D.C. Water Resources Research Center
Annual Technical Report
FY 2010

Introduction

This report summarizes the activities of the District of Columbia (DC) Water Resources Research Institute (the Institute) for the period March 1, 2010 through February 28, 2011. 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 complete renovation of the lab is expected at the end of February 2011. Our Water Quality Testing Laboratory will have 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 five year evaluation was completed and the review panel has recommended that the Institute be recertified for the next funding cycle. 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. 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 reports for the four projects funded are included in this technical report along with three progress reports. Dr. Choi, PI on Determining the Effectiveness of the Design-Build Method on Water Infrastructure Rehabilitation Projects in the District of Columbia relocated to another University in September 2010 and requested cancellation of the project. No report is submitted for this project.

Identifying major sources of fecal pollution in the District of Columbia from both combined sewage outlet (CSO) sites and non-point sources (NPS) is the purpose of Dr. David Morris's research project, The Application of Multiple Antibiotic Resistance Profiles of Coliforms to Detect Sources of Bacterial Contamination of the Anacostia River. The research links pollution-derived coliform levels, antibiotic resistance in mid-summer water samples, and suggests transference of resistance between human and/or animal-derived and natural-source coliforms. As few studies have been carried out to determine the variance of MAR profiles of fecal coliforms in tributary that was studied, the study will provide a comprehensive before and after assessment of fecal contamination in the watershed as projected revitalization continues.

Dr. Harriet Phelps's paper, Active (ABM) and Passive (POM) Chlordane Monitoring in the Anacostia River Watershed (MD), details the active biomonitoring and passive monitoring she employed to assess the presence of chlordane in the Sligo Creek Park watershed of the Anacostia River. Clams, minnows, and sediment were collected and the amounts of chlordane present in samples were analyzed. The use of both types of monitoring yielded a more complete picture of chlordane and other contaminants in the creek sites indicating, for example, the locations where Sligo Creek may be considered a potential ongoing source of chlordane contaminated sediment to the Anacostia tidal region.

Dr. Xueging Song analyzed three tributyltin compounds (TBTs) under varying pH conditions. Dr. Song's research in Speciation of some tributyltin compounds in Anacostia and Potomac River sediments using 119SnNMR spectroscopy, indicated that all TBTs first convert to a hydrated TBT species, with further decomposition depending on the speciation time and the nature of the sediments. As the presence of triorganotin in sediments has been regarded as long-term threat to marine and estuarine environments due to its persistence, understanding its fate in the environment is of primary importance to prevent its migration.

With their research project, A Hierarchical Spatio-Temporal Dynamical Model for Predicting Precipitation Occurrence and Accumulation, Dr. Ali Arab and Dr. Tolessa Deksissa address the problem of predicting occurrence and accumulation of precipitation, which is of considerable interest in many disciplines such as atmospheric sciences, agriculture, and hydrology, among others. The predictions based on climate models are often in a coarse resolution that is unable to provide accurate predictions for specific locations. Alternatively, statistical modeling of precipitation data can provide more reliable predictions at higher resolutions. There are several statistical models suggested in the literature, but most of these models ignore the spatial and/or temporal dependence of precipitation fields which results in lack of prediction accuracy. In this project, the authors developed a statistical method that yields predictive distributions for precipitation occurrence and accumulation while accounting for spatial and temporal correlation in the precipitation fields. The predictive distributions for precipitation accumulation can then be used to obtain exceedance probability of rainfall accumulation beyond a threshold in order to issue flash flood warnings, and optimize evacuation management in case of flooding events. The proposed modeling approach is based on a hierarchical modeling framework that allows breaking down a complex problem into simpler components that are linked together

probabilistically. The proposed approach was implemented using historic precipitation data in the Washington D.C. area.

Research for "Determination of Seasonal Source Variation of Hydrocarbons, Organics and Nutrients in the Anacostia River: Stable Isotope Ratios of Specific Compounds was carried out by Dr. Stephen McAvoy. This project analyzed seasonal nutrient dynamics and organic material sources of the Anacostia River to determine if a seasonal component to water nutrient concentrations and sources exists, and to identify biogeochemical controls within the river in order to discern which geochemical and nutrient variables are driving those controls. Water, sediment, and (when possible) invertebrate samples were collected (in most cases monthly) from three tidal freshwater sites along the Anacostia River since April 2010, and continuing through May 2011. Water nutrients (NO3 and NH4) demonstrate seasonal fluxes; all sites show a peak in nutrients during early summer (June) and subsequent decline. While the examination and interpretation of results is ongoing, Dr. McAvoy's progress report includes initial analysis, which was presented at the Annual Meeting of the American Geophysical Union, December 2010. These and other results will be written up as a manuscript for peer- reviewed publication in summer 2011. A six month, no-cost extension was granted March 3, 2011. The final report will be delivered in October, 2011.

Dr. Arash Massoudieh and Dr. Pradeep Behera continue to assess the impact of construction of various types of Best Management Practices (BMPs) and Low Impact Development (LID) strategies on the loads of various water quality constituents discharging into the water bodies around the District of Columbia. For this purpose, they will develop an urban watershed model using the EPA SWMM model for a region at the eastern part of the city of Washington. Loads of TSS, and nutrients will be calculated for three water years including a wet year, a small year and an average year. These simulations will serve as the baseline scenarios. The impacts of various low impact development strategies including retention and detention basins, infiltration ponds, sand filters, rain barrels and green roofs and permeable pavement will then be incorporated into the model. The LID and BMPs will be incorporated as per-area cover and will influence the amount of runoff per area being generated and also in some cases will impact the water quality of the storm runoff. The project will benefit the public health and the water quality by leading to a more sustainable, cost-effective and affordable stormwater infrastructure.

Listed below are the eight grants awarded to researchers for FY 2012 104B grants.

Title: Urban Stormwater Runoff Prediction Using Computational Intelligence Methods, Dr. Nian Ashlee Zhang, Assistant Professor, Dept. of Electrical and Computer Engineering - University of the District of Columbia.

Title: Integrated Water Use Impact Assessment for DC urban Infrastructure, Dr. Royce Francis, Assistant Professor, Assistant Professor, Department of Engineering Management and Systems Engineering- George Washington University.

