any of these conditions occurs:

- The maximum number of epochs (repetitions) is reached.
- The maximum amount of time is exceeded.
- Performance is minimized to the goal.
- The performance gradient falls below the minimum gradient.
- μ exceeds the maximum mu.

Validation error failed to decrease for six iterations (validation stop).

4. Experimental Results

4.1 Number of Hidden Neurons and Delays

Increasing the number of neurons and the number of delays requires more computation, and this has a tendency to overfit the data when the numbers are set too high, but it allows the network to solve more complicated problems. We continuously increase both the number of neurons in the hidden layer and the number of delays in the tapped delay lines until the network performed well in terms of the mean square error (MSE) and the error autocorrelation function. After several trials, the best number of hidden neurons is determined to be 40, and the best number of delays in the tapped delay lines is 3.

4.2 Mean Squared Error

The mean squared error is the mean squared normalized error performance function. The error is the difference between the output and the target.

Validation vectors are used to stop training early if the network performance on the validation vectors fails to improve or remains the same, as indicated by an increase in the mean square error of the validation samples. Test vectors are used as a further check that the network is generalizing well, but do not have any effect on training.

The best validation performance is 0.18874 at epoch 4 when the inputs are solar energy and solar radiation, as shown in Fig. 6. It demonstrates that training, validation and testing errors decreased to 1.81215e-1, 1.88740e-1, and 1.97490e-1, respectively until iteration 4. It does not appear that any overfitting has occurred, since neither testing or validation error increased before iteration 4.

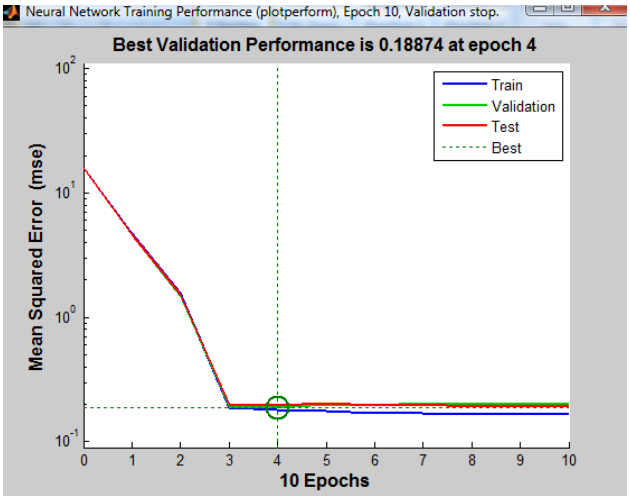

Fig. 6. The best validation performance is 0.18874 at epoch 4 when the inputs are solar energy and solar radiation.

4.3 Error Autocorrelation Function

The error autocorrelation function is used to validate the network performance. The error autocorrelation function is demonstrated in Fig. 7. It describes how the prediction errors are related in time. For a perfect prediction model, there should only be one nonzero value of the

autocorrelation function, and it should occur at zero lag, i.e. this is the mean square error. This would mean that the prediction errors were completely uncorrelated with each other (white noise). If there was significant correlation in the prediction errors, then it should be possible to improve the prediction by increasing the number of delays in the tapped delay lines. In Fig. 7, the correlations, except for the one at zero lag, fall approximately within the 95% confidence limits around zero, so the model seems to be adequate.

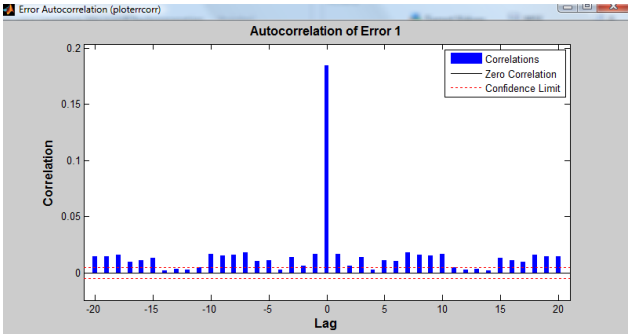

Fig. 7. Error autocorrelation function when the inputs are solar energy and solar radiation. It describes how the prediction errors are related in time.

4.4 Regression Analysis

The following regression plots as shown in Fig. 8 display the network outputs with respect to targets for training, validation, and test sets. The three axes represent the training, validation and testing data. The dashed line in each axis represents the perfect result – outputs = targets. The solid line represents the best fit linear regression line between outputs and targets. The R value is an indication of the relationship between the outputs and targets. If R=1, this indicates that there is an exact linear relationship between outputs and targets. If R is close to zero, then there is no linear relationship between outputs and targets.

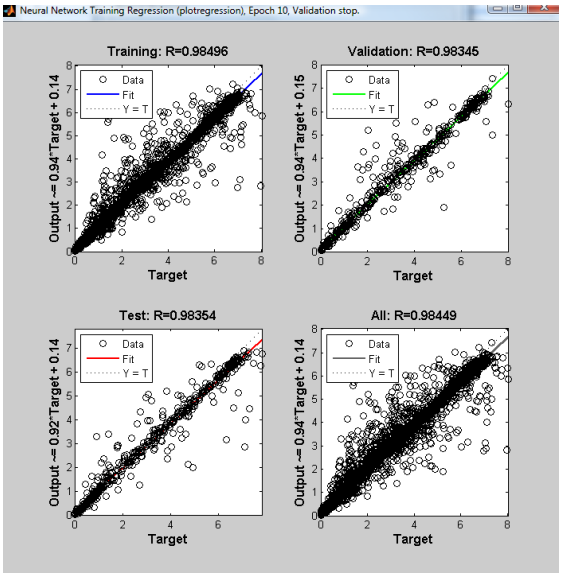

Fig. 8. Regression analysis of the network outputs with respect to targets for training, validation, and test sets.

For a perfect fit, the data should fall along a 45 degree line, where the network outputs are equal to the targets. For this problem, the fit is reasonably good for all data sets, with the overall R values as high as 0.98449.

4.5 Time Series Response

Fig. 9 shows the time series response when the solar energy and previous solar radiation are the inputs, and the solar radiation is the target. The top plot displays the outputs and targets versus time. For each selected time point for training, testing and validation, all the training targets, training outputs, validation targets, validation outputs, test targets, and test outputs are plotted. The bottom plot shows the error versus time. At those selected time point for training, testing and validation, the errors for training target, validation target, and test target are plotted. The solid line is used to measure the magnitude of errors.

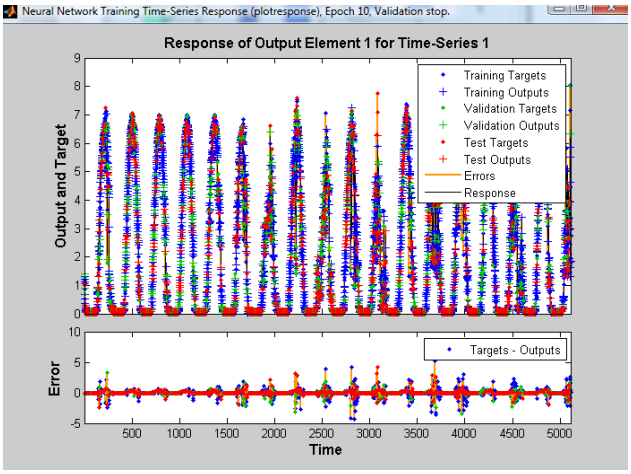

Fig. 9. The time series response when the solar energy and previous solar radiation are the inputs.

5. Conclusions

We proposed a predictive model based on recurrent neural networks trained with the Levenberg-Marquardt backpropagation learning algorithm to forecast the solar radiation using the solar energy and the past solar radiation. A two-layer feedforward network, with a sigmoid transfer function in the hidden layer and a linear transfer function in the output layer was developed. The best number of hidden neurons is 40, and the best number of delays in the tapped delay lines is 3.

Real-time solar energy data and solar radiation data obtained from the Zero Energy Center at the University of the District of Columbia, Washington DC. has been studied, which generally represents the metropolitan Washington DC area including Washington, DC and

Suburban Maryland and Virginia.

The input data used in their study are solar energy and solar radiation between June 27, 2011 and July 15, 2011. Based on the experimental results including the mean squared error analysis, error autocorrelation function analysis, regression analysis, and time series response, it showed that the proposed learning algorithm proved to be successful in training the recurrent neural network for the solar radiation prediction. The training, validation and testing errors are as low as 1.81215e-1, 1.88740e-1, and 1.97490e-1, respectively, which guarantee a high accuracy solar radiation prediction.

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Pollution Source Identification in Washington DC storm-water using Bayesian Chemical

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UNIVERSITY OF THE DISTRICT OF COLUMBIA
COLLEGE OF AGRICULTURE, URBAN SUSTAINABILITY AND ENVIRONMENTAL SCIENCES

Pollution Source Identification in Washington DC Stormwater using Bayesian Chemical Mass Balance Modeling

Progress Report

Submitted to the

DISTRICT OF COLUMBIA WATER RESOURCES RESEARCH INSTITUTE

By:

Arash Massoudieh, Ph.D.
Catholic University of America

Tolessa Deksissa, Ph.D.
University of the District of Columbia

Progress Report: Pollution Source Identification in Washington DC storm-water using Bayesian Chemical Mass Balance modeling

Arash Massoudieh, Tolessa Deksissa

1 Executive Summary

To prioritize the reduction of pollutions and nutrients in the stormwater and also in order to determine the most effective approaches in the reduction of the pollutants entering streams as a result of stormwater discharge, it is important to identify the major contributors of specific pollutants in the stormwater. Particularly in highly urbanized areas this is an important and at the same time a challenging task due to the large number of potential contributors to stormwater pollution. The goal of the proposed research is to identify the source major pollutants and nutrients at a highly urbanized area at the vicinity of the Anacostia River in North East Washington DC. This is to test/demonstrate the ability of the method in finding the sources of contaminants with an acceptable confidence. For this purpose, an innovative method herein referred to as Bayesian Chemical Mass Balance modeling will be used. This method uses the elemental profiles of potential sources as well as the stormwater runoff samples to infer the contribution of each sources. Traffic and non-traffic related sources (e.g. street dust, wet deposition, and roof runoff) are identified and multiple samples of each is collected and analyzed for their elemental profiles. The elemental profiles of the source samples and the discharged water will be analyzed using mass spectrometry technique. Then, the Bayesian CMB method (Massoudieh et. al, in review) will be utilized to infer the contribution of various sources into the stormwater runoff. We have already submitted proposals to EPA or NSF proposing to apply the method at a larger scale by applying it to a larger number of discharge points in the city of Washington to the stormwater being released into the Anacostia and Potomac rivers.

2 Introduction

Receptor modeling has been widely used for source apportionment of air pollutants (Miller, Hidy et al. 1972; Friedlander 1973; Gordon 1988). Although they have been also used in some disciplines related to water resources, including surface water (Su, Christensen et al. 1998; Kelley and Nater 2000), groundwater (Olmez and Hayes 1990), wastewater (Soonthornnonda and Christensen 2008) and sediments source apportionment (Collins and Walling 2002; Collins and Walling 2004), the use of such models in studies of water pollution is still in its infancy (Kelley and Nater 2000; Su, Li et al. 2010). One of the main reasons for the rare use of receptor models in apportioning water pollutants is that diffuse sources often play an important role and source signatures can change during the transport from source to receptor. However, it has been suggested that information from several receptor sites can be used to incorporate retardation and chemical transformation into multivariate receptor models (Grimvall and Stalnacke 1996).

One of the main assumptions in source apportionment is that the elemental composition of the phases being studied (e.g. particulate or aqueous phases) will not change during the transport as a result of mass exchange with the surrounding medium of reactions. This assumption holds in most cases for air pollutants as the mass exchange between the aerosols and the surrounding air media is very small. In aquatic systems however, there can be a significant mass exchange between the particulate phase and the aqueous phase for at least some of the elements. Furthermore, the facts that a) the particulate matter and dissolved chemicals can have different transport behaviors and b) the dissolved phase elements can undergo adsorption and desorption to the solid surfaces such as pavement or stormwater channel surface during their transport, makes the use of receptor modeling in stormwater source apportionment more challenging.

Furthermore, there are uncertainties in the estimated pollutant source contributions due to the uncertainties in measured concentrations of sources, and runoff caused by both measurement errors and spatial and temporal heterogeneities. Thus, it is important to determine the reliability of the outcomes of such models by evaluating the confidence intervals of the estimated source contributions. Bayesian approach has been used in conjunction with various receptor modeling techniques including CMB (Billheimer 2001; Fox and Papanicolaou 2008) and positive factor analysis (Park, Oh et al. 2000). In none of the works done in the past, however, the impact of the non-persistence of the elemental compositions of the sources have been evaluated or have been incorporated into the Bayesian approach. The method proposed in this research can identify the impact of solid-water mass exchange on the elemental fraction of different elements used for receptor modeling. Using the Bayesian approach, the variabilities of the fraction of each element will be implicitly incorporated as a weighting factor into the receptor modeling. The outcome of this study will also reveal which elements comprise the most useful signature for pollutant sources.

The dry weather accumulation of pollutants is spatially variable due to the different nature of various sources of pollutants and different behavior of different types of land surfaces. For example, the wet and dry atmospheric deposition can be to a large extent considered uniform over a small watershed. On the other hand, the traffic related pollutants are highly heterogeneous even over small scales. This variability can have a highly important implication when designing BMPs or water quality control strategies. Stormwater model calibration often times cannot reveal the spatial variability of the buildup model parameters, due to the fact that when incorporating different accumulation rates into the model, they become over parameterized and obtaining a unique parameter set to represent the observed concentrations becomes impossible. Therefore, it is especially useful to link the accumulation rates of pollutants with the sources generating them, and consequently, linking the accumulation of pollutants from various sources to land use/climate and anthropogenic factors, such as population density and traffic. This research is an attempt to enhance the stormwater quality models by separately incorporating the dynamics of pollutants from various sources into them.

3 Methods

3.1 Bayesian Chemical Mass Balance Receptor Modeling

The chemical mass balance method used in this study is based on Massoudieh et al., (under review). The method is briefly described here. The mass balance method can be written in Matrix form as:

$$\mathbf{C} = \mathbf{YX} \tag{1}$$

where $\mathbf{C} = [c_i]_{m\times 1}$ is a vector representing the true elemental composition of the fluvial sample normalized by the sum of the measured elemental concentration recipient elemental profile vector henceforth referred to as the fluvial sample elemental composition vector. $\mathbf{Y} = \left[y_{ij} \right]_{m\times n}$ is the *true* source elemental composition matrix, each of its columns representing the normalized elemental composition of sources by the sum of the measured elements' concentrations in each source. $\mathbf{X} = \left[x_j \right]_{n\times 1}$ is the source contribution vector, containing the true values of fractional contributions of each source into the fluvial sample, *m* is the number of elements measured and *n* is the number of sources considered. Since X is defined as the fractional contribution of sources the sum of its elements should be unity:

$$\sum_{j=1}^{n} x_j = 1 \tag{2}$$

It should be noted that due to measurement errors and heterogeneities in the elemental composition of both the fluvial and source samples, one can never know the exact values of the true fluvial sample elemental composition vector, $\mathbf{C}$, and the true source elemental composition matrix $\mathbf{Y}$ and therefore one can never know the true source contribution vector $\mathbf{X}$. The goal here is to infer the posterior probability distribution of $\mathbf{X}$ based on observed elemental compositions of sources and fluvial samples henceforth referred to as $\tilde{\mathbf{Y}}$ and $\tilde{\mathbf{C}}$ using Bayesian inference. Considering that the prior distributions of $\mathbf{X}$ and $\mathbf{Y}$ are independent, based on Bayes' theorem the posterior distribution of $\mathbf{X}$ and, given the observed source and fluvial sample elemental composition can be expressed as:

$$p(\mathbf{Y},\mathbf{X}\,|\,\tilde{\mathbf{C}},\tilde{\mathbf{Y}}) \propto p(\tilde{\mathbf{C}}\,|\,\mathbf{Y},\mathbf{X}) \cdot p(\tilde{\mathbf{Y}}\,|\,\mathbf{Y})\, p(\mathbf{Y})\, p(\mathbf{X}) \tag{3}$$

In Eq. (3) $p(\tilde{\mathbf{C}}\,|\,\mathbf{Y},\mathbf{X}) \cdot p(\tilde{\mathbf{Y}}\,|\,\mathbf{Y})$ is the likelihood function, and $p(\mathbf{Y})$ and $p(\mathbf{X})$ are the prior distributions for $\mathbf{Y}$ and $\mathbf{X}$ respectively. Assuming the recipient elemental profiles $\tilde{\mathbf{C}}$ is log-normally distributed with known variances with its elements independent of each other, the first component of the likelihood function can be expressed as:

$$p(\tilde{\mathbf{C}} \mid \mathbf{Y}, \mathbf{X}) \propto \frac{1}{\prod_{i=1}^{m} \tilde{c}_i \delta_{c,i}} e^{-\sum_{i=1}^{m} \frac{\left[\ln(\tilde{c}_i) - \ln\left(\sum y_{ij} \cdot x_j\right)\right]^2}{2\delta_{c,i}^2}} \tag{4}$$

where $\delta_{c,i}$ is the variance of the logarithm of elemental composition and $\sum y_{ij} \cdot x_j$ is the "true" recipient elemental composition for element *j*. In order to make sure all source elemental fractions $\tilde{y}_{ij}$ vary between zero and one, the transformation $\tilde{y}_{ij} \big/ \left(1 - \tilde{y}_{ij}\right)$ of observed source elemental compositions are assumed to be log-normally distributed and therefore we can express the second component of the likelihood function as:

$$p(\tilde{\mathbf{Y}} \mid \mathbf{Y}) \propto \frac{1}{\prod_{j=1}^{n} \prod_{i=1}^{m} \tilde{y}_{ij}\left(1 - \tilde{y}_{ij}\right) \delta_{y,ij}} e^{-\sum_{j=1}^{n} \sum_{i=1}^{m} \frac{\left[\ln\left(\frac{\tilde{y}_{ij}}{1-\tilde{y}_{ij}}\right) - \ln\left(\frac{y_{ij}}{1-y_{ij}}\right)\right]^2}{2\delta_{y,ij}^2}} \tag{5}$$

where $\delta_{y,ij}$ is the variance of element *j* measured in source *i* calculated from multiple observations of elemental fractions for each source*:*

$$\delta_{y,ij} = STD\left[\ln\left(\frac{\tilde{y}_{ij}}{1-\tilde{y}_{ij}}\right)\right] \tag{6}$$

The prior distribution for X was considered a Dirichlet distribution with parameters all equal to one and therefore satisfying constraint in Eq. (2):

$$\begin{cases} p(x_1, \ldots x_n) = n! & for\ 0 \le \sum_{j=1}^{n-1} x_j \le 1 \\ p(x_1, \ldots x_n) = 0 & otherwise \\ x_n = 1 - \sum_{j=1}^{n-1} x_j \end{cases} \tag{7}$$

Since no additional information about the source elemental profiles other than the measured elemental concentrations is available, a uniform PDF between 0 and 1 was considered for the prior distribution of Y. Substituting Eqs. (5) and (4) into Eq. (3), the following relationship for the posterior probability is obtained:

$$p(\mathbf{X}, \mathbf{Y} \mid \tilde{\mathbf{Y}}, \tilde{\mathbf{C}}) \propto \frac{1}{\prod_{i=1}^{m} c_i \delta_{c,i}} e^{-\sum_{i=1}^{m} \frac{\left[\ln(c_i) - \ln\left(\sum y_{ij} \cdot x_j\right)\right]^2}{2\delta_{c,i}^2}} \cdot \frac{1}{\prod_{j=1}^{n} \prod_{i=1}^{m} \tilde{y}_{ij}\left(1 - \tilde{y}_{ij}\right) \delta_{y,ij}} e^{-\sum_{j=1}^{n} \sum_{i=1}^{m} \frac{\left[\ln\left(\frac{\tilde{y}_{ij}}{1-\tilde{y}_{ij}}\right) - \ln\left(\frac{y_{ij}}{1-y_{ij}}\right)\right]^2}{2\delta_{y,ij}^2}} p(\mathbf{Y})\, p(\mathbf{X}) \tag{8}$$

Eq. (8) can be used to calculate various moments of the posterior probability distributions of **X** and **Y** through integration. Due to the large number of dimensions, evaluating the integral in equation (8) using conventional methods is prohibitive. Therefore a Markov Chain Monte Carlo (MCMC) approach (Gamerman and Hedibert 2006) is used to generate random samples according to the posterior distribution of X and Y. Specifically in this research the Metropolis-Hasting Algorithm (Metropolis, Rosenbluth et al. 1953) is used to obtain a sequence of random numbers from the posterior probability distribution presented in Eq. (8)

3.2 Site Description and Sampling

The sample collection is already conducted during the rain event on 22nd of May 2012. Four student researchers participated in the sampling campaign. Figures 1 and 2 show the map of the study site at the shore of Anacostia River in North East Washington DC. The location of all the sampling stations including source samples and runoff samples are shown in Figures 3 and 4. The stations and number of water samples collected at each station is listed in Table 1 along with the designated codes to the samples. Samples were collected totally at 12 locations at each of them at least three water samples were collected to represent the temporal variations of the elemental profiles of the samples. The runoff samples were collected at two outfalls into the Anacostia River. Each sample were filtered onsite using 0.45μm Whatman Autovial 5 Syringeless Filters (Fischer Scientific). The portion passing through the filters were considered. The portion passing through the filter was considered dissolved and the unfiltered part was considered as the total. The particulate elemental composition will be obtained by subtracting the dissolved from the total elemental compositions. At least 5mL of each fraction (i.e. dissolved and total) of each sample were collected. The sample were put in fridge and were shipped to UC Davis for ICP-MS analysis at Peter Green's lab.