Title: Metropolitan Washington Public Officials' Water Leadership Program, Howard Ways, AICP (Principal Investigator), Director of Planning and Sustainability and Adjunct Professor, College of Arts & Sciences, Department of Urban Studies - University of the District of Columbia; Dr. Catherine Shrier (Co-PI), Watercat Consulting LLC.

Title: Hormone Disruption and Environmental Pollutants in Anacostia and Potomac River Fish, Washington DC, Dr. Stephen McAvoy, Department of Environmental Science American University and Dr. Cathy Schaeff, Biology Department - American University.

Title: National Capital Region Flood Risk Assessment: Inter-university Collaboration Initiative, Dr. Pradeep Behera (Principal Investigator), Associate Professor, Engineering, Architecture & Aerospace Technology-

University of the District of Columbia; Dr. Gerald Galloway (Co-PI), Glenn L. Martin Institute Professor of Engineering, Department of Civil and Environmental Engineering -University of Maryland; Dr. Michael J. Casey (Co-PI), Assistant Professor and Graduate Director Department of Civil, Environmental, and Infrastructure Engineering, The Volgenau School of Info. Tech. and Engineering - George Mason University.

Title: Pollution Source Identification in Washington DC storm-water using Bayesian Chemical Mass Balance Modeling, Dr. Arash Massoudieh, Assistant Professor, Department of Civil Engineering Catholic University (Principal Investigator); Dr. Ali Arab (Co-PI), Assistant Professor - Georegtown University; Dr. Tolessa Deksissa (Co-PI), Program Director, Professional Science Master's in Water Resources Management, College of Agriculture, Urban Sustainability and Environmental Sciences (CAUSES) - University of District of Columbia.

Title: Monitoring of Glyphosate and its Degradation of Residue by Phosphorus-31 Nuclear Magnetic Resonance Spectroscopy, Dr. Xueging Song, Assistant Professor of Chemistry - University of the District of Columbia.

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, Dr. Tolessa Deksissa, Program Director, Professional Science Master's in Water Resources Management, College of Agriculture, Urban Sustainability and Environmental Sciences (CAUSES) - University of District of Columbia.

Determining the Effectiveness of the Design-Build Method on Water Infrastructure Rehabilatation Projects in the District of Columbia

Basic Information

Title:	Determining the Effectiveness of the Design-Build Method on Water Infrastructure Rehabilatation Projects in the District of Columbia
Project Number:	2010DC108B
Start Date:	3/1/2010
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	DC
Research Category:	Engineering
Focus Category:	Education, Methods, Economics
Descriptors:	None
Principal Investigators:	Kunhee Choi, Pradeep K. Behera

Publications

There are no publications.

Dr. Choi, PI on *"Determining the Effectiveness of the Design-Build Method on Water Infrastructure Rehabilitation Projects in the District of Columbia"* relocated to another University in September 2010 and requested cancellation of the project. The co-PI also declined to continue the project, therefore neither progress nor final report is submitted.

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Abstract:

The majority of existing water infrastructure facilities in the District of Columbia and elsewhere in the United States are being deteriorated rapidly and are thus reaching the end of their serviceable lives (Buchberger et al., 2009). Therefore, in recent years there are serious concerns about public health and safety with increased pressure to modernize aging nation's water infrastructure systems. It has been estimated that more than 7 million people become ill each year from contaminated water, according to the Natural Resources Defense Council. In response, President Obama has called for 2,680 water infrastructure rehabilitation projects with an investment of $15 billion (WaterWorld, 2009). Design-Build (DB) is known as the fast-track project delivery strategy for getting these projects started and completed early. According to an article recently published, the DB has been cited as the key to implementing President Obama's commitment to water infrastructure (WaterWorld, 2009). Yet, the effectiveness of implementing the DB strategy on water infrastructure rebuilding projects is debatable largely because of its inherent characteristics that can increase project cost and cause schedule delay if the DB team lacks capabilities for doing the DB project. Furthermore, little is known about its impact on project performance aspects such as project schedule, cost, and frequency of

contract change orders. The lack of systematic studies to assess it now prevents DCWRRI from planning realistically and budgeting accurately when it is considered for implementation. This study attempts to address these shortcomings by determining the effectiveness of the DB strategy and by providing guidelines for effective use of DB.

Title: Determining the Effectiveness of the Design-Build Method on Water Infrastructure Rehabilitation Projects in the District of Columbia

Statement of critical regional or State water problem:

Similar to many older cities in the nation, the sewer system in the District of Columbia is comprised of both combined and separate sewer systems. Most of them are deteriorated and dysfunctional, thus needing to be rehabilitated. The DC's over-burdened and antiquated water infrastructure creates sustainability issues, too. According to the Congressional Budget Office, more than 20 percent of drinking water is lost and 1.2 trillion gallons of storm water and wastewater overflow every year due to leaks and breaks in the 800,000 miles of water pipes and 600,000 miles of sewer lines in the U.S. Water infrastructure investment is expected to be a significant priority for many years. In fact, to address these problems, the District of Columbia Water and Sewer Authority (WASA) has developed a Long Term Control Plan (LTCP) that provides the alternative solutions and their implementation costs. The implementation cost of recommended plan stands at 1.6 billion dollars.

Currently Washington Aqueduct and WASA are facing a daunting task of financing the implementation of water and wastewater infrastructure rehabilitation in an equitable manner without placing an unreasonable burden on ratepayers. The WASA has used the following two methods to document the burden on the District of the proposed LTCP:

- Long-term rate impact analysis using the Authority's financial planning and rates model, and
- Affordability analysis using procedures developed by EPA.

Based on the analysis, a 40-year implementation time has been proposed for the entire recommended plan if no outside financial assistance is received. If significant outside financial assistance is obtained, it is technically feasible to accelerate the schedule to a 15-year implementation time frame.

Statement of results or benefits

With the DCWRRI seed grant, this research will be focused on:

- Quantitative analysis of the measurements and interpretations of data arising from an agency's selection of an innovative contracting strategy in construction of new and existing water infrastructure; and
- Quantitative analysis of the observed impacts of the contracting strategy choice on project performance components such as schedule and cost.