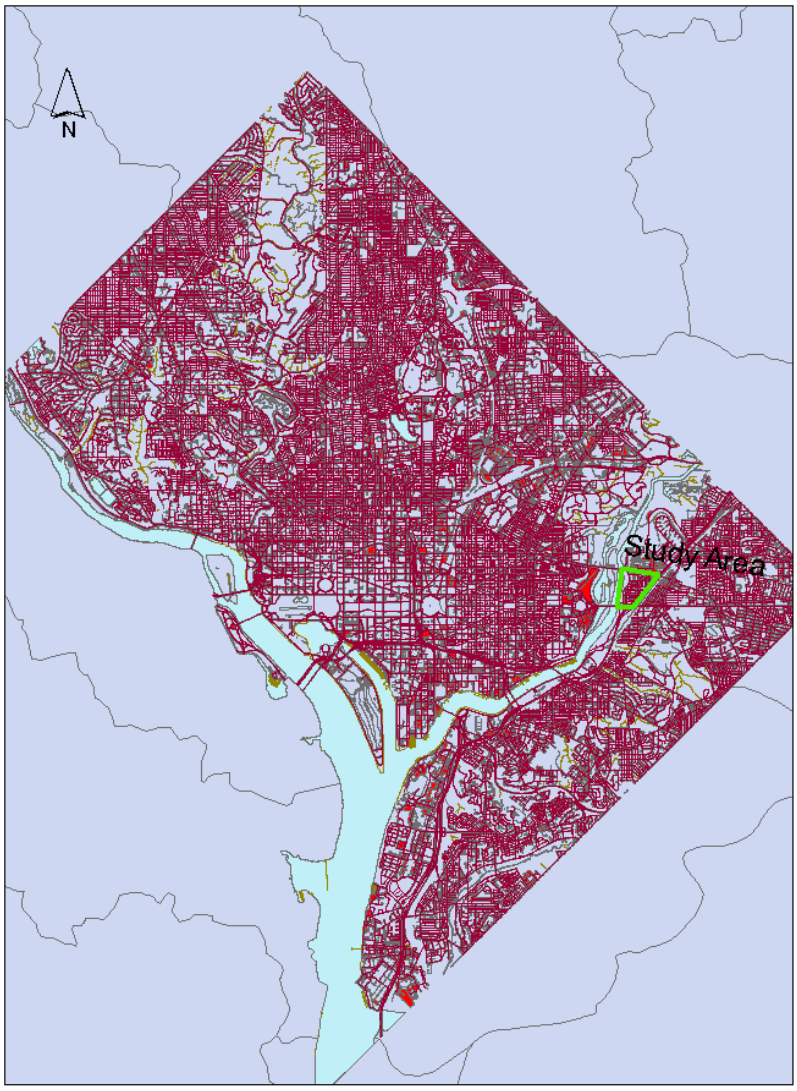

Figure 1: The location of the study site in the District of Columbia

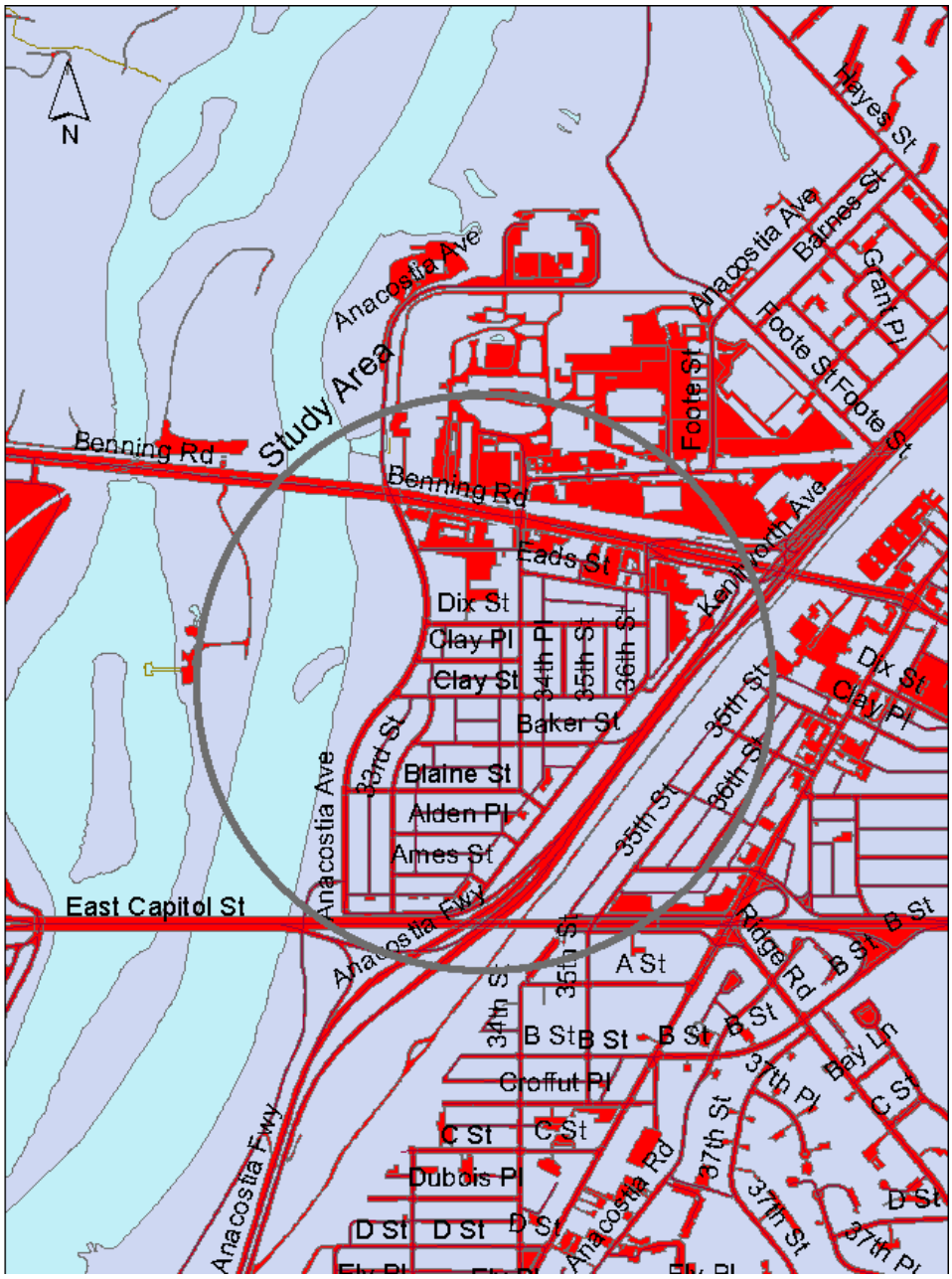

Figure 2: Detailed location of the study site at the shore of Anacostia River

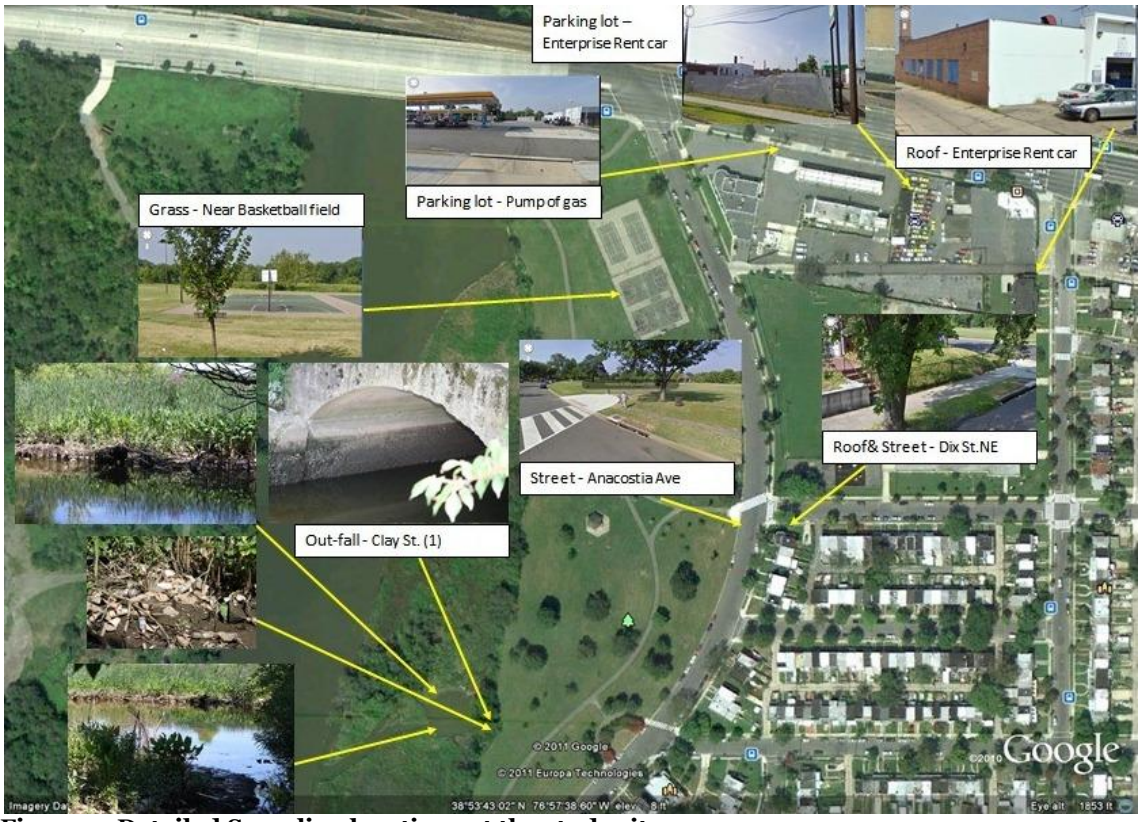

Figure 3: Detailed Sampling locations at the study site

Figure 4: Source and runoff sampling locations in the study site

3.3 Future Steps

Due to lack of significant rain the project was delayed and we asked for a no-cost extension until September which was granted. We expect the ICP-MS analysis to be finished by the end of May. As soon as we receive the results of the ICP-MS analysis the Bayesian CMB will be performed separately on the dissolved and particulate fractions. We plan to identify the contribution of the potential sources including (grass, street, and roof runoff) into the Phosphorus, Pb, Cu, Zn and Cd into the Anacostia River.

Table 1: List and location of samples collected for source identification and the codes attributed to each sample

source	Site	codes	Disolved			total		
			10 min	20 min	30 min	10 min	20 min	30 min
Grass	Near Basketball field	G1	G1-10-D	G1-20-D	G1-30-D	G1-10-T	G1-20-T	G1-30-T
Out-fall	Clay St. (1)	O1	O1-10-D	O1-20-D	O1-30-D	O1-10-T	O1-20-T	O1-30-T
	Blaine St. (2)	O2	O2-10-D	O2-20-D	O2-30-D	O2-10-T	O2-20-T	O2-30-T
Street	Dix St.NE	S1	S1-10-D	S1-20-D	S1-30-D	S1-10-T	S1-20-T	S1-30-T
	Blaine St.	S2	S2-10-D	S2-20-D	S2-30-D	S2-10-T	S2-20-T	S2-30-T
	Clay St.	S3	S3-10-D	S3-20-D	S3-30-D	S3-10-T	S3-20-T	S3-30-T
	Anacostia Ave	S4			S4-30-D			S4-30-T
	Anacostia Ave	S5			S5-30-D			S5-30-T
Bridge	East Capitol St. NE (South)	B1	B1-10-D	B1-20-D	B1-30-D	B1-10-T	B1-20-T	B1-30-T
	East Capitol St. NE (North)	B2	B2-10-D	B2-20-D	B2-30-D	B2-10-T	B2-20-T	B2-30-T
Parking lot	Enterprise Rent car	P1	P1-10-D	P1-20-D	P1-30-D	P1-10-T	P1-20-T	P1-30-T
	Pump of gas	P2	P2-10-D	P2-20-D	P2-30-D	P2-10-T	P2-20-T	P2-30-T
Roof	Dix St.NE	R1	R1-10-D	R1-20-D	R1-30-D	R1-10-T	R1-20-T	R1-30-T
	Clay St.	R2	R2-10-D	R2-20-D	R2-30-D	R2-10-T	R2-20-T	R2-30-T
	Enterprise Rent car	R3	R3-10-D	R3-20-D	R3-30-D	R3-10-T	R3-20-T	R3-30-T
	First Alley (near Bridge)	R4	R4-10-D	R4-20-D	R4-30-D	R4-10-T	R4-20-T	R4-30-T
Rain	Blaine St.	Rain1				Rain1-10-T		
	Blaine St.	Rain2					Rain2-20-T	
	Blaine St.	Rain3						Rain3-30-T

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Hormone Disruption and Environmental Pollutants in Anacostia and Potomac River Fish, Washington DC

Basic Information

Title:	Hormone Disruption and Environmental Pollutants in Anacostia and Potomac River Fish, Washington DC
Project Number:	2011DC130B
Start Date:	3/1/2011
End Date:	2/28/2012
Funding Source:	104B
Congressional District:	DC
Research Category:	Ecological Processes
Focus Category:	Ecology, Toxic Substances, Sediments
Descriptors:	None
Principal Investigators:	Stephen E. MacAvoy, Cathy Schaeff

Publications

There are no publications.

UNIVERSITY OF THE DISTRICT OF COLUMBIA
COLLEGE OF AGRICULTURE, URBAN SUSTAINABILITY AND ENVIRONMENTAL SCIENCES

Hormone Disruption and Environmental Pollutants in Anacostia and Potomac River fish, Washington DC

Progress Report

Submitted to

DISTRICT OF COLUMBIA WATER RESOURCES RESEARCH INSTITUTE

By

Stephen MacAvoy, Ph.D.

American University

May 2012

Preliminary report: " Hormone disruption and environmental pollutants in Anacostia and Potomac River fish, Washington DC"

1. Accomplishments:

Water, sediment (spring, summer and fall 2011/2012) and fish (spring 2012) have been collected from the Anacostia River from three sites (see Figure 1).

We have continued geochemical analysis of the water and extracted organic compounds from the sediment and water column. We have been collecting water geochemistry data since the spring 2010 and data generated under this grant are being added to the overall database. Included in this report are figures showing some of the geochemical data (Figures 2-6). The suite of parameters we are measuring include Ca, Mg, Na, S, K, P, B, Ba, Ni, Co, NO_3, NH_4, PO_4, and total organic carbon (TOC).

We have extracted hydrocarbons (PAHs, hormones, organics that could be hormone disruptors) from sediments and filtered water from 3 sites. A partial list of compounds identified thus far is included in Table 1.

The examination and interpretation of our results is ongoing, however I have included in the progress report the factor scores from a principle component analysis. This analysis examines large databases for correlation patterns amid the data. Preliminary analysis suggests that cations correlate heavily with each other , but also nitrate. Also, nutrient concentrations at baseflow (only baseflow samples were collected) show that inorganic nitrogen concentrations are consistently on the high side of "normal" for a tidal freshwater system. Our initial results, combined with earlier WRRI funded research, were presented at the American Geophysical Union annual meeting in December 2011.

2. What remains to be done:

The largest laboratory work that remains is working up the fishes (*Fundulus heteroclitus*) that were collected in April 2012. Tissues from 6 individual adults will be examined for organic contaminants that may have been taken up from the sediment/water are taken up (such as those in Table 2). There is a chance that the reproductive tissue histology portion of the proposal will not be completed due to shifting responsibilities of personnel (the duties of the Associate Dean may preclude her from completing the work in the time give. If that is the case, the funds that were budgeted for the histology will be returned).

The largest portion of what needs to be completed is a through analysis of the data and we do not see a large amount of field work taking place before the 6-month extension expires.