Design-Build, which is the major focus of the research proposed in this proposal, is a means to ensure faster construction done by a single DB firm, who is responsible for both design and construction. Because DB projects are relatively large-scale and financed with public funds on water infrastructure projects, its misapplication results in a loss of public resources. Therefore, it is especially important that candidate projects be carefully selected and effectively implemented.

Proceeding from this understanding, a quantitative analysis will be performed to determine effectiveness of the use of the DB strategy. The deliverables include:

(1) A literature review that establishes the current state of industry;
(2) Comprehensive summary of project data classified by contracting method, project type, and project scope; and,
(3) A summary evaluation of the effects of DB projects on time and cost compared to conventional projects.

Solutions to problems and contributions of this research are defined in the Table 1.

Table 1. Proposed Solutions to the Problems.

Problems	Solutions and Contributions
Problem I: Disagreement about DB project's effectiveness	▪ Evaluate the effectiveness on schedule performance, cost growth, and contract changes by comparing DB projects with conventionally contracted projects. ▪ Contribution - Promote the effective application of the DB strategy by knowing the percentages and overall performance.
Problem II: Lack of data and systematic studies	▪ Conduct a methodical quantitative analysis. ▪ Contributions: - Provide comprehensive evaluation data. - Provide a synthesized analysis approach and make recommendations for taking the next step to effectively use DB contracting strategy.

Nature, scope, and objectives of the research

The major objective of this research is to determine the effectiveness of DB contracting projects compared to the traditional design-bid-build (DBB) project on aspects of project performance such as construction time, project cost, and frequency of change orders in the water infrastructure.

Tasks to achieve this objective include:

1. Investigate whether use of DB affects construction duration;

2. Determine whether use of DB on water infrastructure improvement projects significantly shortens their duration compared to conventional projects; and
3. Examine whether DB projects increase project costs above the levels seen in conventional DBB projects.

This study has the potential to assist DCWRRI to: (1) make better informed decisions when choosing a DB contracting strategy; and (2) allocate more accurate, realistic budgets for DB projects.

Table 2. Time Line for The Proposed Project by Each Research Task.

#	Description of Activities	Time (months) from start to end of project											
		1	2	3	4	5	6	7	8	9	10	11	12
1	Literature Review												
2	Data Collection & Analysis												
3	Schedule & Cost Analysis												
4	Contract Change Order Analysis												
5	Report												

Methods, procedures, and facilities

The proposed study requires project data recently completed in the District of Columbia to quantify likely impacts of DB on project schedule, cost, and contract change orders compared with the conventional DBB contracting method.

Initial project schedule and contract amount estimates are often adjusted due to contract changes in project scope resulting from frequently occurring contract change orders. Consequently, project data that will be used for quantitative analyses must contain this contract change order information. The PIs will look for data that include the adjusted days and contract amounts so that the impact of contract and schedule changes can be quantified.

Results of this quantitative data analysis could be biased if samples of varied project types and sizes are compared, so to perform an unbiased analysis, project data will be sorted by similar project type and by similar project size.

Based on the nature of data, some appropriate statistical analyses will be performed to evaluate project performance on project schedule and cost using the following ratios:

- **Schedule performance ratio** =
  [(final completion time – original (and amended) contract time) / original (and amended) contract time]
- **The cost change ratio** =
  [(final project cost – original (and amended) contract amount) / original (and amended) contract amount]

The schedule performance ratio is the ratio of the difference between the actual final completion time and the original contract time to the original contract time. A negative value implies that the project was completed sooner than originally scheduled. A positive value implies that the project took longer than originally scheduled. If the ratio equals zero, that implies the project was completed on time.

The cost changes ratio will be used to examine the level of cost growth for DB projects over conventional projects. It is defined as the ratio of difference between the final project cost and the original contract amount to the original contract amount. A positive ratio implies cost growth and a negative one means a reduction.

Related Research

Dr. Choi completed his Ph.D. degree in Civil and Environmental Engineering at the University of California at Berkeley in the Fall of 2008. Currently, he is an assistant professor at the University of the District of Columbia. During his study at Berkeley, he was selected as the recipient of the Earle C. Anthony Fellowship, which is the most prestigious honor awarded college-wide to Ph.D. students for excellence in academic and research performance. Prior to joining a graduate program at Berkeley, he held a position as a field engineer for two years in the residential construction sector. He also worked as a graduate student researcher and a post-doctoral researcher at the Institute of Transportation Studies of UC Berkeley for six years. His research has centered around the following three areas on urban infrastructure rehabilitation projects: 1) improved project delivery systems with the special emphasis on evaluating the contractors' cost and schedule performance of different types of projects (residential, commercial, etc.) built under different delivery systems (design-build, design-bid-build, etc); 2) development of an engineered decision-support computer model for complex civil infrastructure systems to aid selection of a solution that would enable agencies to make better-informed decisions; and 3) labor productivity study and streamlined strategies to maximize construction productivity by minimizing project uncertainties. To date, he has published and co-authored more than 15 peer-reviewed scholarly papers in these three areas, and the research behind these papers has drawn praise from his peers in the academic and professional engineering worlds.

Training potential

The proposed preliminary study will create an excellent opportunity for training students, researchers and water resources professionals.

1. Budget Breakdown:

The budget breakdown for this proposed project is provided in Table 3.

Table 3. The Budget Breakdown for the Proposed Project.