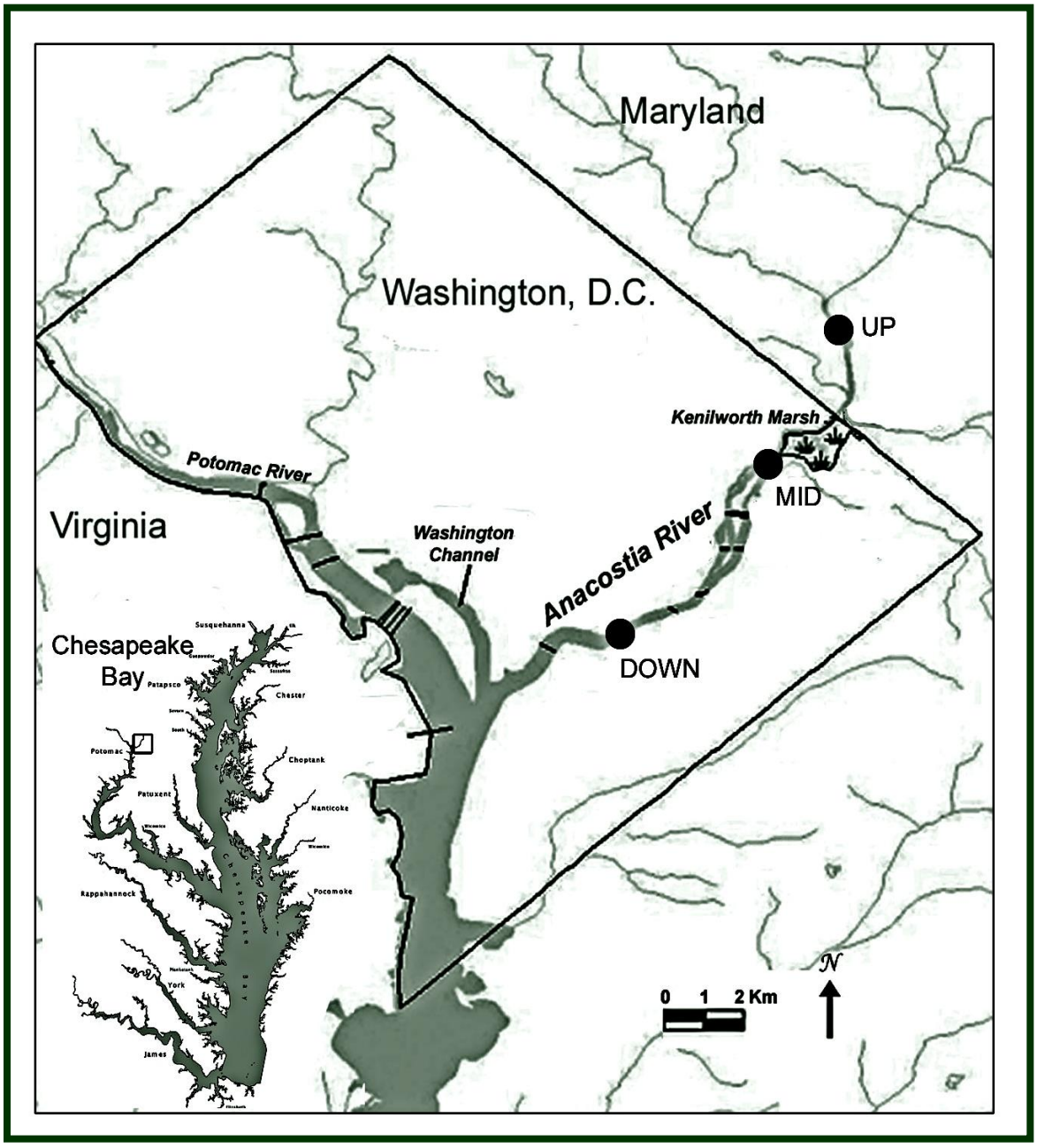

Figure 1. Site map

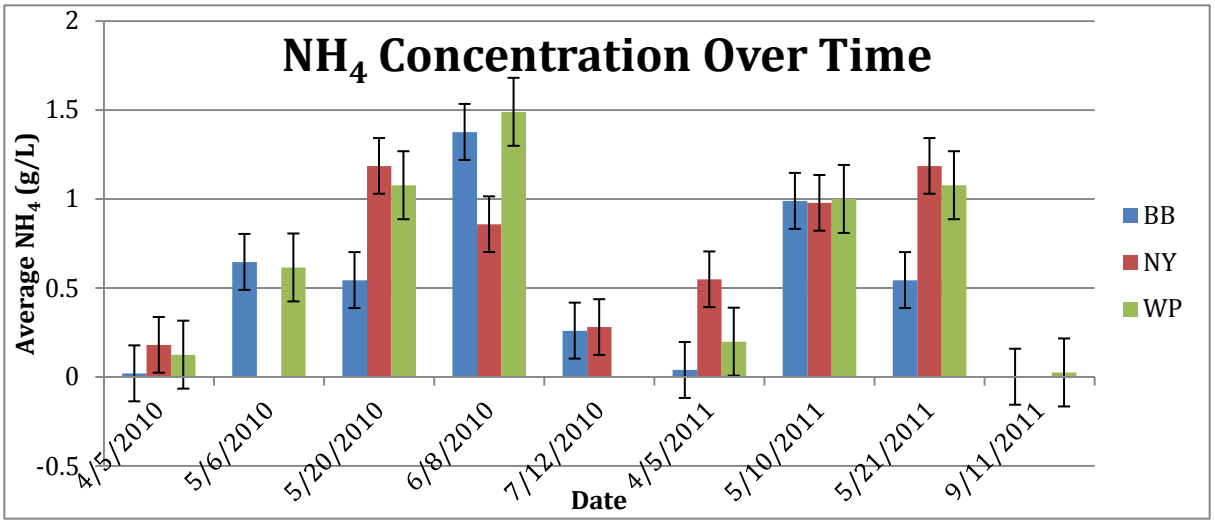

Figure 2. Sediment ammonium (NH4+) concentrations over time

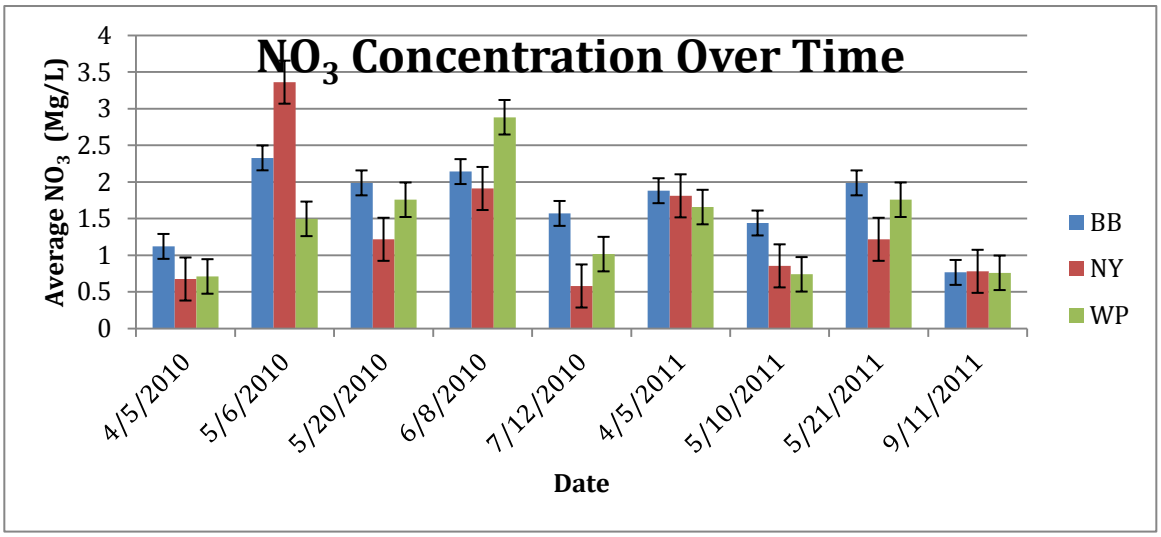

Figure 3. Sediment nitrate (NO3) concentrations over time

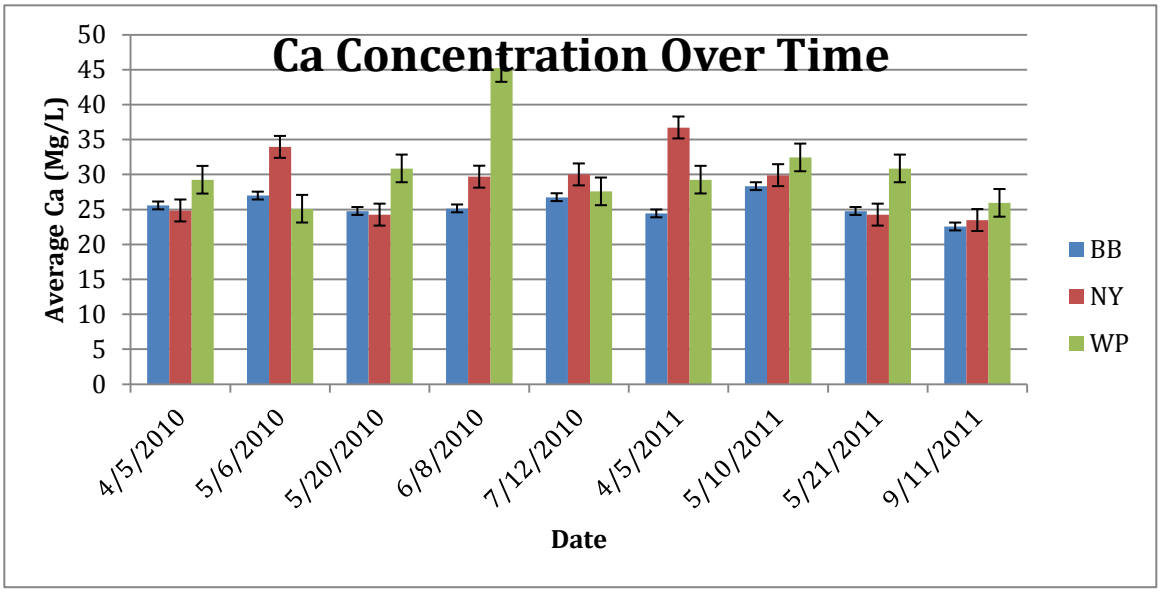

Figure 4. Sediment calcium concentrations over time.

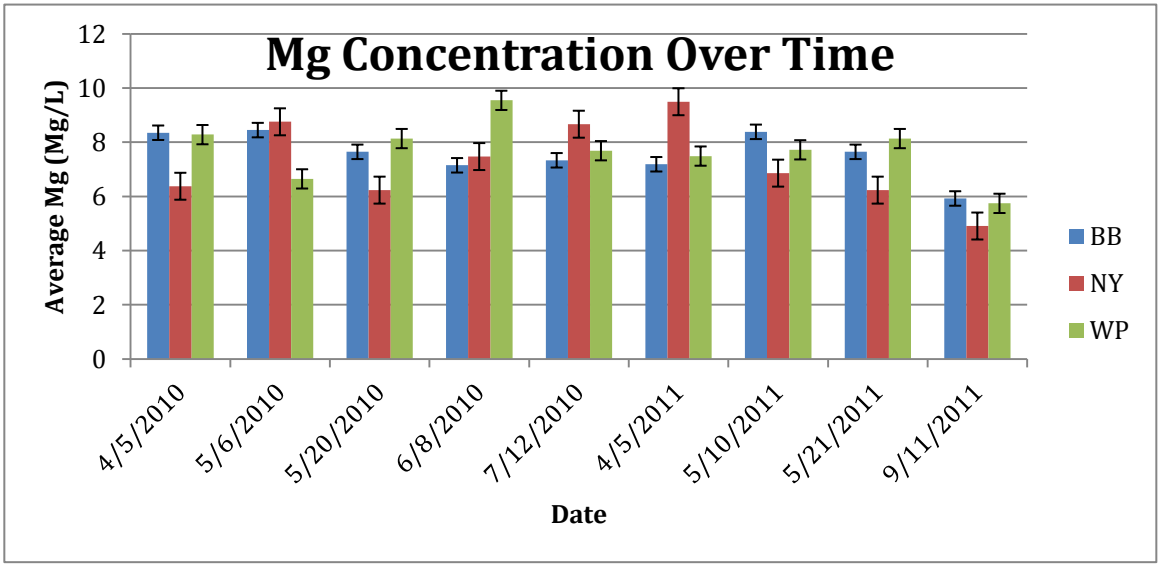

Figure 5. Sediment magnesium concentrations over time.

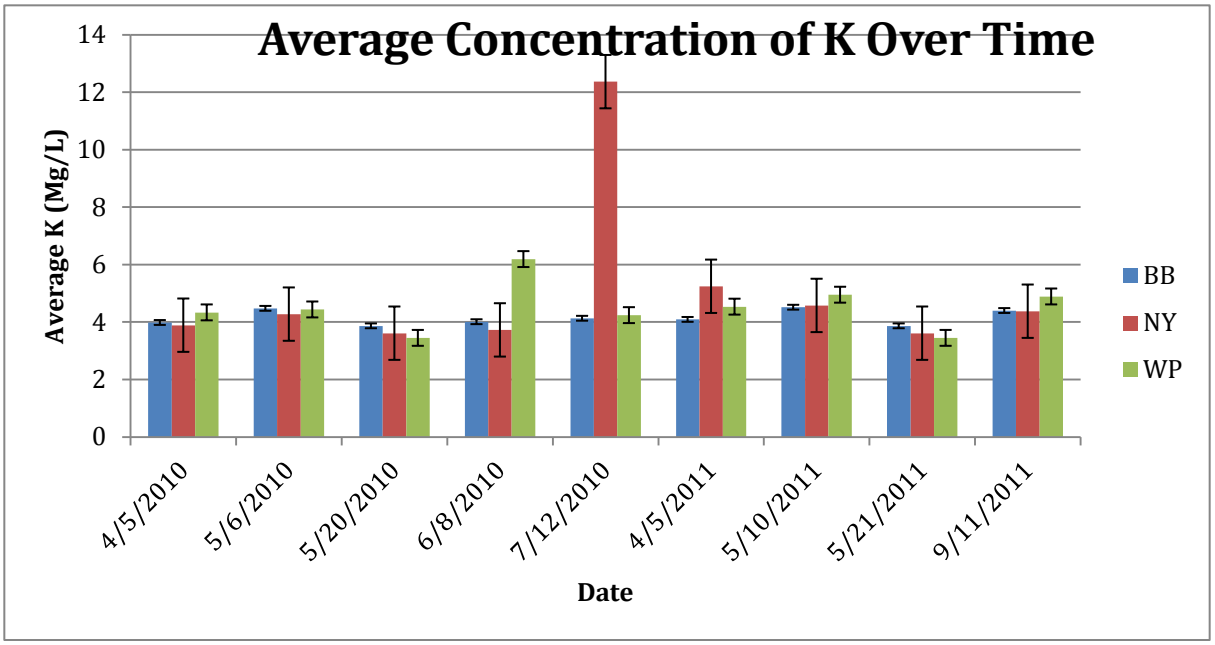

Figure 5. Sediment potassium concentrations over time..

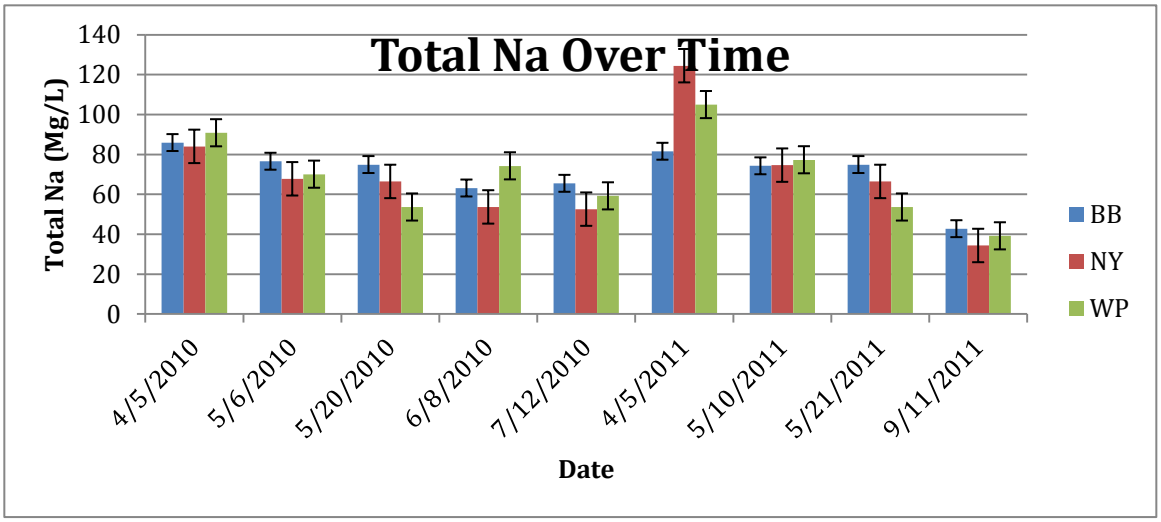

Figure 6. Sediment sodium concentrations over time.

Table 1. Organic compounds extracted from Anacostia sediments. Characterized by GC/MS

Water park sediment	Bladensburg sediments	Navy Yard sediments
possible endocrin disrupters	**possible endocrin disrupters**	**possible endocrin disrupters**
bis-phenol		
Aromatic hydrocarbons (including PAHs)	**Aromatic hydrocarbons (including PAHs)**	**Aromatic hydrocarbons (including PAHs)**
phenanthrene	phenanthrene	phenanthrene
pyrene	pyrene	pyrene
Floranthere	Floranthere	Floranthere
dibutyl phthalate	dibutyl phthalate	phthalic acid
phthalic acid	Anthracenedione	Benz(a)azulene
isophthalic acid	Benzene	naphthalene
terephthalic acid		Benzene
possible degraded hormone	**possible degraded hormone**	**possible degraded hormone**
Cyclopenta(a)phenanthren	12-Oleanen-3-yl acetate	
chain hydrocarbons	**chain hydrocarbons**	**chain hydrocarbons**
Hexadecadienal	methyl-z-tetradecen-1-ol acetate	butenoic acid
Octadecadienoyl chloride	tetradecene	Octadienen
heptadecane		
fatty acids	**fatty acids**	**fatty acids**
n-hexadecanoic acid	hexadecenoate	n-hexadecanoic acid
pentadecanoic acid	methyl 15-methylhexadecanoate	methyl 10-methyl-undecanoate
cis-10-Nonadecenoic acid	dodecanoic acid	tridecanoic acid, 12-methyl
dodecanoic acid	tridecanoic acid, 12-methyl	9-Octadecenoic acid
oxalic acid	methyl 15-methyl-heptadecanoate	methy tetradecanoate
	tetradecanoic acid	

Table 2. Factor scores for geochemical parameters.

Principle components analysis: Factor Scores						
	UP		Mid		DOWN	
variable	Factor 1	Factor 2	Factor 1	Factor 2	Factor 1	Factor 2
	-31.60%	19.90%	39.50%	20%	36.80%	14.90%
soluble salts	0.060	**0.431**	-0.056	-0.171	-0.262	0.109
hardness	**0.932**	0.075	**0.964**	0.071	**0.975**	0.027
SAR	**0.656**	**-0.63**	-0.085	**0.917**	**0.51**	**0.494**
Alkalinity	0.132	**0.648**	**0.528**	**-0.43**	0.374	-0.075
Ca	**0.848**	0.289	**0.957**	0.004	**0.944**	0.113
Mg	**0.916**	-0.203	**0.863**	0.288	**0.983**	0.135
Na	**0.761**	**-0.564**	0.163	**0.9**	**0.674**	**0.467**
K	-0.031	**0.53**	**0.657**	-0.121	0.25	**-0.744**
Fe	**-0.484**	0.206	**-0.497**	**0.431**	-0.142	**0.557**
Mn	-0.135	-0.374	-0.384	**0.807**	**0.592**	**0.516**
Zn	-0.198	**-0.777**	**-0.44**	**-0.79**	0.187	**-0.806**
Ba	**0.720**	**0.491**	**0.687**	0.071	**0.92**	0.232
S	-0.112	**-0.691**	**0.883**	-0.146	**0.788**	-0.397
Sr	**0.929**	0.092	**0.97**	0.097	**0.979**	-0.084
NH4	0.353	0.491	**0.671**	0.074	0.035	0.353
NO3	**0.561**	0.232	**0.716**	0.188	**0.483**	0.294
PO4	0.336	0.268	0.217	-0.384	0.148	0.074
Ni	0.135	**-0.697**	-	-	0.125	**-0.443**
P	0.311	0.268	0.269	**-0.47**	-0.142	0.224
pH	-0.119	0.1555	**0.647**	-0.124	**0.638**	**-0.376**
Al	**-0.893**	0.08	**-0.535**	-0.322	**-0.64**	0.089

Information Transfer Program Introduction

We continue to collaborate with our Cooperative Extension Service Water Quality Education program for engaging our statkeholders. Our Research Associate for Information Transfer Program, Ms. Gerri William has an extensive background as a technical writer and a radio talk show host on environmental issues. She has already contributed to revamping our Water Highlights Newsletter from biannually to quarterly issues. Two issues of the Highlights were completed and distributed while the Institute organized The Rewards of Re¬search from the Student Interns' Perspec¬tive, a Forum to highlight the contributions of graduate student researchers from area universities. Hosted on the UDC campus on September 20, 2011, the Forum created an opportunity for nine students participat¬ing in WRRI seed grant research projects to share their research experiences and findings in an open dialogue. The Forum focused, not on the results of the projects, but rather on the experiences and benefits that students derive from collaborating on research projects. Keynote speaker Sarah Neiderer, Water Communications Coordinator for DC WASA, addressed the audience on a topic of ¬ continuing interest, DC drinking water vs. filtered and bottled water quality.