Proposed Start Date: March 1, 2010	**Proposed Completion Date**: February 28, 2011		
Project Number: (to be assigned by institute)			
Project Title: Determining the Effectiveness of the Design-Build Method on Water Infrastructure Rehabilitation Projects in the District of Columbia			
Principle Investigator Dr. Kunhee Choi			
Cost Category	Federal	Non Federal	Total
1. Salaries and wages:	$	$	$
- Principal Investigator (s)			
Kunhee Choi	$ 4,000	$ 18,800	$ 22,800
Pradeep Behera	$ 4,000	$ 8,000	$ 12,000
Students	$ 4,000		$ 4,000
Total Salaries and wages:	$ 12,000	$ 26,800	$ 38,800
2. Fringe benefits			
3. Supplies	$ 400		$ 400
4. Equipment			
5. Services or consultants			
6. Travel	$ 1,000		$ 1,000
7. Other direct costs			
8. Total direct costs	$ 13,400	$ 26,800	$ 40,200
9. Indirect costs on federal share		$ 4,556	$ 4,556
10. Indirect costs on non- federal share:		$ 9,112	$ 9,112
11. Total estimated cost	$ 13,400	$ 40,468	$ 53,868

Budget Justification:

The budget required for each of these categories is estimated on the basis of minimum requirements to perform the proposed research tasks identified in the Table 2. The PIs, Dr. Choi and Dr. Behera, will be directly involved in the research activities and an amount of $8,000 is allocated for their summer salary support. Engineering undergraduate students from the University of the District of Columbia will be involved for collecting data and research for three months. The travel money will be used for presenting the results in the local conference.

Investigator's qualifications:

Please see a two-page biographical sketch for the PIs attached.

Literature cited

Buchberger, S., Clark, R., Crayman, W., Li, Z., Mccutcheon, M., and Yang, J. (2009). "Needs and Trends of the Nation's Water Infrastructure – The Utility Perspective." World Environmental and Water Resources Congress 2009, May 17-21, Kansas City, Missouri.

WaterWorld (2009). “Design-Build Method Key to Implementing President Obama’s Commitment to Water Infrastructure.” <http://www.waterworld.com/index/display/article-display/351730/articles/waterworld/drinking-water/infrastructure/rehabililtation/design-build-method-key-to-rehabilitating-water-infrastructures.html> (Accessed on November 30, 2009).

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EDUCATION

UNIVERSITY OF CALIFORNIA, BERKELEY	Ph.D. in Engineering & Project Management (2008) Department of Civil and Environmental Engineering Minors in Finance and Statistics
TEXAS A&M UNIVERSITY AT COLLEGE STATION	M.S. in Construction Management (2002) Department of Construction Science
KOREA UNIVERSITY AT SEOUL	B.E. in Architectural Engineering (1999)

ACADEMIC APPOINTMENT

UNIVERSITY OF THE DISTRICT OF COLUMBIA (tenure-track) (08/2009 – To date)	Assistant professor of construction management
UNIVERSITY OF CALIFORNIA, BERKELEY INSTITUTE OF TRANSPORTATION STUDIES (03/2009 – 07/2009) *research projects in the*	Post-doctoral researcher Principal Investigator: Professor Carl L. Monismith − *Plan, organize, and carry out long-term and short-term* *area of highway infrastructure management.*
UNIVERSITY OF CALIFORNIA, BERKELEY PAVEMENT RESEARCH CENTER (UCPRC) *design, construction,* (06/2003 – 12/2008) *management.*	Graduate Student Researcher (50-100% appointment) − *Working with a multidisciplinary cross-functional team of* *and transportation.* − *Develop expertise in strategic infrastructure project*
TEXAS A&M UNIVERSITY appointment) (01/2002 – 05/2002)	Graduate Student Teaching Assistant (25%

INDUSTRY APPOINTMENT

BR CONSTRUCTION GROUP, LLC (10/1998 – 07/2000) *for a large-scale high-rise* *comparison and periodic*	Scheduling Engineer − *Developed full CPM logic generated baseline schedules* *residential building project (project size: US $217 million).* − *Perform monthly progress updates and create target* *look-ahead schedules.*
SAMSUNG C&T CORPORATION (10/1991 – 05/1992)	Assistant Engineer (Internship) − *Prepared contract change order as-built drawings.* − *Coordinate the execution and completion of budgets.*

RELATED RESEARCH EXPERIENCE FOR THE PROJECT

PROJECT DELIVERY SYSTEMS
strategies on aspects of

change orders.

(US$ 50,000) for the

design-bid-build

- Quantified the impact of alternative contracting project performance such as project schedule, cost, and
- As the PI, developed a research grant proposal quantitative study of design-build over the conventional building construction projects (under review)

INFRASTRUCTURE PROJECT MANAGEMENT
area of sustainable

materials, streamlined

planning concepts.

- Developed an interdisciplinary research program in the infrastructure systems that integrate design and transportation management strategies, and advanced

STATE-OF-THE-ART *CA4PRS* SOFTWARE
implementation, and

infrastructure management.

feasible construction

design/schedule/cost/traffic analysis.

requirements of a

Caltrans.

- Played a pivotal role in development, enhancement, validation of *CA4PRS* computer program for
- Using *CA4PRS*, helped agencies select the most scenarios by providing an integrated
- Developed a work plan and a feasibility study report as research funding grant of $1.2 million from FHWA and

GRANT WRITING
conceptualization and

FHWA, Caltrans,

innovative contracting,

incentives/disincentives

- Initiated search for new grant opportunities, initiated writing of grants, and co-wrote with PI.
- Written over 8 research grants to agencies including NCHRP, NECA, and DCWRRI.
  - *CA4PRS enhancement studies, I-15 Devore project, implementation study for long-life rehabilitation projects,*

SELECTED PUBLICATIONS

REFEREED ARCHIVAL JOURNAL PUBLICATIONS

Choi, K., Lee, E.B., Ibbs, C.W., and Kim, Y. (2009). "Multifaceted Public Outreach and Cost-Benefit Analysis for Its Effectiveness Validation." Journal of Construction Management and Economics, 27 (8), 771-782.

Lee, E.B., **Choi, K.,** and Lim, D.S. (2008). "Streamlined Strategies for Faster, Less Traffic-Disruptive Highway Rehabilitation

in Urban

(Construction Management

No. 2081, TRB,

Construction for Concrete

Network."

Rehabilitation Section):

1949, TRB,

REFEREED CONFERENCE PROCEEDINGS
Are They Really

Procurement (IPPC2010),

Sustainable Rebuilding of

of Engineering

Pennsylvania, October

SELECTED CONFERENCE PRESENTATIONS
Less Traffic-Disruptive

87th TRB Annual

track Construction for

Highway Network." In the

Outreach for Minimizing

Rehabilitation." In the 85th TRB

Networks." Transportation Research Record

Section): Journal of the Transportation Research Board,

National Research Council, Washington, D.C., 38-45.