Howard Ways reported on the Feasibility Assessment for a Metropolitan Washington Public Officials' Water Leadership Program . The purpose of the project was to be to develop a means of providing a baseline understanding of area water resources, water infrastructure, regulations, and funding considerations, and related water quality, water resources, and water use management issues, and to provide an opportunity for incoming public officials involved in water decisions to develop applicable leadership and policy development skills, network and form the basis for regional collaboration and understanding. This project was developed as part of a series of water education projects completed with funding from the DC Water Resources Research Institute, including the 2009 Preliminary Inventory and Assessment of Resources and Accomplishments and the 2010 DC Area Water Issues Program. Public officials involved in water decisions had been identified as a potential audience for a tailored education program. Watercat prepared a summary of water leadership training programs and a list of current water leadership at MWCOG, DC Water, and WSSC. The Co-PI also presented on the program at meetings of the American Water Resources Association and the American Water Works Association. Although none of the major water leader organizations elected to commit to participation in a program this year, there was some interest in potential future coordination of joint events for water leaders to learn about water decision making in the DC area and examples of water innovations in other areas, and to provide opportunities for greater interaction among water leaders in the region. While a formal water academy program was not held during the period of this contract, the process of working with major water decision-making organizations in the DC area including MWCOG, DC Water, and WSSC resulted in a greater awareness of the current water leadership development activities underway, summarized in the project report.

Integrated Water Use Impact Assessment for DC urban Infrastructure

Basic Information

Title:	Integrated Water Use Impact Assessment for DC urban Infrastructure
Project Number:	2011DC132B
Start Date:	3/1/2011
End Date:	2/28/2012
Funding Source:	104B
Congressional District:	DC
Research Category:	Water Quality
Focus Category:	Management and Planning, Models, Water Use
Descriptors:	None
Principal Investigators:	Royce Francis

Publications

There are no publications.

INTEGRATED WATER USE IMPACT ASSESSMENT FOR DC URBAN INFRASTRUCTURE

Progress Report

Submitted to the

DISTRICT OF COLUMBIA WATER RESOURCES RESEARCH INSTITUTE

By:

Royce A. Francis, Ph.D.
George Washington University
Assistant Professor
Department of Engineering Management and Systems Engineering

May 2012

PROGRESS REPORT

INTEGRATED WATER USE IMPACT ASSESSMENT FOR DC URBAN INFRASTRUCTURE

Royce A. Francis, Ph.D.

2 May 2012

The original goals of this project were proposed as follows:

> *Major Contribution #1—Sustainability Measurement and Evaluation.* **The objective of this research is to identify cost-effective approaches to reduction of the water use footprint of The George Washington University (GWU).** In collaboration with the GWU Office of Sustainability and the DCWRRI, we will integrate life cycle cost analysis and life cycle impact assessment to evaluate GWU infrastructure investments intended to reduce its water use footprint. Potential investments will be identified through multi-criteria decision analysis (MCDA) and subsequently evaluated by a team of GWU students led by a Department of Engineering Management and Systems Engineering (EMSE) Ph.D. student. Dr. Royce Francis, an assistant professor in EMSE, will direct this team.
>
> *Major Contribution #2—Integration of LCIA and LCCA*. In this proposal, we will use the cradle to cradle life cycle of a selected system as the system boundary, units or monetary value of system-relevant purchases as the functional unit of analysis, and employ a synthetic framework for the combination of life-cycle impact assessment (LCIA) and life cycle cost (LCC) and risk assessment (RA) methodologies where the impact of concern is life cycle cost over the life cycle of an infrastructure project. **This proposal will demonstrate the potential for a natural synergy between life-cycle cost analysis and life-cycle impact assessment, while also making methodological contributions to the practice of water footprinting.**

Currently, we have submitted one peer reviewed journal publication communicating the results of our research activities related to contribution #1. This manuscript, titled "Urban water sustainability definition: a decision analytic approach," describes a decision analysis undertaken with GW stakeholders to gain insight into the multiple objective tradeoffs large DC Water customers may undertake in the decision context in which low-impact development (LID) decisions are made. We constructed an objective-value hierarchy, and obtained strength of preference and tradeoff weights in order to construct this sustainability definition for GW water use. This paper is currently addressing minor reviews requested by the editor before publication.

Concerning contribution #2, we have requested a no-cost extension to complete this work. The PI and his graduate students are constructing an extended life-cycle cost analysis for the implementation of LIDs in DC. The goal is to gain insight into strategies for compensating private developers or DC Water customers for installing LID based on the distribution of costs and benefits. We are in the model building stages of this work, and expect to complete this before the end of the project. While water footprinting is not currently a key aspect of this work, we have extended it to include a framework for rapid benefit-cost analysis for the evaluation of LID installations.

Metropolitan Washington Public Officials Water Leadership Program

Basic Information

Title:	Metropolitan Washington Public Officials Water Leadership Program
Project Number:	2011DC133B
Start Date:	3/1/2011
End Date:	2/28/2012
Funding Source:	104B
Congressional District:	DC
Research Category:	Not Applicable
Focus Category:	Education, Management and Planning, Water Quality
Descriptors:	None
Principal Investigators:	Howard Ways, Catherine Shrier

Publications

There are no publications.

Feasibility Assessment for a Metropolitan Washington Public Officials' Water Leadership Program

Final Report

Submitted to

DISTRICT OF COLUMBIA WATER RESOURCES RESEARCH INSTITUTE

By:

Howard Ways (PI)
Director of Planning and Sustainability
Adjunct Professor, College of Arts & Sciences, Department of Urban Studies
University of the District of Columbia

Cat Shrier (Co-PI)
Watercat Consulting LLC

May 2012

EXECUTIVE SUMMARY

The concept for the Metropolitan Washington Public Officials Water Academy (MWPOWA) was developed by Watercat Consulting LLC (Watercat) and the UDC Office of Sustainability (UDC). The intent of this project was to develop a program to provide training for public officials. The purpose of the programs was to develop a means of providing a baseline understanding of area water resources, water infrastructure, regulations, and funding considerations, and related water quality, water resources, and water use management issues, and to provide an opportunity for incoming public officials involved in water decisions to develop applicable leadership and policy development skills, network and form the basis for regional collaboration and understanding. This project was developed as part of a series of water education projects completed with funding from the DC Water Resources Research Institute, including the 2009 Preliminary Inventory and Assessment of Resources and Accomplishments and the 2010 DC Area Water Issues Program. Public officials involved in water decisions had been identified as a potential audience for a tailored education program.

In developing the concept for MWPOWA, Watercat reviewed water leadership development programs offered by organizations including the American Water Works Association (AWWA), Water Education Foundation (WEF), and Colorado Foundation for Water Education. Watercat consulted with several members of the DCWRRI board, particularly Metropolitan Washington Council of Governments of Governments (MWCOG) Environmental Programs Director Ted Graham, who was near retirement. Watercat identified several potential public officials water academy topics and program features for a program to be held through MWCOG with partnerships with various area water utilities and agencies and private sector sponsorships. Watercat was to develop the program and UDC was to obtain agreements from water entities to participate in the program.

After award of the contract, the MWCOG contact (Ted Graham) had retired and the new environmental programs staff declined to participate in the program, recommending instead that UDC work with DC Water. Watercat and UDC developed a new program outline and proposal for DC Water. Watercat began redesigning the program for DC Water while UDC was to secure participation by DC Water. Watercat attended DC Water Board Meetings and reviewed past and future activities for orientation and training of board members. DC Water declined to work with UDC on this program. Watercat and UDC then prepared a new program outline and proposal for WSSC. Watercat began redesigning the program for WSSC while UDC was to secure participation by WSSC. Watercat attended a WSSC Board Meeting and reviewed past and future activities for orientation and training of board members. WSSC declined to work with UDC on this program. Watercat explored the possibility of developing a stand-alone program to be held at Busboys and Poets or at UDC, with private sponsorships and entrance fees, but UDC was not able to secure commitments for participation in a water leadership program.

Watercat prepared a summary of water leadership training programs and current water leadership at MWCOG, DC Water, and WSSC. The Co-PI also presented on the program at meetings of the American Water Resources Association and the American Water Works Association.

Although none of the major water leader organizations elected to commit to participation in a program this year, there was some interest in potential future coordination of joint events for water leaders to learn about water decision making in the DC area and examples of water innovations in other areas, and to provide opportunities for greater interaction among water leaders in the region. While a formal water academy program was not held during the period of this contract, the process of working with major water decision-making organizations in the DC area – including MWCOG, DC Water, and WSSC – resulted in a greater awareness of the current water leadership development activities underway, summarized in the project report.

TABLE OF CONTENT

APPENDICES

1. INTRODUCTION

The Metropolitan Washington Public Officials Water Academy (MWPOWA) was a concept developed by Watercat Consulting LLC and UDC's Office of Sustainability as a pilot program for elected and appointed officials responsible for water policy decisions in the Metropolitan Washington area. The intent of this UDC offering was to create a program for public officials to address regional water research, education, and outreach needs as identified in strategic planning activities by the DC Water Resources Research Institute and its stakeholder advisory committee. The original proposal (Appendix A) was developed for a program to be delivered through the Metropolitan Washington Council of Governments (MWCOG), was participation by water leadership from throughout the DC area and financial support from area water utilities and private companies. After MWCOG decided not to participate in the program, revised programs were proposed to DC Water and to the Washington Suburban Sanitary Commission (WSSC), both of which ultimately declined to participate in the program this year.

Watercat and UDC retained the services of an intern, Chelsea Burns, a master's student in Sustainability at American University.

1.2 Project Rationale

Area water providers and governments have elected or appointed new leadership who will be faced with several critical decisions on water-related issues. Area water and wastewater service providers, agencies, and policymakers have also expressed a strong interest in developing the District of Columbia as a "green city" providing leading programs on green urban infrastructure, while redefining the meaning of the word "green" and "sustainability" within the context of a economically and ethnically diverse urban area. There have also been increasing efforts to address water-related issues on a regional or watershed basis, involving coordination and collaboration among multiple municipalities and local governments, water and wastewater service providers, and with other stakeholders, including federal agencies, water advocacy organizations, and business sectors.

Many of the area water organizations have new public officials in key decision making roles, including appointed water and sewer board officials at DC Water and Washington Suburban Sanitary Commission; new elected officials in DC City Council and Mayor's Office and other communities in the Metropolitan Area, with new appointed staff supporting those elected officials. While education programs often focus on school-aged children, universities, or a "general public" audience, the development of effective water education programs for public officials – outside of the context of supporters or detractors of specific policies and projects – is not widely addressed. As new public officials step into leadership roles on water-related decisions, there is a need to communicate and build an understanding of current physical, natural, and political "infrastructure" and organizational cultures that govern how water is managed and protected; emerging issues and potential ways to address those issues. Particularly as water utilities, water agencies and other municipal, regional, and federal agencies are encouraged to work in a more collaborative manner, it is critical to provide public officials with an opportunity to gain a common understanding of water issues facing the region, and to network with each other and work together to explore these issues before being faced with decisions in the context of a public hearing.

1.3 Goals and Objectives

The purpose of this program was to develop a baseline understanding of area water resources, water infrastructure, regulations, and funding considerations, and related water quality, water resources, and water use management issues, and to provide an opportunity for incoming public officials involved in water decisions to develop applicable leadership and policy development skills, network and form the basis for regional collaboration and understanding.

The program was a good opportunity to examine the current make up of the DC Water board, what role the board plays in the decision making process, and the current gaps/needs in leadership development. The program was proposed to provide training for a student intern.

The research component will include a review of public officials water education programs around the United States and of the evaluations to be completed by the participants.

Potential training objectives identified for inclusion in a water leaders academy were:

- To provide a baseline understanding of area water resources, water infrastructure, and regulations, and related water quality and water use management issues,
- to evaluate leadership and policy development skills as applied to service on water boards or similar elected and appointed positions, including those related to project financing and media and public relations,
- to support network development among water policymakers and enhance regional collaboration on water,
- to provide context for integrated policy decisions and demonstrate how water policy is related to energy, land use, climate change adaptation, workforce development and jobs creation, and other critical issues.

1.4 Project Origin

During the development of the initial proposal for the Metropolitan Washington Public Officials Water Academy (MWPOWA), three main factors led to the development of the grant proposal:

- 2010 The DC Area Water Issues Program, and the preceding DC Water Resources Research Institute (DCWRRI) 2010 5-year plan and 2009 White Paper assessment, developed by Dr. Cat Shrier in conjunction with UDC faculty and staff, identified needs for water education in the DC area outside of the standard university student population, including the need for education on water issues for elected and appointed public officials. DCAWIP had been (BROAD PROGRAM, GEERAL AUDIENCE, DEEVELOP MORE FOCUSED AUDIENCE). DCAWIP included presentation by Ted Graham as well as staff from other water organizations, many of whom serve on the DCAWIP Advisory Board, including (NAME ALL). However, none of the DCAWIP speakers had been elected or appointed officials.

- UDC Sustainability Director, and former Deputy Mayor's office sustainability director, Howard Ways recommended a focus on appointed members of water boards, including DC Water and Washington Suburban Sanitary Commission (WSSC) in recognition of the appointment of new board members on both boards. Further review of recent board membership and appointed leadership changes at other water organizations (e.g. Metropolitan Washington Council of Governments (MWCOG) and Interstate Commission on the Potomac River Basin (ICPRB)) further reinforced the concept that this would be an important target audience for a tailored education program.

- MWCOG and DCWRRI Advisory Board Member Ted Graham was consulted for further development of the program.

The initial program concepts This project will begin with meetings with senior staff at DC Water and other area water utilities to review current board member orientation and capacity-building activities, and to coordinate the development of this program as a means of enhancing and complementing existing efforts. Upon consultation with DC Water, we will contact other area water utilities which may include Washington Suburban Sanitary Commission, Fairfax Water, and other organizations addressing regional water issues (e.g. Metropolitan Washington Council of Governments, Interstate Potomac River Basin Commission).

1.5 Scope of Work and Revisions

As shown in the proposal (Appendix A), the original program was to include

1) a paid internship
2) Initial program planning, organization, administrative set-up, arrangements for in-kind sponsorships, and recruitment of participants
3) Metropolitan Washington Public Officials Water Leadership Program Kick-off Reception and Water 101 Weekend
4) Public Officials Program at AWWA
5) Potomac Basin and Chesapeake Bay Field Trip and Group Project Formation
6) a review of the the roles and activities of board members and other public officials with examples from DC Water, WSSC, and MWCOG
7) evaluate what knowledge the board has of current regional water issues and what gaps are missing
8) an evaluation of the various public officials' knowledge and incorporation of ideas of "sustainability" and "green" ?
9) a leadership program based on what the board members identified as their needs.
10) network development among water policymakers to enhance regional collaboration on water
11) a review of current approaches education/orientation for water boards, including summary of national examples
12) a one-time gathering of public officials from throughout the area, possibly with a panel of speakers, opportunity for introductions by all officials, and opportunity for interaction through a lunch and/or reception
13) A full evaluation of where the DC Water board "where they are now" and what their needs are for the future, in order to determine the current roles, activities, selection, and preparation of the individuals and boards, commissions, and councils making these decisions.
14) Fall 2011-Winter 2012 evaluation of results and preparation of DCWRRI newsletter article and final report.

After MWCOG declined to partner on this project, the scope was revised to focus on a tailored program targeting an individual water board – first for DC Water, then for WSSC. The revised scopes are reflected in the proposals to DC Water and WSSC, provided in Appendix B. When both DC Water and WSSSC declined to work with UDC on this project, Watercat and UDC explored possible stand-alone programs hosted either by Watercat at Busboys and Poets, or by UDC at UDC. However, with no water utilities committed to participation, and no financial support available without commitments from water utility leadership to participate, it was not feasible to hold a program.

A brief review of water leadership programs and current water leadership in the DC area was completed, along with recommendations for future water leadership programs in the metropolitan Washington area.

2. PROGRAM COMPONENTS

2.1 Review of Other Water Leaders Programs

In developing the concept for this project, Watercat Consulting LLC – led by Cat Shrier, the Co-PI for the project - conducted a review of water leader training programs available through several water education organizations, including the American Water Works Association, Water Environment Federation, the Colorado Foundation for Water Education, and Bighorn Institute. Watercat also reviewed past programs in the DC area offered the Interstate Commission on the Potomac River Basin, and a new Watershed Leaders Academy, offered through the Anacostia Watershed Society and UDC. Descriptions of these programs are provided in Appendix C.

APPENDIX A

INITIAL PROPOSAL AND REVISED SCOPES OF WORK

Title: Metropolitan Washington Public Officials' Water Leadership Program

Project Type: Information Transfer, Research, and Education

Focus Categories: LIP, M&P, EDU

Keywords: Local water issues, professional development, leadership training, education program

Start Date: March 1, 2011

End Date: February 28, 2012

Principal investigator(s)

Howard Ways, Howard Ways, AICP
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Co-Principal Investigator:

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Abstract

Area water providers and governments have elected or appointed new leadership who will be faced with several critical decisions on water-related issues including:

- replacement of aging and failing water infrastructure, and associated financing issues;
- new technologies and new requirements for water and wastewater retreatment in accordance with regulatory requirements such as the Total Maximum Daily Load (TMDL) for the Chesapeake River and its tributaries (including the Potomac River and Anacostia River); emerging contaminants and their impacts on drinking water;
- replacement of older water infrastructure systems such as lead pipes and combined sewer overflow with healthier, safer water and wastewater systems, and associated financial issues;
- development of rain gardens, infiltration basins, and other green building techniques, and associated regulations;
- management of water resources for recreation and habitat, and associated educational opportunities;
- development of education, communications, and outreach strategies, and funding of research to address water issues;
- job creation and environmental equity issues associated with various policies, programs, and projects.

Area water and wastewater service providers, agencies, and policymakers have also expressed a strong interest in developing the District of Columbia as a "green city" providing leading programs on green urban infrastructure, while redefining the meaning of the word "green" and "sustainability" within the context of a economically and ethnically diverse urban area. There have also been increasing efforts to address water-related issues on a regional or watershed basis, involving coordination and collaboration among multiple municipalities and local governments, water and wastewater service providers, and with other stakeholders, including federal agencies, water advocacy organizations, and business sectors.

Many of the area water organizations have new public officials in key decision making roles, including appointed water and sewer board officials at DC Water and Washington Suburban Sanitary Commission; new elected officials in DC City Council and Mayor's Office and other communities in the Metropolitan Area, with new appointed staff supporting those elected officials. While education programs often focus on school-aged children, universities, or a "general public" audience, the development of effective water education programs for public officials – outside of the context of supporters or detractors of specific policies and projects – is not widely addressed. As new public officials step into leadership roles on water-related decisions, there is a need to communicate and build an understanding of current physical, natural, and political "infrastructure" and organizational cultures that govern how water is managed and protected; emerging issues and potential ways to address those issues. Particularly as water utilities, water agencies and other municipal, regional, and federal agencies are encouraged to work in a more collaborative manner, it is critical to provide public officials with an opportunity to gain a common understanding of water issues facing the region, and to network with each other and work together to explore these issues before being faced with decisions in the context of a public hearing.

Statement of critical regional or State water problem

Area water providers and governments have elected or appointed new leadership who will be faced with several critical decisions on water-related issues. Area water and wastewater service providers, agencies, and policymakers have also expressed a strong interest in developing the District of Columbia as a "green city" providing leading programs on green urban infrastructure, while redefining the meaning of the word "green" and "sustainability" within the context of a economically and ethnically diverse urban area. There have also been increasing efforts to address water-related issues on a regional or watershed basis, involving coordination and collaboration among multiple municipalities and local governments, water and wastewater service providers, and with other stakeholders, including federal agencies, water advocacy organizations, and business sectors.

Many of the area water organizations have new public officials in key decision making roles, including appointed water and sewer board officials at DC Water and Washington Suburban Sanitary Commission; new elected officials in DC City Council and Mayor's Office and other communities in the Metropolitan Area, with new appointed staff supporting those elected officials. While education programs often focus on school-aged children, universities, or a "general public" audience, the development of effective water education programs for public officials – outside of the context of supporters or detractors of specific policies and projects – is not widely addressed. As new public officials step into leadership roles on water-related decisions, there is a need to communicate and build an understanding of current physical, natural, and political "infrastructure" and organizational cultures that govern how water is managed and protected; emerging issues and potential ways to address those issues. Particularly as water utilities, water agencies and other municipal, regional, and federal agencies are encouraged to work in a more collaborative manner, it is critical to provide public officials with an opportunity to gain a common understanding of water issues facing the region, and to network with each other and work together to explore these issues before being faced with decisions in the context of a public hearing.

The purpose of this program will be develop a means of providing a baseline understanding of area water resources, water infrastructure, regulations, and funding considerations, and related water quality, water resources, and water use management issues, and to provide an opportunity for incoming public officials involved in water decisions to develop applicable leadership and policy development skills, network and form the basis for regional collaboration and understanding.

The program will provide training for area public officials as well as for student interns. The research component will include a review of public officials water education programs around the United States and of the evaluations to be completed by the participants.

Statement of results or benefits

The purpose of this program will be develop a means of providing a baseline understanding of area water resources, water infrastructure, regulations, and funding considerations, and related water quality, water resources, and water use management issues, and to provide an opportunity for incoming public officials involved in water decisions to develop applicable leadership and policy development skills, network and form the basis for regional collaboration and understanding.

The proposed Metropolitan Washington Public Officials Water Leadership Development Program will be developed with input and cooperation from the leadership of key stakeholder organizations in the DC area including

- DC Water, Washington Sanitary Sewer Commission, Fairfax Water, Washington Aqueduct, and other water and wastewater service providers

- DC City Council, DC Department of the Environment, and other local governments and agencies

- Metropolitan Washington Council of Governments, Interstate Potomac River Basin Commission, Chesapeake Bay Foundation, Anacostia Watershed Association, and other area organizations involved in regional coordination on water issues

In addition, input will be sought from National Capital Region offices of federal agencies with extensive lands in the DC area, and congressional leadership with oversight over DC government decisions related to water. Initial scoping efforts will result in the development of a common knowledge base, to be identified by current water leadership, to be communicated to new public officials who will make decisions impacting water quality protection and water management in the Metropolitan Washington Area.

Working with input and support from these water stakeholder organizations, we will develop an educational program designed to provide area public officials with:

- a common baseline understanding of the rivers and aquifers in the DC area, including water bodies used for municipal water supplies, agriculture, energy and power, other industrial uses;

- a common baseline understanding of DC area water systems, wholesale and retail water and wastewater service providers, and associated issues

- a common baseline understanding of current and emerging regulatory, financial and economic issues

- a common baseline understanding of the impacts on water from climate change and opportunities for mitigation and adaptation, as well as other approaches to sustainability and "greening" the DC area.

There is also an opportunity for DC area public officials to take advantage of national conferences to be based in the DC area that will address emerging issues in water resources, as well as provide additional opportunities for public officials training and network building. These opportunities include the American Water Works Association Annual Conference and

Exposition, to be held at the Washington Convention Center in June 2010, including the AWWA Public Officials Training Programs, and the American Water Resources Association 5th National Water Policy Dialogue and Spring Specialty Conference on Climate Change and Water Resources, to be held in Baltimore, Maryland, April 2010.

From a research perspective, there is an opportunity to review and analyze education programs designed for public officials, including programs offered by associations such as the American Water Works Association; federal programs such as the Congressional Water Caucus programs; state programs such as the Association of California Water Agencies and Colorado Water Caucus state legislature programs, and comparable local or regional programs if any can be found, as well as the Bighorn Institute Leadership Development Program, designed for future public officials. An evaluation procedure will also be developed to test the incoming knowledge level of the participants, outgoing knowledge level, and otherwise obtain feedback from Metropolitan Washington Public Officials Water Leaderships Program participants.

Nature, scope, and objectives of the research. Include a timeline of activities.

January-February 2011: Pre-Project Matching Commitments and Coordination: If the proposal is selected by DCWRRI for inclusion in the USGS submittal, we will meet with the leadership of the area municipal and county governments and water and wastewater service providers. We have spoken with several organizations that coordinate multi-stakeholder activities related to water (e.g. Metropolitan Washington Council of Governments, Interstate Potomac River Basin Commission, and DC Department of the Environment), who will assist in these communication efforts, which will include meetings to be held in conjunction with the Chesapeake Bay Committee Meeting of MWCOG and other regional board meetings. We will confirm cash and in-kind matches as well as level of participation in the program development and execution. We will also begin identifying associations with public officials' water education programs for the research component as well as for program development ideas. We anticipate participation, including cash matches, from at least half of the area municipalities and water providers, and will provide match commitment letters prior to the USGS submittal. **Internship announcement and hiring:** An internship announcement will be posted and two spring/summer interns will be hired. Funding for the spring/summer internships will be sought as part of the match (e.g. DC Water or Washington Aqueduct).

March-April 2011: Initial program planning, organization, administrative set-up, arrangements for in-kind sponsorships, and recruitment of participants: With an estimated award date of March 1, 2010, the Metropolitan Washington Public Officials Water Leadership Program development will start with planning and organization and requests for additional in-kind sponsorships for related events (e.g. opening reception, meals during training, boat tour and transportation to field trips, use of UDC facilities and other meeting spaces). We will also work with area governments and water/wastewater service providers to identify and recruit public officials to participate in the program. Participants may be encouraged to attend the American Water Resources Association Spring Specialty Conference on Climate Change Adaptation for Water Resources Management in late April 2011.

May or June 2011: Metropolitan Washington Public Officials Water Leadership Program Kick-off Reception and Water 101 Weekend. A weekend will be selected for the initial program, to include a Friday night Potomac River dinner cruise with participants,

instructors, and sponsors, with an opening speaker. Metropolitan Washington Water 101 weekend will continue the next day (Saturday), to include a series of briefings, breakout discussions and activities, and selection of groups to work on sample policy development. Participants will have a chance to network with one another over breakfast and lunch. A fish fry or picnic will be held with area water advocacy groups on the Anacostia River. Metropolitan Washington Water 101 weekend will continue Sunday morning with review of policy development approaches, sessions on project financing and how to interact with the media and public meetings.

June 2011: Public Officials Program at AWWA: Public Officials will be encouraged to attend the AWWA program with support from their governments or organizations. An AWWA orientation program will be held by the PI/Co-PI and AWWA staff to identify opportunities for Metropolitan Washington public officials to learn through attendance at AWWA sessions and to interact with water/sewer commissioners and other public officials from around the US and Canada through the AWWA Public Officials program. Interns will accompany the program.

July 2011: Potomac Basin and Chesapeake Bay Field Trip and Group Project Formation: A field trip will be organized for participants to travel to the headwaters of the Potomac River Basin and travel to the Chesapeake Bay Foundation Headquarters in Annapolis. Participants will also be asked to develop and present ideas for policies. Participants will vote on the top policy ideas and form groups for group projects. Meals, transportation, and lodging will be provided, with costs covered through in-kind sponsorships. Interns will accompany the program.

August 2011 Graduation Weekend: Participants will present their policy ideas to a panel of retired policymakers and other area experts. The program will end with a final dinner and guest speaker. Participants will also be asked to provide feedback. Meals will be provided with costs covered by area sponsors. Interns will accompany the program.

Fall 2011-Winter 2012 evaluation of results and preparation of DCWRRI newsletter article and final report. The final report will be prepared along with a newsletter article for DCWRRI. If sufficient cash match is acquired to cover the conference and travel costs, an abstract will be submitted for presentation at a national conference.

Table 1. Timeline of activities

Task	Activities	Time from 3/1/10 thru 2/28/11 (in months)											
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
1	Program planning, organization, administrative set-up, and announcements. Intern Position Announcement Development and Posting	X	X										
2	Kick-Off and Water 101 Weekend			X	X								
3	Field Trips and Group Selection Weekend					X							
4	Pilot Summer Water Tours				X	X	X						
5	Internship (April thru September 2010		X	X	X	X	X	X					
6	Final Report Preparation and Presentations to Sponsors							X	X	X	X	X	X

Related Research:

The need for the development of more cohesive multi-disciplinary and multi-university information exchanges with areas stakeholders was discussed in the 2009 DCWRRI White Paper entitled "District of Columbia Water Resources Research Institute (DCWRRI) Preliminary Inventory and Assessment of Resources and Accomplishments." This White Paper drew upon communications with university faculty and administration, research programs at federal and local agencies, the NCRS of AWRA, USGS, and current and former directors of other Water Resources Research Institute. Further input on this program was obtained during the October 2009 meeting of the DC Stakeholder Advisory Committee and UDC Deans of Research and of Cooperative Extension and Outreach. Several area stakeholders participated in the DC Area Water Issues Program Weekly Seminar Series during the Fall 2010 semester, funded by the USGS DCWRRI Seed Grant Program.

Public Officials training programs have been conducted by AWWA, Congressional Water Caucus, Association of California Water Agencies, Colorado Water Congress, and the Bighorn Institute.

Training potential:

Two paid UDC student internships are included in the proposal to support research on public official water training and development of the Metropolitan Washington Training Program, and to provide logistical support for the program execution during the spring and summer of 2011. Additional volunteer student assistants would also be recruited to support program events, with oversight by the Principal Investigator and Co-Principal Investigator, as well as by the paid student interns, who would gain experience in supervisory and logistical management skills. The program itself would provide training benefits for the public officials participating in the program. Funding for the spring internships will be requested from DC Water, Washington Aqueduct, and other area organizations as part of their matching support. (NOTE: a Washington Aqueduct internship would not be a non-federal match.)

One additional UDC student internship will be included during the Fall of 2011 to support the development of the final report.

Budget Breakdown. As requested by the attached form;

Proposed Start Date: March 1, 2011	Proposed Completion Date: February 28, 2012		
Project Number: (to be assigned by institute)			
Project Title: Metropolitan Washington Public Officials Water Leader Program			
Principle Investigator (s): Mr. Howard Ways and Dr. Cat Shrier			
Cost Category	Federal	Non Federal	Total
1. Salaries and wages:	$		
-Principal Investigators:			
-PI @ $50/hr for 236 hrs	$	$11,800.00	$11,800.00
-Student interns: 2 spring interns @ $13/hr at 10 hrs/week for 10 weeks 1 summer intern @ $13/hr at 10 hrs/week for 10 weeks	$1,300.00	$2,600.00	$3,900.00
Total salaries and wages			
2a. Fringe benefits @ 7.65% for students	$199.00	$398.00	$597.00
2b Fringe benefits @ 23% for PI		$2,714	$2,714.00
3. Supplies		$3,000	
4. Equipment			
5. Services or consultants Co-PI $150/hr for 240 hrs	$12,000.00	$24,000.00	$36,000.00
6. Travel and conference fees	$1,500.00	$46,000.00	$47,500.00
7. Other direct costs		$15,000.00	
8. Total direct costs	$14,999.00	$196,624.00	$45,574.00
9. Indirect costs on federal share			
10. Indirect costs on non-federal share:		$4,800.00	
11. Total estimated cost	$14,999.00	$201,424.00	$216,423.00

1. Budget Justification. Brief statement justifying use of funds;

Federal funding request includes:

- $2,600 plus $199 fringe benefits for a student program coordinator internship ($10/hour, 10 hours/week, for 26 weeks)
- $12,000 for contracted services (80 hours at $150/hour) from USGS funds
- $1,500 for contractor travel and conference fees to present results at conference

Matching cash funds will include:

- Cash match of $1000 per enrolled participant, to be paid by municipality or water utility (estimated 24 participants for a total cash match of $24,000) to cover additional contracted services (160 hours at $150/hour)

Matching in-kind support will include:

- University of the District of Columbia contribution of PI faculty salary plus 23% fringe benefits for
    - 4 hrs/week for 26 weeks for meetings and liaison = 104 hours
    - 3 Metropolitan Washington Water Leadership Program hours at 24 hours per weekend = 72 hours
    - 3 conferences (AWRA, AWWA, and presentation of final results) at 2.5 days (20 hours) per conference = 60 hours
    - Total hours = 236 hours * $50/hour = $11,800
- University of the District of Columbia contribution of fringe benefits for PI faculty = $11,800 * 23% = $2,714
- Sponsor support for 2 spring/summer interns @ $13/hr at 10 hrs/week for 10 weeks = $2,600.00
- In-kind match of payment for food and materials for 3 training weekends, dinners, and field trips, to be paid by area consulting firms, developers, watershed organizations, and other area water interests, to total $15,000, including $3,000 in supplies, $7,000 in travel and lodging, $5,000 in food, boat tour, and dinner cruise facility expenses, plus $26,000 for participants and PI and Co-PI costs of conference attendance at AWWA.
- in-kind support for use of university meeting space and audiovisual support by the University of District of Columbia valued at $100/hr for two weekends at 16/hours per weekend ($3,200), plus in-kind support for use of meeting space and audiovisual support by external facility (possibly Chesapeake Bay Foundation headquarters) for valued at $100/hr for one 8-hour day ($1,600)

Investigator's qualifications. Include a resume(s) of the principal
The project will be led by the PI, Mr. Howard Ways, the University of the District of Columbia, and Co-PI, Dr. Cat Shrier, Watercat Consulting LLC.

Mr. Ways is the Director of Planning and Sustainability for the University of the District of Columbia where he coordinates the university's sustainability initiative, which is intended to help conserve energy, reduce waste and promote recycling on the campus. Mr. Ways is also Adjunct Professor in UDC College of Arts and Sciences Urban Studies Program, where he teaches courses including Sustainable Community Development, Politics of the Green Economy, Introduction to Urban Planning and Urban Policy Analysis. Mr. Ways has over 14 years of planning and real estate development experience, working in such cities as Philadelphia, Baltimore and Washington, DC. Prior to coming to Washington, DC in 2000, Mr. Ways developed affordable housing in Baltimore and has managed over $96 million of real estate and public facilities projects. During his ten years in District of Columbia government, Mr. Ways has worked on various policy initiatives, including housing policy, targeted public investments and workforce development. He completed the city's first green collar jobs demand analysis. He also led the planning effort on reuse of excess school facility space and managed the vacant property acquisition and disposition process. Mr. Ways has a Master's Degree in City and Regional Planning from Morgan State University and a Bachelor of Architecture degree from Temple University. He attended the John F. Kennedy School for Government's Senior, State and Local Government Officials Program in 2006. He has taught at the graduate School of Architecture at Catholic University of America and the School of Architecture at Philadelphia University. Additionally, Howard is the Washington DC representative for the German Marshall Fund's Transatlantic Cities Network, a collaboration of 20 American and European public policy practitioners. He is a member of the American Institute of Certified Planners and the American Planning Association. Mr. Ways' 2-page resume is attached.

This proposal includes a contract for the Co-Principal Investigator, Dr. Cat Shrier, President of Watercat Consulting LLC, a practice in water resources planning and policy that specializes in higher education in water resources. Dr. Shrier is currently the Co-PI for the DCWRRI-supported DC Area Water Issues Program. While with the Colorado Water Resources Research Institute, Dr. Shrier developed public education documents to communicate the findings of research funded by CWRRI/USGS. Also for the Colorado Water Resources Research Institute (CWRRI), she developed successful proposals for projects funded by Colorado Division of Wildlife (CDOW) and matching funding from the Colorado Water Resources Research Institute (CWRRI) and U.S. Geological Survey (USGS), and supported faculty research proposal development on survey water utility conservation measures, groundwater-surface water interactions, and riparian ecosystems. She has organized numerous workshops, conference sessions, and seminars related to various water issues, and co-led the Iowa Institute of Hydraulic Research International Perspectives in Water Resources Planning course in China. Dr. Shrier has been an environmental resources consultant and water agency staff person for more than 15 years, and has served as a senior project manager for large and small projects for agencies, universities, and private industry. She will work closely with Mr. Ways, DCWRRI staff, faculty, and interns. Dr. Shrier's 2-page resume is attached.

References

Watercat Consulting LLC. District of Columbia Water Resources Research Institute (DCWRRI) Preliminary Inventory and Assessment of Resources and Accomplishments. White Paper submitted to DCWRRI Director October 23, 2009.

Howard Ways

SUMMARY OF EXPERTISE
Experienced, professional manager with demonstrated political acumen working in diverse, fast paced urban environments. Creative, detailed oriented problem solver well versed in establishing new business lines for government agencies, private companies and non-profit organizations. Managed over $90 million in real estate development and capital improvement projects.

ACADEMIC EXPERIENCE

Adjunct Professor – *University of the District of Columbia, College of Arts and Sciences, Urban Studies Program, Fall 2007 to Present*
Courses include: Housing Policy, The District of Columbia, Sustainable Community Development, Politics of the Green Economy, Introduction to Urban Planning and Urban Policy Analysis.

Thesis Advisor – *Philadelphia University, School of Architecture, Spring 2010 to present*

Lecturer – *Howard University, College of Engineering, Architecture and Computer Science, Fall 2010*
Courses include: Affordable Housing Development and Environmental Sustainability

Lecturer – *Catholic University of America, Graduate School of Architecture and Planning, Spring 2010 to present*
Courses include: Applied Planning Topics.

Lecturer – *George Washington University, Center for Excellence for Public Leadership, Program for Excellence in Municipal Management, 2007-2008*
"Creating Public Value as a Public Sector Manager"

Lecturer – *Philadelphia University, School of Architecture, Spring 2007*
"Introduction to Urban Planning and Design"

Volunteer Instructor - *Architecture in the Schools Program, 2003*
Philadelphia Chapter of the American Institute of Architects, Philadelphia, PA.