Lee, E.B. and **Choi, K.** (2006). "Fast-Track

Pavement Rehabilitation: California Urban Highway

Transportation Research Record (Pavement

Journal of the Transportation Research Board, No.

National Research Council, Washington, D.C., 3-10.

Choi, K. (2010). "Alternative Contracting Strategies:

Effective?" 4th International Conference of Public

Seoul, South Korea, August 26-28.

Choi, K. (2009). "A State-of-the-art Tool for

Aging Infrastructure Systems." 2009 American Society

Education Mid-Atlantic Conference, King of Prussia,

23-24.

Choi, K. (2008). "Streamlined Strategies for Faster,

Highway Rehabilitation in Urban Networks." In the

Meeting, Washington, D.C., Jan. 15.

Choi, K. (2006). "California Experience with Fast-

Concrete Pavement Rehabilitation on an Urban

85th TRB Annual Meeting, Washington, D.C., Jan. 23.

Choi, K. (2006). "Dynamic Approach to Public

Traffic Inconvenience in Urban Highway

Annual Meeting, Washington, D.C., Jan. 25.

PRADEEP K. BEHERA, Ph.D., P.E.

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Research Interests: Urban Stormwater Management, Non-point Source Pollution, Water Resources Engineering, Erosion and Sediment Control, Sustainable Urban Water Systems.

EDUCATION AND CREDENTIALS

- NSERC Industrial Post-Doctoral Research Fellow, Canada
- Ph.D., Environmental Engineering, University of Toronto, Canada
- M.S. Civil Engineering, Sambalpur University, India
- B.S. (Honors) Civil Engineering, Sambalpur University, India

PROFESSIONAL EXPERIENCE

- Associate Professor, Department of Engineering, Architecture and Aerospace, University of the District of Columbia, Washington DC Aug 05-Present
- Senior Water Resources Engineer, BPC Group Inc., Orlando, Florida May-Jul 2005
- Water Resources Engineer, Clarifica Inc., Richmond Hill, Ontario 2001 – 2005
- Doctoral Student, Dept. of Civil Eng., University of Toronto, Canada 1997-2001
- Senior Lecturer, National Institute of Technology, Rourkela, India 1990-1996

RESEARCH PUBLICATIONS (Partial List)

Peer Reviewed Journal Publications

- Behera, P, K., J. Y. Li, and B. J. Adams, "Runoff Quality Analysis of Urban Catchments with Analytical Probabilistic Models" *Journal of Water Resources Planning and Management.* ASCE January 2006.

- Behera, P, K., J. Y. Li, and B. J. Adams, "Characterization of Urban Runoff Quality: A Toronto Case Study" *Applied Modeling of Urban Water Systems.* W. James (Ed.), CHI Guelph, Ontario, January 2000.

- Behera, P, K., F. Papa, and B. J. Adams, "Optimization of Regional Storm-Water Management Systems." Journal of Water Resources Planning and Management. ASCE, January 1999, Vol. 125, No. 2, March-April, 1999.

Book Chapter Publication

- Chapter 5 for the book '*Urban Stormwater Management Planning with Analytical Probabilistic Models*' by B. J. Adams and F. Papa, John Wiley & Sons, New York, 2000.

Technical Reports

- Author of Research Report (2004) "Assessment of Construction Sediment Control Ponds to Protect Receiving Waters".
- Author of Research Report (2004) "Assessment of Construction Sediment Control Ponds to Protect Receiving Waters".

Presentations

- "Probabilistic Approaches for Assessment of Non-Point Source Pollutant Loads from Urban Watersheds" in the International Conference on "World Environmental & Water resources Congress 2008 at Honolulu, Hi during May 12-17, 2008.

- Application of Analytical Models for TMDL Analysis" Behera, P.K., World Environmental Congress, Omaha, May 21-25, 2006.

- "Performance Evaluation of a Construction Sediment Control Pond", by Krasnova, R., J. Y. Li and P. K. Behera, International Conference on Stormwater and Urban Water Systems Modeling, Toronto, Ontario, Feb 24-25, 2005.

- "Runoff quality analysis of urban catchments with analytical probabilistic models: model development, verification, and application" by Behera, P.K., J.Y. Chen, I.O. Poon, B, J. Adams, B.J, EGU-1st General Assembly Conference, Nice, France, 25-30, April 2004.

- "Runoff Quality Analysis for Metropolitan Toronto Waterfront" Annual Conference on Storm water and Urban Water Systems Modeling, by Behera, P.K, B. J. Adams, and J.Y. Li, Toronto, Ontario, Feb 18-19, 1999.

- "Analytical Probabilistic Model to Estimate Long-term EMC of Pollutants in Urban Runoff" by Behera, P.K, and B. J. Adams - 35th Central Canadian Symposium on Water Pollution Research, Burlington, Ontario, 2000.

PROFESSIONAL AFFILIATION

- Professional Engineer, State of Maryland, U.S.A.
- Associate Member, American Society of Civil Engineers, U.S.A.
- Diplomate, American Academy of Water Resources Engineer
- Professional Engineer, Ontario, Canada

A Hierarchical Spatio-Temporal Dynamical Model for Predicting Precipitation Occurrence and Accumulation

Basic Information

Title:	A Hierarchical Spatio-Temporal Dynamical Model for Predicting Precipitation Occurrence and Accumulation
Project Number:	2010DC111B
Start Date:	3/1/2010
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	DC
Research Category:	Climate and Hydrologic Processes
Focus Category:	Floods, Methods, None
Descriptors:	None
Principal Investigators:	Ali Arab, Valbona Bejleri, Tolessa Deksissa

Publications

There are no publications.