INTERNATIONAL EXPERIENCE

Genoa, Italy – *May 2010*
Waterfront and economic development tour

Torino, Italy and Belgrade, Serbia – *February 2009*
Cultural and public policy tour including the first capital of a unified Italy

Tokyo, Hiroshima, Kyoto and Nara, Japan – *January 2008*
Cultural tour of current and past Japanese capital cities

Accra, Cape Coast and Kumasi, Ghana and Abidjan, Côte d'Ivoire – *August 1993*
Cultural summer study tour including former capital of Côte d'Ivoire and the capital of the Ashanti Nation

NOTABLE PROFESSIONAL EXPERIENCE

TransAtlantic Cities Network, Washington, DC Representative – *German Marshall Fund, 2008 to Present*
Serve as the representative for the nation's capital for a program that brings together local leaders and public policy practitioners from 22 American and European cities.

Director of Planning and Sustainability – *University of the District of Columbia, August 2010 to present*
Manage the university's sustainability initiative by enhancing academic offerings, greening the physical campus and promoting sustainable procedures to reduce energy consumption, reduce waste, improve recycling and advance the use of renewable energy.

Special Assistant – *DC Office of Planning, September 2007 to July 2010*
Manage several key initiatives including the establishment of a city-wide Green Collar Jobs policy, green infrastructure assessment for New York Avenue, and the creation of a district based carbon offset program.

Director – Ward 7 Initiatives – *Anacostia Waterfront Corporation, February 2006 to September 2007*
Direct capital investments for a Transit Oriented Development of 2,000 mixed income housing units and 750,000 square feet of commercial space. Coordinate environmental remediation for various park projects. Manage the design and development of a new Environmental Education Center (the second LEED Platinum certified building in Washington, DC). Supervised a professional staff of three.

Special Assistant to the Deputy Mayor – *The Office of the Deputy Mayor for Planning and Economic Development, June 2002 to January 2006*
Formulated several housing and community development policies for Washington, DC including the Home Again Initiative, Supervised a professional staff of five and an administrative staff of two.

Community Development Coordinator – *DC Office of Planning, June 2000 to June 2002*

Provided planning, urban design and real estate development expertise on a variety of public and private sector projects, including HOPE VI projects and projects that received other public subsidies including CDBG funds and local capital funds.

Director of Planning and Housing Development, Historic East Baltimore Community Action Coalition (HEBCAC) - *Enterprise Social Investment Corporation (ESIC), March 1998 to June 2000*
Implemented a comprehensive neighborhood revitalization effort in one of Baltimore's most impoverished areas, working directly with state and local elected officials. Coordinated the rehabilitation of 37 homes and the demolition of 450 vacant homes. Hired and supervised a professional staff of three and an administrative staff of two.

Community Planner – *The Enterprise Foundation, June 1996 to March 1998*
Assisted community-based organizations in Baltimore, Denver, Cleveland and St. Louis through Enterprise's technical assistance contract with HUD. Provided project-specific assistance to organizations in underserved urban communities and Native American populations looking to develop affordable housing. Conducted several community development trainings for planning and development issues.

EDUCATION

- Kennedy School of Government, Harvard University – Cambridge, MA, Senior Executives in State and Local Government
- Morgan State University - Baltimore, MD, Master of City and Regional Planning
  Concentration: Real estate development - Graduated Summa Cum Laude
- Temple University - Philadelphia, PA, Bachelor of Architecture

PROFESSIONAL MEMBERSHIPS

- American Institute of Certified Planners (AICP)
- American Planning Association
- Certified Green Advantage professional

NOTABLE PRESENTATIONS

- Washington Council of Governments, Green Affordable Housing Forum, *Green Jobs and Green Building Practices in the District of Columbia,* 2009.
- World Energy Engineering Congress, *The District of Columbia's Approach to Conducting a Green Collar Jobs Demand Analysis,* 2009.
- Heinrich-Böll-Foundation North America, Brookings Institute and the Ecologic Institute Urban Mobility Roundtable, *Urban Mobility in Washington, DC,* 2009.
- Frequent presenter and key note speaker at various conferences, universities and events including the American Planning Association National Planning Conferences, the University of Maryland, the Catholic University of America, Temple University and Morgan State University.
- National Building Museum: DC Builds Initiative, *The District's Neighborhood 10 Initiative,* 2002.

Cat Shrier is President and Founder of Watercat Consulting LLC (Watercat), an international water resources planning and policy consulting practice created to facilitate communication and understanding of water and other natural resources management issues, technologies, and policy approaches. Cat has more than 25 years experience, having worked with environmental consulting firms since 1992, and with water and environmental agencies and legislative offices on environmental issues since 1984. Cat's clients have included public and private companies in the water utility, oil & gas, power, and mining sectors; educational institutes; water users and other stakeholder organizations. Her areas of expertise include integrated water and energy planning and policy; integrated water management for habitat, municipal, agricultural, recreational, and industrial uses; conjunctive use and management of groundwater and surface water resources; development of cohesive research strategies involving universities, institutes, agencies, consulting firms, and private industry; and development of education and outreach programs and other communication vehicles.

Cat is currently Co-Principal Investigator of the DC Area Water Issues Program for the University of the District of Columbia College of Agriculture, Urban Sustainability, and Environmental Sciences (CAUSES), organizing weekly seminars as well as water tours and related activities intended to "create a cohesive water research community" throughout the DC Area. For the DC Water Research Institute, she conducted an analysis of water research and education resources and accomplishments. For state water agencies, US Department of Energy, and national laboratories, she organized the September 2009 "Water-Energy Sustainability Symposium" in Salt Lake City, and authored the symposium report "Water-Energy Sustainability Perspectives and Policy Approaches."

As a Senior Project Manager for Golder Associates in Calgary, Alberta, and Denver, Colorado, Cat managed hydrology baseline studies and environmental impact assessments, using state-of-the-art modeling, assessment, and river restoration technologies for large Athabasca oil sand projects for clients including Shell, Suncor, PetroCanada, and ExxonMobil, and power projects for TransAlta. She led several projects for energy clients to evaluate alternatives for wastewater management and treatment for reuse and recycling throughout their facility operations. She planned public scoping meetings developed educational materials to support environmental impact assessments for power projects in US and Canada. She co-led a review of environmental impact assessment approaches in 6 countries.

For Alberta Environment's Water for Life provincial water strategy, she led the development of agency programs, studies, and educational tools to support development of "alternative" water supply storage and management, including water reuse for oil sands operations. In Western Colorado, she has organized forums on water-related impacts, sustainable development of energy resources, and opportunities for treatment, reuse, and minimization of water demands for oil shale production. She organized the National Research Council's forum on policy, permitting, planning, and public perception issues on managed underground storage of recoverable water

Selected Experience

- **Colorado Water Conservation Board (CWCB) Basin Planning Meetings and Site Tours (Colorado)** Organized and led 17 public meetings in every major river basin of Colorado to identify current and future water needs and public policy concerns for consideration in the revision of CWCB's long-range plan. Organized site tours and other events with local water stakeholders and presented on behalf of CWCB's Office of Water Conservation at basin meetings. Coordinated with board members, agency staff, and local water user organizations on meeting preparation and oversaw implementation.
- **International Perspectives in Water Resources Planning Course (China).** Co-taught University of Iowa Institute of Hydraulic Research's International Perspectives in Water Resources Planning Course in Beijing, Wuhan, the Three Gorges Dam, Nanjing, and Shanghai, China. Led students and presented to US and Chinese students and faculty at Tsinghua, Wuhan, and Hohei Universities.
- **National Research Council Managed Underground Storage Forum (Washington, DC)** Organized first national meeting, with agency and project personnel from 25 states and 3 federal agencies, on "institutional issues" of managed underground storage such as science- and risk-based managed underground storage (MUS) policy and regulations.
- **Chicago Water Bike Tour for American Water Works Association Conference Attendees (Chicago, IL).** Produced bike tour of Chicago water features and history for attendees of annual conference for largest association of North American water utilities.
- **Water and Energy Sustainability Policy and Technology Forums and Educational Documents (Washington, DC; Salt Lake City, Utah; Gunnison, Colorado).** For the state water agencies, US Department of Energy and national laboratories, organized the September 2009 "Water-Energy Sustainability Symposium" in Salt Lake City, and authored the symposium report on Perspectives on the Water+Energy Nexus.
- **DCWRRI Research and Education Program Analysis and Development (Washington, DC).** For the District of Columbia (DC) Water Resources Research Institute (WRRI), conducted analysis and strategic plan development for creation of a cohesive water research community throughout the District of Columbia. Co-Director of DC Area Water Issues Program, including seminar series, boat tour and weekly events.

Selected Publications

Shrier, Cat, and Matthew Frank. 2010. *Meeting the Challenges of Water Tours.* American Water Works Association (AWWA) Annual Conference and Exposition Proceedings.

Shrier, Cat. 2009. *District of Columbia Water Resources Research Institute (DCWRRI) Preliminary Inventory and Assessment of Resources and Accomplishments.* DC Water Resources Research Institute White Paper.

Shrier, Catherine. 2008. *Using and Protecting Water Resources in Energy Development.* Mid-Atlantic Water Resources Research Institutes Regional Water Conference, Shepherdstown, West Virginia.

National Academy of Sciences Study Committee (Member). 2008. *Prospects for Underground Storage of Recoverable Water.* National Academy of Sciences, Water Science & Technology Board.

Michaela Bell, Catherine Shrier, Marian Muste, and Witold Krajewski. 2003. *The University of Iowa's International Perspectives in Water Resources Planning Program*. UNESCO World Transactions on Engineering and Technology Education. Vol. 2, No. 1.

McKee, Thomas B., Nolan J. Doesken, John Kleist, and Catherine J. Shrier. 2000. *A History of Drought in Colorado: Lessons Learned and What Lies Ahead.* Colorado Water Resources Research Institute Water in the Balance Series, No. 9.

Shrier, Catherine J. 1999. *North Carolina's Responses to Water Use Conflicts: Restrictions on Individual Users vs. Regional Management*. AWRA Proceedings, Specialty Conference on Science into Policy: Water in the Public Realm. Middleburg, VA.

APPENDIX B

INTERN ANNOUNCEMENT

Watercat Consulting LLC (Watercat) is considering candidates for an unpaid internship for the Summer of 2011.

ABOUT WATERCAT CONSULTING LLC

Watercat Consulting, LLC is an international, woman-owned consulting practice which serves as a catalyst for innovative approaches to sustainable water resources policy and management. Founded in 2007, Watercat offers a multidisciplinary understanding of communications, educational program development and implementation, policy development and implementation, environmental management, hydrogeology and hydrology, water resources engineering, planning and systems analysis. Headquartered on Capitol Hill in Washington, DC, with a second office in Colorado, Watercat works with mission-driven clients, including; federal, state/provincial, and local government agencies; association and nonprofits, and private entities in efforts to incorporate innovative solutions to sustainable water management of water resources in accordance with their organizational missions.

ABOUT THE INTERNSHIP

The intern will work with Watercat Consulting staff on Capitol Hill in Washington, DC. Some work can be completed remotely. Interns must commit to a minimum of 10 hours/week. The student intern may be working independently, indoors and outdoors, in a position requiring self-direction and the ability to adjust quickly to new developments. Must maintain a positive attitude while performing a range of tasks. Preference given to applicants with prior cycling, and tour guide experience. Other qualifications include:

- Excellent research, writing, communication, and organizational skills
- Comfort using Windows and the Microsoft Office
- Ability to troubleshoot computer/network/website/social media issues preferred
- If working on bike tours, must have ability to ride a bike

Specific projects in which interns may be involved this summer may include:

- **Water Education Bike Tours:** During upcoming American Water Works Association Annual Conference and Exposition, which will bring 15,000 water utility managers, agency personnel, and consultants from all over the US and Canada to the Washington Convention Center, you may be asked to support development of a bike tour of downtown DC, with stops and guest speakers from DC water agencies and community water organizations, highlighting DC water issues and innovations. You may also be asked to help organize and promote Water Education Bike Tours in Colorado for the Universities Council on Water Resources and Western Water Workshop; in Baltimore in August for the National Conference on Ecosystem Restoration and the Global Conference on Coastal Seas; and in Atlanta in September for the Ground Water Protection Council.

- **The Metropolitan Washington Public Officials Water Leaders Academy:** You may be asked to support the engagement of public officials in water leadership in the metropolitan Washington area for the 2011 program, co-directed by the UDC Sustainability Initiative and Watercat Consulting LLC, as part of a seed grant funded by the USGS through the DC Water Resources Research Institute.

- **The First Tee DC/FedEx Fore!Ever Community Outreach and Environmental Sustainability Programs at the Langston Golf Course:** You may be asked to support the development of golf sustainability education programs that incorporate local knowledge, environmental and community development activities with the FedexCup Fore!Ever Campaign programs, working in conjunction with the Audubon Society and Langston Golf Course in Anacostia, as well as associated media involvement and community outreach with organizations such as the Earth Conservation Corps and Anacostia Watershed Society.

To support these projects, you may also be asked to perform general office tasks, and to attend meetings around the DC area, including:

- Developing and maintaining electronic and paper filing systems and contacts databases
- Developing promotional materials such as flyers, pamphlets, articles, and press releases

- Attending water and sustainability events and meetings and preparing summaries
- Supporting development of presentations, posters, and conference handouts
- Basic bookkeeping, logistical planning, travel arrangements, and event coordination
- Administrative support including phone and emails
- Updating website content

Student must also complete work through the internship to support their degree, and is responsible for making arrangements for course credit with their university.

ELIGIBILITY

Eligible applicants will be students enrolled in undergraduate or graduate programs. Students can be in any major (science/engineering, social sciences, humanities, law) but should demonstrate a strong interest in water issues and policy.

APPLICATION

Applicants must submit:

- a cover letter stating their interest in the program,
- dates of availability,
- a writing sample,
- resume,
- contact information for two references (one professional, one academic), and
- copy of transcript.

Applications must be received by Thursday, May 5, 2011. Applications must be received by email (cat@watercatconsulting.com). For questions regarding internship, contact Cat Shrier, 202-344-7894.

APPENDIX C

PROPOSALS SUBMITTED TO DC WATER AND WSSC

Metropolitan Washington Public Officials Water Academy
Fall 2011 Pilot Program Proposal to DC Water (DRAFT: 07/05/11)

Summary: The Metropolitan Washington Public Officials Water Academy (MWPOWA) – offered by UDC's Office of Sustainability – is a pilot program for elected and appointed officials responsible for water policy decisions in the Metropolitan Washington area. The MWPOWA concept was developed to address regional water research, education, and outreach needs as identified in strategic planning activities by the DC Water Resources Research Institute and its stakeholder advisory committee.

Purpose: The purpose of this project is to design and implement a pilot educational program for public officials:

- To provide a baseline understanding of area water resources, water infrastructure, and regulations, and related water quality and water use management issues,
- to enhance leadership and policy development skills as applied to service on water boards or similar elected and appointed positions, including those related to project financing and media and public relations,
- to support network development among water policymakers and enhance regional collaboration on water,
- to provide context for integrated policy decisions and demonstrate how water policy is related to energy, land use, climate change adaptation, workforce development and jobs creation, and other critical issues.

Approach: This project will begin with meetings with senior staff at DC Water and other area water utilities to review current board member orientation and capacity-building activities, and to coordinate the development of this program as a means of enhancing and complementing existing efforts. Upon consultation with DC Water, we will contact other area water utilities which may include Washington Suburban Sanitary Commission, Fairfax Water, and other organizations addressing regional water issues (e.g. Metropolitan Washington Council of Governments, Interstate Potomac River Basin Commission).

Program Design (flexible): Program design may include:

- presentations by area agency and utility staff to provide an overview of area water resources, water infrastructure, regulations, funding programs, and related water quality and water use management issues
- activities for policymakers to test and enhance their understanding of water and their board participation skills, such as developing policy, talking with the media, developing and voting on motions
- field trips to gain a first-hand understanding of water features and facilities in the region
- an opportunity for a retreat (possibly combined with field trips) for DC Water board members to know each other and key staff, to discuss DC Water's mission and their role and responsibilities
- additional activities, as funding/in-kind support becomes available, may include boat tours, receptions or other networking events through which board members can interact with key water stakeholders in the region.

- Program may be divided into three components: 101 (basic DC area water overview); 201 (board member skills); and 301 (integration of water with other issues).

Support and Timeline: Initial funding for program development has been provided by a US Geological Survey (USGS) seed grant through DC Water Resources Research Institute (DCWRRI), with participating entities and other supporting organizations to provide matching funds; payment for food, materials, and other resources; use of meeting space; and other cash and in-kind support; as well as faculty time and other support provided by UDC.

- July 2011: Initial funding available.
- July-September 2011: Program planning, coordination with DC Water
- October-December 2011: Program execution
- January-February 2012: Program evaluation and reporting to USGS and DC Water

APPENDIX D

DESCRIPTIONS OF OTHER WATER LEADER PROGRAMS:

AWWA Public Officials Program

The Water Education Foundation Water Leaders Class

The Colorado Foundation for Water Education Water Leaders Program

AWWA Public Officials Program

The AWWA Public Officials Program at AWWA's Annual Conference and Exhibition is designed for and by public officials, geared strictly for their interests as water/sewer board commissioners, mayors and councilpersons. This is the only program of its kind.

The program focuses specifically on water issues and provides elected and appointed public officials with ongoing professional development and a platform for networking opportunities with other policy leaders. It is designed to develop and enhance critical skills and abilities necessary to achieve excellence in organizations, and to enhance communication and sharing between public officials from diverse communities.

From June 12th through June 16th 2011, commissioners, mayors, city council members and other elected and appointed officials discussed and debated finance, management and sustainability during the American Water Works Association's Annual Conference and Exposition in Washington, D.C. For the third year, public officials had the opportunity to earn the AWWA Public Officials' Certificate by participating in three 4-hour courses June 12, 13 and 14. Content for the June 14 course, "Financing Your Water and Sewer Utility in the Future," was an entirely new course, allowing those who have already earned the certificate an opportunity to further expand their knowledge. Courses 1 and 2 included "Introduction to Water and Sewer Operating Environments" and "Water and Sewer Infrastructure, Operation and Maintenance." Renowned water educator Frederick Bloetscher, PhD, P.E., author of *Water Basics for Decision Makers*, led the course. Additionally, Public Officials had an opportunity to discuss common concerns and share ideas in a relaxed setting during a public officials reception, a networking event held mid way through the program.

The Water Education Foundation Water Leaders Class

The **William R. Gianelli Water Leaders Class** is a one-year program that identifies up-and-coming community leaders from diverse backgrounds, including members of minority and ethnic communities, and educates them about water issues. The program enhances individual leadership skills and prepares participants to take an active, cooperative approach to decision-making about water resource issues. Leading stakeholders and top policymakers serve as mentors to class members.

Designed as a program for working professionals, participation involves a **time commitment** from both the class member and the employer. Class members are required to:

- Attend a special one-day class orientation in January;
- Attend two Foundation water tours (each tour is three days);
- Attend the Foundation's 1-1/2 day Executive Briefing in the Spring;
- Spend a day “shadowing” a major water leader (from government, urban, agriculture,
- environmental organization, private businesses, or public interest group);
- Interview the water leader about an issue selected by the class;
- Attend a special meeting in August to develop a class PowerPoint presentation about the assigned water topic;
- Attend the Foundation's Winter Board meeting to present the PowerPoint.

The William R. “Bill” Gianelli Water Leaders Class is primarily funded through grants, with partial support from tuition fees. Tuition is $3,000 for the year-long program, which helps to cover attendance at Foundation events. Each year, some scholarship funding is available, including the William R. “Bill” Gianelli, Jean Auer, Dave Kennedy and Tom Graff scholarship funds.

The 2011 class included professionals with careers in environmental planning/engineering, public/private water utilities, legislative, agricultural, legal, and state/federal agencies and organizations. The theme that ties all the Water Leaders together is water and the key role that water plays in each of their professions. Through this program the Water Leaders have the opportunity to learn from other professionals with different backgrounds and expertise to develop a broad, holistic understanding of water-related issues.

Each Water Leader was partnered with a Mentor with a leading role in California water issues. Just as the group of Water Leaders represents a wide spectrum of interests in water, Mentors also come from diverse backgrounds and provide a range of perspectives related to current water issues. The Mentors for the 2011 class include policy makers and advocates, public agency officials, agricultural and urban water users, and habitat advocates.

The Colorado Foundation for Water Education

The Colorado Foundation for Water Education is committed to providing education and leadership opportunities to professionals throughout the West. The Water Leaders Program was created in 2006 to offer emerging Colorado professionals the opportunity to develop their leadership potential with a focus on water resources issues. The year-long program has since provided training in conflict resolution, communication and negotiation to participants from across Colorado. The program also includes extensive self-assessment and networking opportunities.

The Water Leaders course is open to any mid-level professional in Colorado with an interest in water resources and career development. Candidates must exhibit clear leadership potential within their own organization, on-the-job experience in a leadership position, commitment to understanding water issues, and interest in seeking leadership roles on public boards and commissions or have the potential for advancement to key leadership roles within their own organization.

The program's focus is on personal and professional leadership skills, networking and career development. Leaders are expected to leave the program with: a better understanding of strengths and how to exploit them, challenges and how to work on them, skills to enhance staff and team management work, and a network of peers to further career growth.

APPENDIX E

SUMMARIES OF DC AREA WATER BOARDS/COMMITTEES:

Metropolitan Washington Council of Governments

DC Water

Washington Suburban Sanitary Commission

Metropolitan Washington Council of Governments

For more than 50 years, the Metropolitan Washington Council of Governments, known as COG, has helped develop regional solutions to such issues as the environment, affordable housing, growth and development, public health, child welfare, public safety, homeland security, and transportation. Founded in 1957, COG is an independent, nonprofit association comprised of elected officials from 22 local governments, members of the Maryland and Virginia state legislatures, and members of the U.S. Congress. COG is supported by financial contributions from its participating local governments, federal and state grants and contracts, and donations from foundations and the private sector.
Policies are set through the COG Board of Directors, the National Capital Region Transportation Planning Board, and the Metropolitan Washington Air Quality Committee. These three boards are responsible for a broad range of issues under the COG umbrella. Supporting committees help shape programs through the dedicated work of a wide array of public servants, from police chiefs to social workers.

Board of Directors

The Board of Directors is COG's governing body and is responsible for its overall policies, functions, and funds. Board members are appointed each year by the participating local governments and by caucuses of state legislative delegations from the region. Letters requesting appointments are sent to the heads of the legislative and executive branches. The current board consists of 31 members, four selected from the District of Columbia, three each from Fairfax, Montgomery and Prince George's counties, two from Prince William County, one from each of the remaining local jurisdictions, and one each from the Maryland and Virginia General Assemblies.
The meetings, which are usually two hours long, are held in the COG Board Room, 777 North Capitol Street, N.E., Suite 300, Washington, D.C. This Web site displays documents for upcoming and past meetings. Items on the agenda are normally generated from COG's policy and technical committees. The Board takes action on committee recommendations, discusses current and emerging regional problems, and receives briefings on issues facing the region. Board meetings are open to the public, and representatives from the media frequently attend.

District of Columbia

District of Columbia

Phil Mendelson, Council Member Vice Chair	Michael A. Brown, Council Member Member
Allen Lew, City Adminstrator Principal Member	Vincent Gray. Mayor Member

Maryland

Montgomery County

Isiah Leggett, County Executive Member	Roger Berliner, Council Member Member
Valerie Ervin, Council President Member	

Fredrick County

David P. Gray, Commissioner Vice President	Karen Young, Board of Alderman Member

City of Gaithersburg

Cathy C. Dryzgula, Council Member Vice President	Sidney A. Katz, Mayor Member

Prince George's County

Andrea C. Harrison, Council Member Vice Chair	Karen Toles, Council Member Member
Rushern Baker, County Executive Member	

Prince William County

Frank J. Principi, Supervisor Vice Chair	W.S. Wally Covington, III, Supervisor Member

Bowie

G. Fredrerick Robinson, Mayor Member

College Park

Andrew M. Fellows, Council Member Member

Greenbelt

Judith F. Davis, Mayor Member

Rockville

John Britton, Council Member Member

Takoma Park

Bruce R. Williams, Mayor Member

Virginia
City of Manassas

Sheryl L. Bass, Council Member Secretary-Treasurer	Suhas Naddoni, Council Member Member

Fairfax County

Penelope A. Gross, Vice Chair Member	Dan Dummond, Council Member Member
Sharon Bulova, Board Chairman Member	John W. Foust, Supervisor Member

Arlington County

Walter Tejada, Board Member Member

Alexandria

William D. Euille, Mayor President

Falls Church

Nader Baroukh, Mayor Member

Loudoun County

Andrea McGimsey, Supervisor Member

Virginia General Assembly

James M. Scott, Delegate Member

Andrea Harrison, COG Chair.
Ms. Harrison has served as the District 5 Council Member on the Prince George's County Council since 2008. She had served as COG Vice Chair for the past two years.

Frank Principi , COG Vice Chair.
Mr. Principi has served as the Woodbridge District Supervisor on the Prince William Board of County Supervisors since 2008.

Phil Mendelson, COG Vice Chair.
Mr. Mendelson has served as a Council Member At-Large of the Council of the District of Columbia since 1998. He has previously served as both COG Chairman and President.

DC WATER

DC Water distributes drinking water and collects and treats wastewater for more than 600,000 residential, commercial and governmental customers in the District of Columbia. DC Water also provides wholesale wastewater treatment services for a population of 1.6 million in Montgomery and Prince George's counties in Maryland, and Fairfax and Loudoun counties in Virginia. We are proud to provide these vital, safe, and high-quality services to our customers, while also protecting and enhancing our environment.

To distribute drinking water, DC Water operates more than 1,300 miles of pipes, four pumping stations, five reservoirs, four elevated water storage tanks, 36,000 valves and 9,100 public hydrants. To collect wastewater, DC Water operates 1,800 miles of sanitary and combined sewers, 22 flow-metering stations, and nine off-site wastewater pumping stations. To treat wastewater, DC Water operates the Blue Plains Advanced Wastewater Treatment Plant, the largest advanced wastewater treatment facility in the world.

Board of Directors

DC Water is governed by a Board of Directors consisting of 11 principal and 11 alternate members. The Board is composed of six District of Columbia representatives, two each from Montgomery and Prince George's counties in Maryland, and one from Fairfax County in Virginia.

The Mayor of the District of Columbia appoints, and the DC Council confirms, all six District Board members and alternates, including the Chairman. In addition, the Mayor appoints the five principal and alternate members who represent the surrounding jurisdictions based on executive submissions from those jurisdictions.

DC Water may only take action on policy matters after it receives a favorable vote of no less than six members of the Board of Directors. All Board members participate in decisions directly affecting the management of joint-use facilities. The District of Columbia members participate in those matters that affect District ratepayers and in setting fees for various services.

Members

District of Columbia	
William M. Walker, Chairman Principal Member	Vacant Alternate
Allen Lew Principal Member	Vacant Alternate
F. Alexis H. Roberson Principal Member	Howard C. Gibbs Alternate
Alan J. Roth Principal Member	Brenda Richardson Alternate
Alethia Nancoo Principal Member	Howard Croft Alternate
Adam Clampitt Principal Member	Joseph Cotruvo Alternate
Prince George's County	
Bradford Seamon Principal Member	Samuel Wynkoop Alternate
Carla Reid Principal Member	Dawn Hawkins-Nixon Alternate
Montgomery County	
Timothy L. Firestine Principal Member	Kathleen Boucher Alternate
Robert Hoyt Principal Member	David W. Lake Alternate
Fairfax County	
Anthony H. Griffin Principal Member	James Patteson Alternate

Board Secretary: Linda R. Manley

William Walker, Chairman, District of Columbia

William M. Walker is Chairman of the Board of Directors for the District of Columbia Water and Sewer Authority. He is Chairman and Chief Executive Officer of Walker & Dunlop, Inc., (NYSE: WD) a commercial real estate finance company. Walker & Dunlop is one of the largest apartment lenders in the United States with significant Fannie Mae, Freddie Mac and HUD origination and servicing expertise

Mr. Walker's board experience is extensive including Chairman of the Board of Transcom Worldwide S.A., a publicly traded European outsourcing company, as well as Chairman of the Board of Walker & Dunlop, Inc. Mr. Walker also sits on the Board of Directors of Sustainable Technologies Fund, a Swedish clean-tech venture capital firm. He is a

member of Young Presidents Organization (YPO), the Mortgage Bankers Association (MBA), and the Urban Land Institute (ULI).

Allen Lew, Principal Member, District of Columbia

Allen Y. Lew was appointed as District of Columbia City Administrator by Mayor Vincent Gray. He is a highly respected manager with more than 25 years of executive-level leadership as an administrator, problem solver and trouble shooter in both private and public sectors.

He has served as Executive Director of the District of Columbia Office of Public Education Facilities Modernization (OPEFM) where he dramatically affected the school construction program in the nation's capital. Since his appointment in June 2007, Mr. Lew orchestrated over $1 billion of construction and renovation work on DC Public Schools.

Alexis Roberson, Principal Member, District of Columbia

Ms. Roberson has extensive experience in leadership positions in local government management with the District of Columbia Department of Recreation and Department of Employment Services.

Ms. Roberson has served on numerous boards and commissions including the Board of Director of the Employee Compensation Appeals, NAACP, District of Columbia Chapter, Washington, DC Urban League, United States Youth Games, Kennedy Center of the Performing Arts, District of Columbia Board of Appeals and Review and the University of District of Columbia Intercollegiate Athletic Advisory Board.

F. Alexis H. Roberson is the President/CEO of the Opportunities Industrialization Center (OIC) of DC and is responsible for the development and implementation of comprehensive pre-vocational and vocational training programs. She also serves a business development consultant for small companies by providing marketing strategies to acquire new business ventures.

Alan J. Roth, Principal Member, District of Columbia

Alan Roth brings 23 years of senior congressional staff and government relations consulting experience to his work in legislative and regulatory advocacy in the telecommunications arena. Before entering the private sector, he served as Staff Director and Chief Counsel to the Committee on Energy and Commerce, U.S. House of Representatives, from 1992 to 1994, and its Chairman, Rep. John D. Dingell (D-MI), and to the Committee's Minority from 1995 to January 1997. Prior to those management roles he was a Counsel to the Committee from 1985 to 1992. Currently, Alan Roth is Senior Executive Vice President of the United States Telecom Association in Washington, DC.

Alethia Nancoo, Principal Member, District of Columbia

Ms. Nancoo is a member of the DC Chamber of Commerce Board of Directors serving in her capacity as General Counsel to the Chamber. Alethia has broad experience in the areas of municipal and corporate finance and disclosure and represents clients in connection with a wide range of financings, including revenue-based and general obligation bond financings, asset-backed taxable and tax-exempt financings, revenue anticipation bond and note financings and other complex, structured public financings for major governmental acquisitions and capital improvement programs. Her experience includes public finance transactions for airports, state departments and water authorities, cities and counties, housing authorities, special districts, and various other municipal issuers, nonprofit corporations, and investment banking institutions.

Adam Clampitt, Principal Member, District of Columbia

Adam Clampitt is a strategic communications and public relations consultant who has spent the past decade leading communications efforts and providing expert counsel and brand management to a variety of public and private stakeholders. Mr. Clampitt develops and implements integrated communications strategies for clients, overseeing long-range initiatives to improve organizational reputation through both traditional and digital means. Current and past clients include the National Association of REALTORS®, DynCorp, Quicken Loans, the American Resort Development Association, Wal-Mart Stores, the North Atlantic Treaty Organization (NATO), the United States Department of Veterans Affairs, and the United States Navy. Mr. Clampitt worked for Gen. Stanley McChrystal as the Director of Public Affairs Planning and Social Media for the NATO-led International Security Assistance Force in Kabul, Afghanistan.

Bradfor Seamon, Principal Member, Prince George's County

Bradford Seamon is the Acting Chief Administrative Officer for Prince George's County. Mr. Seamon has also served in roles for the Office of the County Executive as the Deputy Chief Administrative Officer (DCAO) for Health, Human Services and Education, as well as the DCAO for Budget, Finance and Administration. Prior to his service in the County, he served as Senior Staff Auditor at Deloitte. Mr. Seamon has 20 years of experience as Chief Executive Officer for a professional services firm managing Human Resources, Information Technology, and Finance and Business Development departments. He has conducted federal grant compliance reviews and is experienced with healthcare programs and underserved communities.

Carla Reid, Principal Member, Price George's County

Carla Reid is the Deputy Chief Administrative Officer for the Office of the County Executive, Prince George's County. Ms. Reid has over 21 years of experience leading organizations, which includes serving as Deputy General Manager of the Washington Suburban Sanitary Commission. Previously, she served as the Director of Permitting Services in Montgomery County Government.

Timothy Firestine, Principal Member, Montgomery County

Timothy L. Firestine is currently serving as the Chief Administrative Officer for Montgomery County, Maryland. He has

worked in public sector financial management for 28 years. Firestine has spent most of his career with Montgomery County where he worked in the Office of Management and Budget for 12 years before becoming the Director of the Department of Finance in 1991. In 2006, he was appointed Chief Administrative Officer of the County.

Mr. Firestine is a member and past president of the Maryland Government Finance Officers Association; chairman of the Board of Investment Trustees for the Employee Retirement System for Montgomery County; and the Government Finance Officers Association where he serves as Vice Chair of the Debt Committee.

Robert G. Hoyt, Principal Member, Montgomery County

Robert G. Hoyt serves as the Director of the Department of Environmental Protection in Montgomery County, Maryland. He oversees four divisions comprising solid waste management, watershed management, and environmental policy and compliance, and water and wastewater management with a combined budget of approximately $120 million. He co-chairs the Sustainability Working Group, which has broad representation from among the community, businesses, and other interest groups and drafted the County's Climate Protection Plan. He leads the coordinated response to the state of Maryland-issued municipal separate stormwater permit that covers runoff in most of the County including all public school property. He represents the County at regional water and sewer utilities and commissions. He is responsible for County programs and legislative initiatives on energy, air quality, noise, climate change, litter, streams/watersheds, stormwater and more than a dozen other areas that impact the environment.

Before serving in local government, Hoyt formerly served as Assistant Secretary of the Maryland Department of the Environment. In 2001, Hoyt co-founded the EcoLogix Group, Inc., which provided environmental policy guidance to clients including government agencies, businesses and environmental organizations. Previously, Mr. Hoyt was Senior Vice President for the Chesapeake Bay Foundation, where he developed and oversaw the Strategic Plan. He was also a Deputy Attorney General for the New Jersey Division of Law.

Anthony H. Griffin, Principal Member, Fairfax County

Anthony H. Griffin serves as the County Executive for the Fairfax County Government in Virginia. Mr. Griffin joined the Fairfax County Government in 1989 when he was appointed to the position of Deputy County Executive for Planning and Development. Prior to the time, he served as the Falls Church City Manager from 1983 to 1989. Previously, he also served as Acting County Manager and Deputy County Manager of Arlington County, Virginia.

Washington Suburban Sanitary Commission

WSSC is the 8th largest water and wastewater utility in the nation, serving nearly 1.8 million residents and approximately 460,000 customer accounts in Prince George's and Montgomery counties over an area of nearly 1,000 square miles. We operate and maintain eight water and wastewater plants, more than 5,500 miles of fresh water pipeline and nearly 5,400 miles of sewer pipeline. We currently employ approximately 1,500 people. In our more than 90 year history, our drinking water has always met or exceeded federal standards.

WSSC operates and maintains 3 reservoirs – Triadelphia, Rocky Gorge and Little Seneca with total holding capacity of 14 billion gallons (Note: Jennings Randolph Reservoir holds an additional 13 billion gallons of water shared with Fairfax Water and the Washington Aqueduct); 2 water filtration plants – the Patuxent (max 56 million gallons per day MGD) and the Potomac (max 285 MGD) plants produce an average of 167 million gallons per day (MGD) of safe drinking water; 7 wastewater treatment plants – Western Branch, Piscataway, Parkway, Seneca, Damascus, Marlboro Meadows and Hyattstown, with a total capacity to handle 74.1 million gallons of wastewater per day. The Blue Plains Advanced Wastewater Treatment Plant, operated by DC Water, handles as much as an additional 169 MGD under a cost sharing agreement with the WSSC, treating on average approximately 65% of the Commission's wastewater annually and more than 5,500 miles of water main lines and nearly 5,400 miles of sewer main lines.

Governance
Commissioners are appointed to four year terms by the County Executive of either Montgomery or Prince George's County. Commissioners are subject to confirmation by the County Council of the county from which they are appointed. Each county appoints three Commissioners.

Commissioners

Dr. Roscoe M. Moore, Jr. Chair, Montgomery County

Dr. Roscoe M. Moore, Jr., was appointed as a WSSC Commissioner from Montgomery County in June 2008 to fill the unexpired term of Montgomery County Commissioner Norman E. Pruitt who resigned in March. Moore is an internationally recognized Doctor of Veterinary Medicine with extensive experience and credentials in epidemiology

Gene W. Counihan, Montgomery County

Gene W. Counihan was appointed as a WSSC Commissioner from Montgomery County in October 2007. Mr. Counihan has lived and worked in Montgomery County since 1963. His career includes elected and appointed positions in state, regional and county government and 29 years as a teacher and administrator in the Montgomery County Public Schools.

Commissioner Counihan was elected to and served three, four-year terms in the Maryland House of Delegates. After leaving the legislature in January 1995 Mr. Counihan worked as a special assistant to Governor Parris Glendening before becoming the Maryland Government Relations Officer for the Washington Metropolitan Area Transit Authority (WMATA). In this capacity he worked with Montgomery and Prince George's county officials and the state legislature to secure funding to build, operate and maintain public transit services in the Suburban Maryland Region.

Adrienne A. Mandel, Montgomery County

The Honorable Adrienne A. Mandel was appointed as a WSSC Commissioner from Montgomery County in October 2007. She was elected to serve as chair of WSSC at the October Commission meeting. Ms. Mandel retired from the Maryland Legislature in 2007, after serving three four-year terms as a State Delegate from Montgomery County's Legislative District 19.

Ms. Mandel authored landmark legislation in the areas of highway deaths and injuries, regulation and oversight of WSSC, services and programs for the elderly and expanded access to quality, affordable health care. For seven years, she was Delegation Chair of the Bi-County Committee with jurisdiction over the WSSC. Ms. Mandel was elected president of the 64-member Women Legislators of Maryland and served on the Executive Board of the National Foundation for Women Legislators.

Christopher Lawson, Vice-Chair, Prince George's County

Chris Lawson, President and Principal of Insuraty, Inc. is a CPLH licensed Insurance Broker and Advisor serving some 75 small and mid-sized companies in the area of employee benefits consulting, brokerage and administration including 401k retirement plan advisory and administration. Mr. Lawson has served on the Board of Directors for the Prince George's Chamber of Commerce and was presented with the distinguished service award in 2006. Mr.