A Hierarchical Spatio-Temporal Dynamical Model for Predicting Precipitation Occurrence and Accumulation

Progress Report

Submitted to

DISTRICT OF COLUMBIA WATER RESOURCES RESEARCH INSTITUTE

By:

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Georgetown University

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College of Agriculture Urban Sustainability and Environmental Sciences (CAUSES)
University of District of Columbia

Student researchers: Julie Menken (Georgetown University undergraduate student)
Christianne Greer (Georgetown University graduate student)

April 2011

Summary

The problem of predicting occurrence and accumulation of precipitation is of considerable interest in many disciplines such as atmospheric sciences, agriculture, and hydrology among others. The predictions based on climate models are often in a coarse resolution that cannot provide accurate predictions for specific locations. Alternatively, statistical modeling of precipitation data can provide more reliable predictions at higher resolutions. There are several statistical models suggested in the literature, but most of these models ignore the spatial and/or temporal dependence of precipitation fields, which results in lack of prediction accuracy.

Our goal in this project is to develop a statistical method that yields predictive distributions for precipitation occurrence and accumulation while accounting for spatial and temporal correlation in the precipitation fields. The predictive distributions for precipitation accumulation can then be used to obtain exceedance probability of rainfall accumulation beyond a threshold in order to issue flash flood warnings, and optimize evacuation management in case of flooding events.

Project Status (As of April 30, 2011)

Historic records on total monthly precipitation values were obtained from the main weather stations in the DC area. These three stations are located at

Ronald Reagan Washington National Airport (DCA)
Baltimore/Washington International Airport (BWI) – Also known as: Thurgood Marshall Airport
Washington Dulles International Airport (IAD)

Student researchers have completed an extensive exploratory data analysis (EDA) of these data. The EDA results are essential for the statistical modeling. In the next stage of the project, a statistical model for predicting monthly rainfall values will be finalized based on work in progress.

Single Variable EDA

In this section, we discuss EDA for all three stations. The data for DCA and BWI stations are available for years 1871 through 2010. Note that IAD data is only available starting April, 1963 (through 2010).

Maximum total precipitation (in inches) levels by month and airport

Maximums by Month

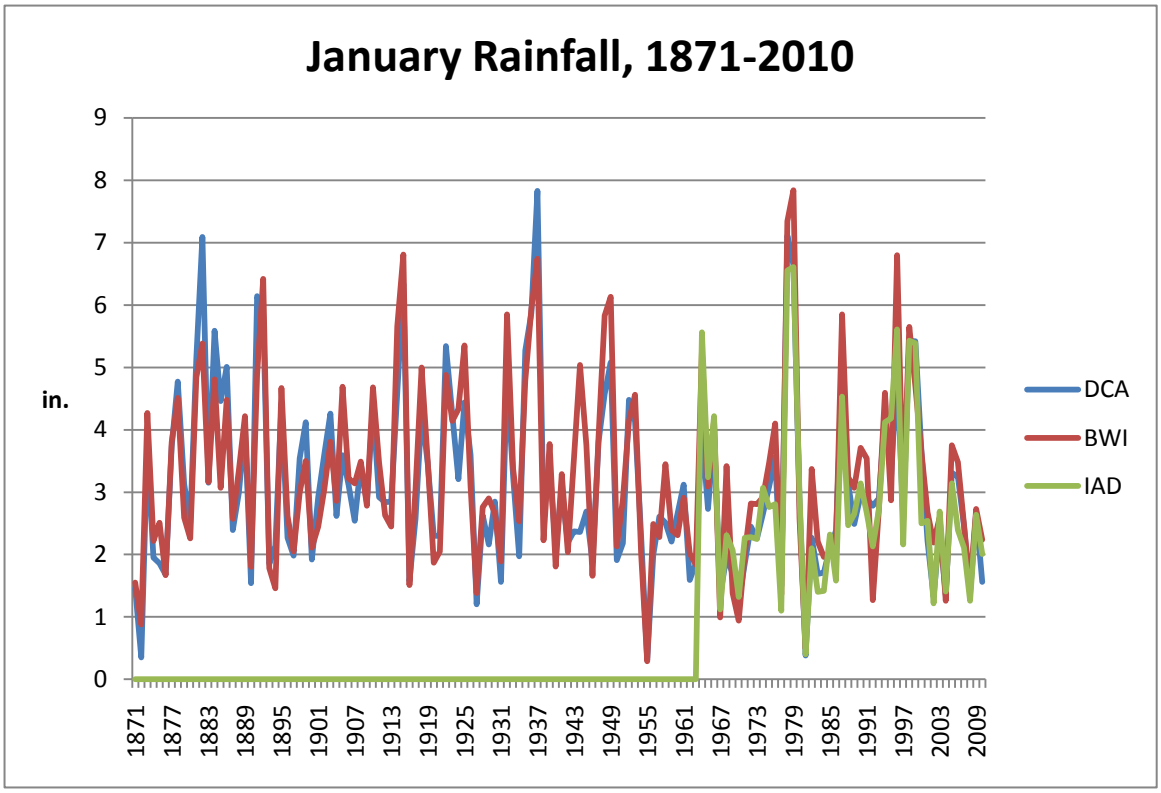
Month	Maximum Value	Year	Airport
Jan	7.84	1979	BWI
Feb	7.16	1979	BWI
Mar	8.84	1891	DCA
Apr	9.13	1889	DCA

May	10.69	1953, 1889	DCA
Jun	18.19	1972	IAD
Jul	11.06	1945	DCA
Aug	18.35	1955	BWI
Sep	17.45	1934	DCA
Oct	9.41	2005	DCA
Nov	7.83	1963	IAD
Dec	8.06	2009	BWI

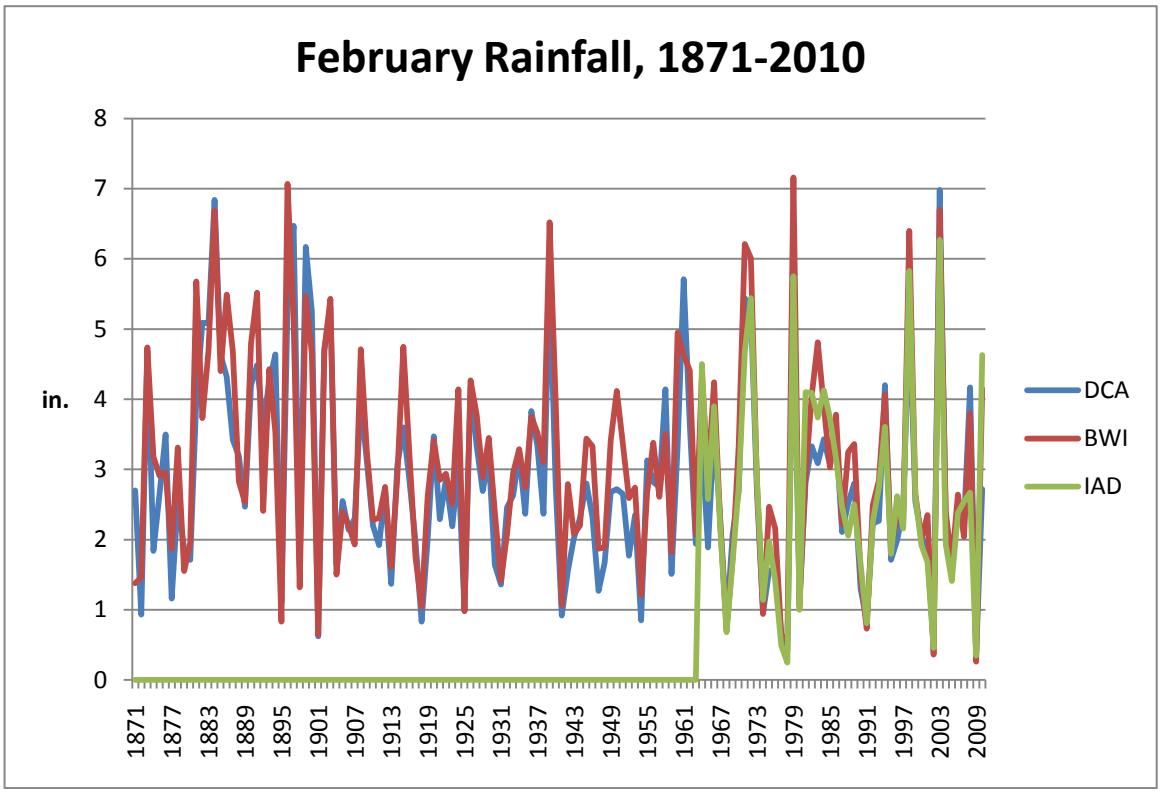
Maximums by Airport

	Maximum Value	Year	Month
DCA	17.45	1934	September
BWI	18.35	1955	August
IAD	18.19	1972	June

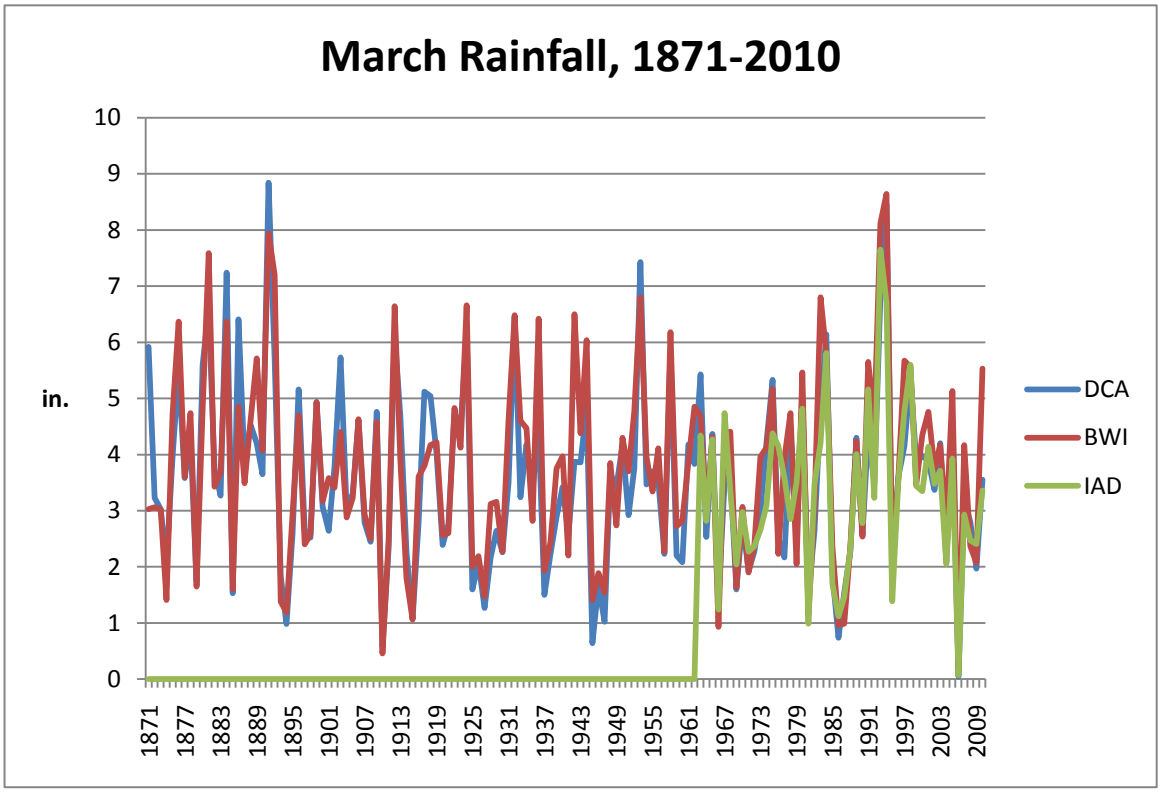
January



February


February Rainfall, 1871-2010
in.
0
1
2
3
4
5
6
7
8
1871
1877
1883
1889
1895
1901
1907
1913
1919
1925
1931
1937
1943
1949
1955
1961
1967
1973
1979
1985
1991
1997
2003
2009
DCA
BWI
IAD