Lawson was an original member of the Washington, D.C. Board of Directors for the National Association of African American Insurance Agents in the capacity of Vice President. He is a current member of the Society for Human Resource Management and the National Association of Health Underwriters.

Antonio L. Jones, Prince George's County

Mr. Jones was appointed as a WSSC Commissioner from Prince George's County on September 9, 2009, where he has worked tirelessly with other commissioners to set utility policies and maintain adherence to prevailing laws. In his 32 years of progressive management and operations experience, Mr. Jones has worked for a number of Fortune 100 companies, including Lockheed-Martin, AlliedSignal and Honeywell Technology Solutions, Inc. He has managed Spacecraft Engineering and Operations, and Community Outreach programs with National Oceanic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration (NASA). He has logged over 1,500 hours facilitating corporate-sponsored training initiatives, including total quality management and performance management training for hundreds of employees.

Melanie Hartwig-Davis, AIA, LEED AP, Prince George's County

Melanie Hartwig-Davis, Principal at HD Squared Architects, LLC, possesses outstanding qualifications and expertise. Hartwig-Davis has emphasized the importance of sustainable building practices since architecture school as exhibited by her platform as a National Director of the American Institute of Architecture Students (AIAS). Upon receiving her MD Architectural license, she began her own architectural practice in Cheverly, MD. Her projects include interior and exterior renovations and additions that address client need, as well as budget and environmental sensibility, by improving energy efficiency. Careful selection of materials for maximum indoor air quality, recyclability and durability are features that Ms. Hartwig-Davis includes in her designs to promote sustainable and healthy living. In the fall of 2008, she earned the title of LEED Accredited Professional to formalize her commitment to sustainability in architecture. In 2010 she was appointed by Governor O'Malley to the Maryland State Board of Certified Interior Designers and served on that Board until May 2011.

Timeline:
1st reaching out to MWCOG to be a partner in the project:

As of beginning of May: Howard contacted Stuart at COG to set up a conference call

6/7/11: Spoke with Stuart from MWCOG

- Can't respond to all materials
- Apologizing that overloaded with things to deal with worthy proposal initiative
- Best I can do is talk to staff people, carve out time to get answer.
- Have a face-to-face or conference call, walk us through program, read or don't read.
- Come to a conclusion, get a timetable, get back in day or so.

6/7/11: Meeting with Tanya (COG)

- Tayna stretched in budget.
- Want to ensure we have permission to work with COG. What can we say about our relationship and how would that be characterized.
- Final budget being reviewed now. What we can cover, what we can't cover.
- Can always say yes, divert staff time to support.
- Will get something back for AWWA what we can say.

6/8/11 phone convo with Greg about AWWA public officials program.

- About registration and getting into the breakfast and reception.
- Course was full.

At this point recommendation how to go forward with the program:

With respect to the agenda for OUR program, I think that we should NOT get too specific at this time, but focus instead on more general announcements of the program and ensure we will have ACCESS to speakers and public officials at AWWA, and buy-in from MWCOG for us to work together in concept (so we can include their name on our initial announcements). With respect to the TYPES of issues we will cover, we identified several likely topics in the proposal, and can also refer to the DCAWIP program for potential topics and speakers. However, I believe we would have far more BUY-IN from the area water boards, etc. if we ASKED THEM for topics they want to have covered as part of our initial conversations from them, so that they feel they are part of the program development and that we are being responsive to THEIR needs.

6/21/11 conference call with MWCOG:

Question or suggestion from Steve Beiber:
with a gap analysis, working with the utilities, program people in local government, their board members knowledge, where there are gaps, some level of orientation, don't want to repeat it. Focus efforts on what not already getting. Get buy=in of utility staff and program people, show how complementary, not duplicate it. Suggest as a first. We talked about a survey tool. Only preliminary conversations.

Tanya: we already have in our work program, plans to do Potomac forum, potential to do something there. Related to steve's we have elected officials and utility folks who do know these things. 2 clear audiences we would start with, water officials from boards, those officials that are newly appointed in that capacity, also newly elected public officials with oversight responsibility.

Stuart, this conversation very informative, appreciate your thoughts. We need to talk internally on our end. Need a gap analysis. Similarly, market research needed here. We have one group of people to work with here. Committee, PIO, work for W&WW, local governments. Key players. Talk with them as a source of information and feedback. A couple elected officials, chair of Chesapeake bay and WR policy committee. Comment is want to partner with UDC to work together on something. Uncertain about how

interested the audience is in spending this amount of time on this issue, would need to come up with compelling partnership. Don't feel know enough. We ought to think about that. Like to be in the room to do that.

6/23/11 Follow up email with Stuart and Tanya.

- Attached the proposal.
- Outlined what the project was.

Regarding the basic structure of the program, some essential elements we see are:

- A one-day (possibly 2-day) intensive "academy" called Water 101 – we need to determine when participants and speakers would be available
- A one-day follow-up program to bring the participants back together -- especially if we have participants work on hands-on projects (e.g. come up with a hypothetical regional workplan on a water issue)
- If we can get something together by mid-June, a possible initial meeting with top water policymakers from around the country who will be in town for AWWA (WEF, WateReuse, AMWA, and Water Research Foundation will all be in town with their own meetings during AWWA – we need to start coordinating that soon)
- Additional "experiential learning" and "community building" activities such as tours of key water features and/or social events with key water stakeholders around tours, field trips, etc.

We have talked with a number of area organizations about this program and have several possibilities for donations of time, meeting facilities, etc. but most of these organizations work with MWCOG anyway – if possible, we'd prefer to coordinate through MWCOG. Again, we're flexible at this point on most of these options and opportunities.

RESULT from MWCOG:
(To David Bardin) Tanya and Stuart decided we should work instead with DC Water, and we started over with a one-page proposal and request for a meeting with DC Water at the end of June (see one-pager sent to George/Alan). I attended my first DC Water Board meeting the first week of July, and recommended changes that would be more in alignment with the activities and focus areas of the board. We were told to wait until after the August recess to get word back from the GM. Howard and I were at the September meeting (where you and I talked), but have received no decision yet on whether DC Water will work with us.

After MWCOG rejected the proposal, focus switched to DC Water, as MWCOG recommended:
7/7/11 DC Water board meeting:

- use facebook to reach out to public
- NACWA conference – many of us going.
- Principal advocate in DC, national advocate on issues that matter to us.
- AWWA is support network on knowledge, less advocacy.
- George nominated to be member of executive committee of NAWCA. Will be in Chicago in July, chair of money matters task force, band together with authorities around the country, increases all authorities, disproportionately hitting population, whether dollars smartly spend, we are greenest organizations in country, but in a point where decreasing return, investments not smart, more effective in other areas. Never have enough time but good investment
- Walker went to AWWA, many comments on George and dc water, praise.
- *See note below with follow up email to Howard.*

7/17/11 Email correspondence with Howard about a DC Water board meeting that Cat just attended the week before.

We may want to seriously re-think the topics we cover – please be sure to let the GM's office know that we can be flexible on the topics as needed. It seems that the GM is really trying to enlist the Board in his effort to rebrand and re-direct the entire "ethic" of the organization. There are 3 separate entities we are

dealing with here – the Board, the GM's office, and the staff. The GM is apparently making some big shifts in how he uses his staff, and in how he controls what work the Board creates for the staff to do.

FYI, some of the range of topics covered at the Board meeting include (just a quick survey from my notes):

- Procurement especially using local businesses – and the difference between hiring local and using disadvantaged businesses
- Plant performance and consent order
- Capital improvement program
- Rate stabilization, "surplus" and "true-up" with retail and wholesale water users (note: lots of time spent on financial issues with CFO called to the mic several times)
- Board member etiquette and procedures (note: definitely opportunity for improved intraboard relations and discussions that are better held away from public meetings, if board members willing to do a retreat of some sort)
- Better public distribution of monitoring results and what they mean (public doesn't understand the significance of levels of lead, copper, etc. in reports) – reports too constrained by EPA reporting requirements, not doing enough to interpret for public
- Success of Tap-it program – restaurants using DC tap water – and of ads on trucks
- Use of facebook and friending DC Water on facebook
- Bardin's retirement and whether he can be hired as a consultant (note: it might be helpful to work with retiring board member on MWPOWA)
- AWWA conference
- Rebranding campaign and change in "ethic of enterprise" from Board to staff, all levels
- New Organizational Development program (NOTE: OD is very effective – we might arrange a demonstration for the Board of OD from DC Water OD staff)
- Automatic metering program
- PR around changes in rates – not communicating rate increases well.

Charles also does the tours for new Board members, which some of the current Board members still haven't taken, and he won't do any until all of the new Board members are on board – so we may have a good opportunity to plan a tour for Board members combined with other activities.

09/01/11 DC Water board meeting, Cat and Howard attended:

- Two new board members: adam clampett. City administrator Lew.
- Honor of thanking one of longest term board members, a little time, board breakfast to thank david bardine over 10 years. If you'd been at breakfast, heard directors talk about david's dedication, energy, focus on his role to DC water and sewer authority board. Gave more to this board than any other, raise bar to level almost impossible to jump. Attended almost every committee meeting.
- Environmental highlight: In 3 years gone from outlined by Chesapeake bay foundation, total nitrogen levels, hovered around XX million pounds a year. 8.74 required. Don't need to hit target until 2013 but we are there now. Amount this plant put into river, ½ what required by permit. Already at 2015 levels. Great achievement for authority.
- Discussed hurricane and earthquake prep/ stability.

Continue to try and reach out to DC Water as well as WSSC.

9/24/11 Meeting with Howard.

- Target population has been changed. Initially through MWCOG. Now focused on DC Water.
- DC Water is just one aspect of the public water managers that we said we want to target.

- Washington aqueduct, Tom Jacobus.
- Joe Hoffman retiring, someone to replace him.
- WSSC.
- Survey based on expected outcomes of academy. Even if 10 individuals, specific work to work with.
- White paper, interviews

Design a program, survey whether people would want information. Feedback
Given that we currently have no institutional arrangement for an "audience" of public officials to participate in MWPOWA, despite our efforts to work first with MWCOG (as per original proposal), then with DC Water, we discussed alternative approach to completion of this pilot program:

1) Confirm DC Water is not interested in incorporating MWPOWA into their orientation for new board members and board retreat (for all board members) at institutional level (Howard). We will not attempt to integrate MWPOWA into another existing orientation program, but will reach out to other organizations with new board members to identify potential participants for a regional academy program (e.g. WSSC and Washington Aqueduct).
2) Prepare a review of current approaches education/orientation for water boards, including summary of national examples but focus on DC area boards, and review the role/activities of board members and other public officials with examples from DC Water as well as MWCOG, IPRBC (Cat).
3) Contact and meet with newly-retired DC Water Board Member Dave Bardin for his insights into the development of a board member education program (Cat).
4) Put together a draft program and options for how to execute (Cat and Howard).
5) Compile a list of board members to include in pilot program (Cat/Howard/intern).
6) Complete a survey of board members (new ones as well as ones with more experience) with "you have been selected as a leader…" letter, to gain input on topics to cover as well as check on logistical options (potential dates, Saturday vs. weekday evenings, retreat vs. in-town location)(Cat/Howard/intern)
7) Based on responses and findings, finalize program, select date/location and begin promotion. Note that program may not occur until early 2012, depending upon how long it takes to develop program and gain buy-in from area water boards/organizations to encourage members to participate. We may extend this project a year and request a 2nd grant.

10/4/11
Howard had a chance to talk with Jerry Johnson yesterday, and that he is interested in receiving the one-pager on the program. Attached is my revised version of the one-pager. At this point, in light of the late date of starting with another area water provider, and the planning that would be required for a tailored program, and the time of year (running into holidays and bad weather, not great for field trips), I do not feel we can offer some of the additional receptions, boat tours, and other activities we had previously offered to MWCOG and DCWater. If WSSC were planning its own orientation (please let me know whether you discussed that in your conversation with Jerry), we may be able to work with their existing board staff on augmenting their current board member orientation or retreat, if the timing works with our schedule and theirs. If WSSC is willing to be the local champion for this effort, to host an event and ensure participation of their board members, and to invite other area public officials as well, for a program that focuses on regional cooperation and innovation, that could be worthwhile. As you know, this contract had only budgeted for 80 hours of my time, which has been used through the various meetings necessary with MWCOG, DC Water, UDC/DCWRRI and other potential participants in this academy. In order to ensure that we reach a rapid resolution to the question of how we will complete this project, it is essential that I be copied on any correspondence with WSSC, receive copied of any emails you receive, and be included in conversations with WSSC to determine what we can do with the limited remaining time and resources

If things don't work out with Jerry, our final effort is likely to consist of :

1) a summary report of the current policy leadership in the DC area and current approaches to public officials orientation and activities
-THIS HAS TO BE THE FOCUS OF OUR REPORT.

2) a one-time gathering of public officials from throughout the area, possibly with a panel of speakers, opportunity for introductions by all officials, and opportunity for interaction through a lunch and/or reception. We may need to call this a "forum" rather than an "academy." I can possibly secure a space and sponsor for an event like this, likely to be held in early to mid-January after the holidays, if I can start planning for it within the next week (we may also need to check back with MWCOG with this change in format, as this may be getting into their turf).

10/6/11 Cat attended DC board meeting.

(from minutes) Ms. Caldwell summarized the DC Water approach to the Blue Plains Tunnel. The approach included the following goals:

(i) keep local project dollars local
(ii) encourage the First Source Agreement goals of having 51% of new hires be DC residents and having 35% of apprenticeship hours be performed by DC residents;
(iii) encourage hiring opportunities for residents of the user jurisdictions
(iv) encourage the use of district-based and user jurisdiction-based MBE/WBEs
(v) achieve the MBE/WBE goals of 28%/4% for professional services and 32%/6% for construction and related services
(vi) submit contractor monthly reporting in a timely manner, to keep community partners informed but expressed concern about the definition of the term 'new hire' and the fact that there are few openings for 'new hires' and that the fundamental problem is not being addressed.

Current and Upcoming Presentations.
The fall season includes a wide range of speaking opportunities for DC Water to continue to advance our story. As always, I'm honored to continue representing the people and work of Team Blue to our customers, external stakeholders and industry peers. Highlights include addressing groups as varied as the Chesapeake Water Environmental Association, the Autovation Smart Utilities conference, the Greening Greater Washington seminar, the American Metropolitan Water Association (AMWA) and the DC Building and Industry Association.
-somehow work this into the report?

The Committee on the status of appropriations for the Clean Rivers Project:
While the House Appropriations Committee, through the Financial Services and General Government Operations Appropriations Bill, provided no funding for the Clean Rivers Project, DC Water reached out to the Senate Appropriations Committee and was able to brief them in depth about the Project. The Governance Committee asked if the Clean Rivers Project appropriation would be reviewed by the congressional Super Committee. Ms. Turner replied that everything was going to be reviewed by that Committee. Ms. Turner noted that both DC Water's external and internal lobbyists were working this issue.
Ms. Turner next reported that Senator Benjamin Cardin (D-MD) and Chairwoman Barbara Boxer invited DC Water to testify before the Senate Environment and Public Works Committee to discuss the DC Water Digester Initiative as an innovative model deserving national attention. Ms. Turner noted that NACWA has finalized a working draft of its regulatory prioritization legislation which sets forth a process under the Clean Water Act to prioritize the growing array of regulations. The legislation is the product of the 'Money Matters Task Force' led by DC Water's General Manager, George Hawkins. Ms. Turner concluded her report on federal issues by pointing out that DC Water had filed comments on EPA's and the Army Corps of Engineers' Guidance Regarding Identification of Waters Protected by the Clean Water Act.

Cats notes:
Their commitment to hire local employees, wanted to make sure internal and 3rd party compliance aware that that's what focusing on and looking at in quarterly reports on regular basis. Roth: excellent summary. Only addition, interesting discussion, went back to debate here at board a couple months ago, related to definition of new hires. How many of these contactors are they bringing from outside area relative to totality of project, and what tiers, laborer, skilled laborers, managers, executives. Operate on real information not allegations. Very helpful to see those facts and figures. Benefit all of the user jurisdictions. Breakdown of employment of construction contracts. Interesting document. Not seeing a lot of hiring from CA, OH. DC doesn't have as much hiring as we would like. Sorry city administrator not here, starting new process with city administrator, employment program targeting specific jobs. Funds to district, particular effort, train people for particular jobs. Where are the actual people working here. Focus on individual employees. Staff at DC Water not grown, but a ton of contracting that brings in employment opportunities. Are those new hires? Is I new person or someone who was moved to a new position.

Retreat: working on date, tentatively November 1

- Enahce workforce development
    - Team blue
    - Vchangeing culture and improving processes, work as a team

Outreach/conservation:
First wanted to see, as raising head, get a lot more visitors, inquiring our place, go out into community, see and recognize. Tour guides, remarkable how may tours to blue plains, almost every week, international program here. One of best known in world. Recognize people who take their time to welcome folks. 2nd group of employees into schools, whole program into schools. sewer science team. 3rd group: Water conservation, work with over 2000 DC area homeowners, seeking how to conserve water, counterintuitive , less billing, but the right thing.

Thought:

- Start compiling a framework for the review,
- Reach out to boards, and offer the outline, and state an objective of identifying education needs for elected and appointed leadership on water in the Metropolitan Washington area.
- See if they want to consider program for next year.
- Organize by topic/subject area or by different entities.
- More interesting by topic area. 5-6 different topics.
- Most relevant water related topics.

Appendices by entity, main text by topic
- History (brief)
- Board member composition
- Selection process, term of office, and current membership
- Committees, types of decisions made by board
- Needs assessment

Email to Howard following the board meeting:

Before and after yesterday's DC Water Board Meeting, George Hawkins and William Walker and I had an opportunity to speak about the Metropolitan Washington Public Officials Water Academy project. Ultimately, this project is about leadership and the decision-makers on water related issues in the DC area, and on the current roles, activities, selection, and preparation of the individuals and boards,

commissions, and councils making these decisions. Before we can develop a program that meets the needs of these organizations, we need to have a solid understanding of "where they are now" and what their needs are for the future, and to have their buy-in on any education program to be developed to meet those needs.
-I think the report must bring to light this issue. This grant has allowed us to explore where they are now and what their needs are in the future.

Based upon the discussions with Chairman Walker and General Manager Hawkins, I would like to recommend the following course of action for this year's project:

- Perform an assessment and summary report on the current make-up of the boards, the backgrounds and water knowledge for the individual members, and the roles and responsibilities of the various organizations and boards with respect to water. (Note that we have already been doing this over the course of the year in trying to set up the academy.) This report will be prepared as an initial "primer" for elected and appointed officials to get to know the various decision-making bodies involved in water decisions in the DC Area.

4. Conclusions and Recommendations

- Working with the board/commission contacts we have made this year, evaluate the needs for future water education and coordination among elected and appointed officials in water. (If the board members' schedule permits, we may be able to prepare a presentation and set up a conference call for area board members to discuss our initial findings and invite discussion and feedback.)
- Work with DC Water, MWCOG, WSSC, DDOE, DC City Council, and other entities to develop a program to support continuing education and inter-board coordination, with their commitments to provide financial, in-kind, and participation support for a program for next year's DCWRRI grant. (NOTE: Howard, I am making arrangements to be able to attend the October 19 WSSC board meeting. Please confirm we can follow up with Jerry by then.)

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	3	0	0	0	3
Masters	8	0	0	0	8
Ph.D.	1	0	0	0	1
Post-Doc.	0	0	0	0	0
Total	12	0	0	0	12

Notable Awards and Achievements