March


March Rainfall, 1871-2010
in.
0
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5
6
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8
9
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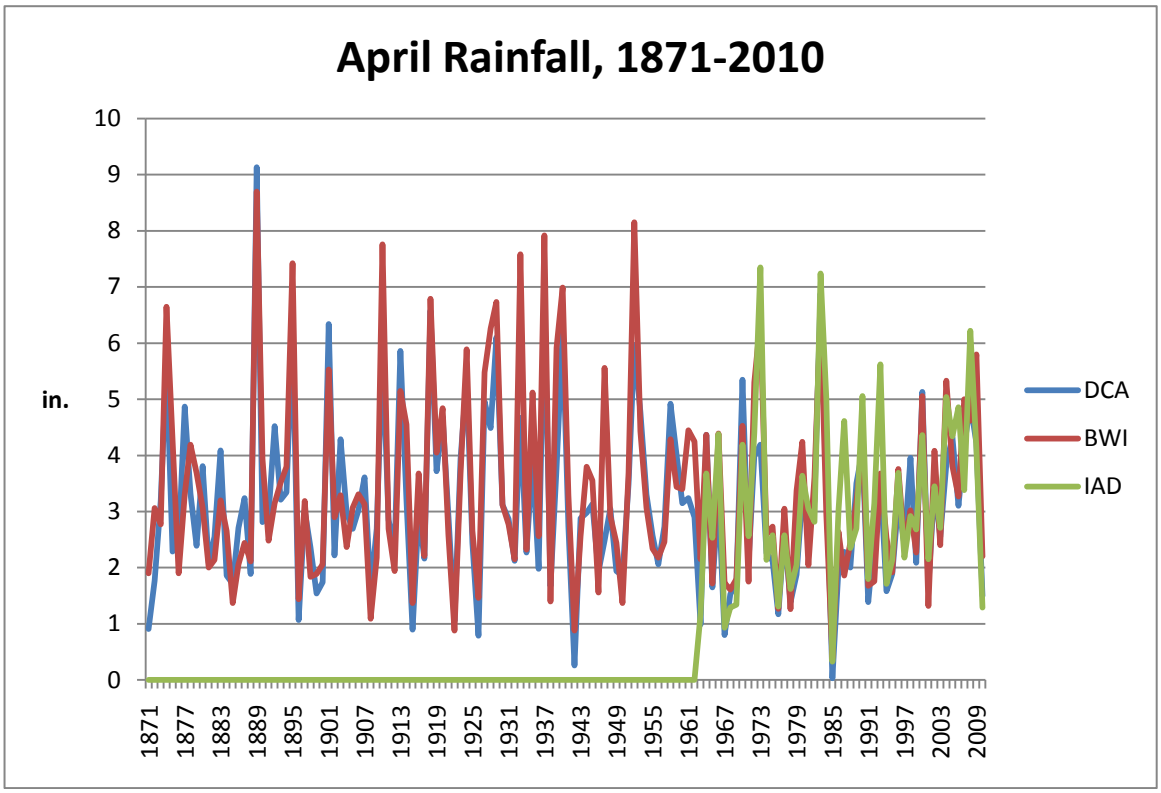
1871
1877
1883
1889
1895
1901
1907
1913
1919
1925
1931
1937
1943
1949
1955
1961
1967
1973
1979
1985
1991
1997
2003
2009
DCA
BWI
IAD

April


April Rainfall, 1871-2010
in.
0
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1871
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1889
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1919
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1937
1943
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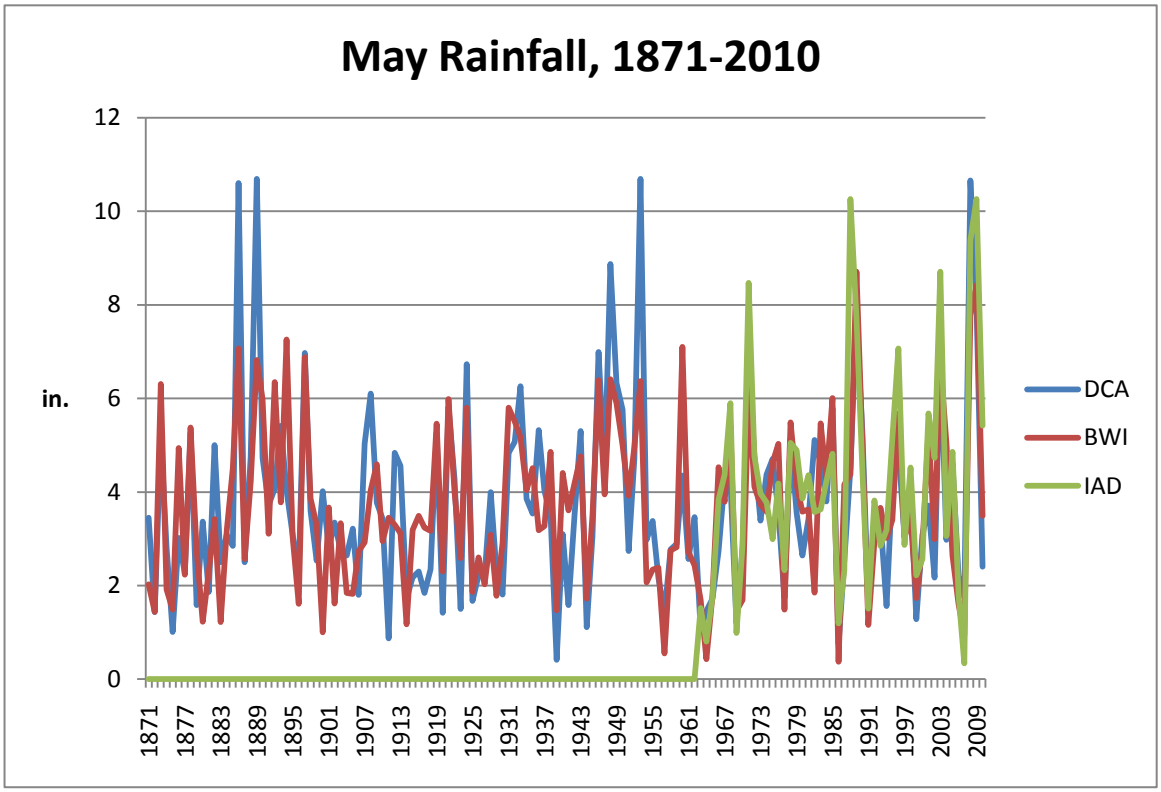
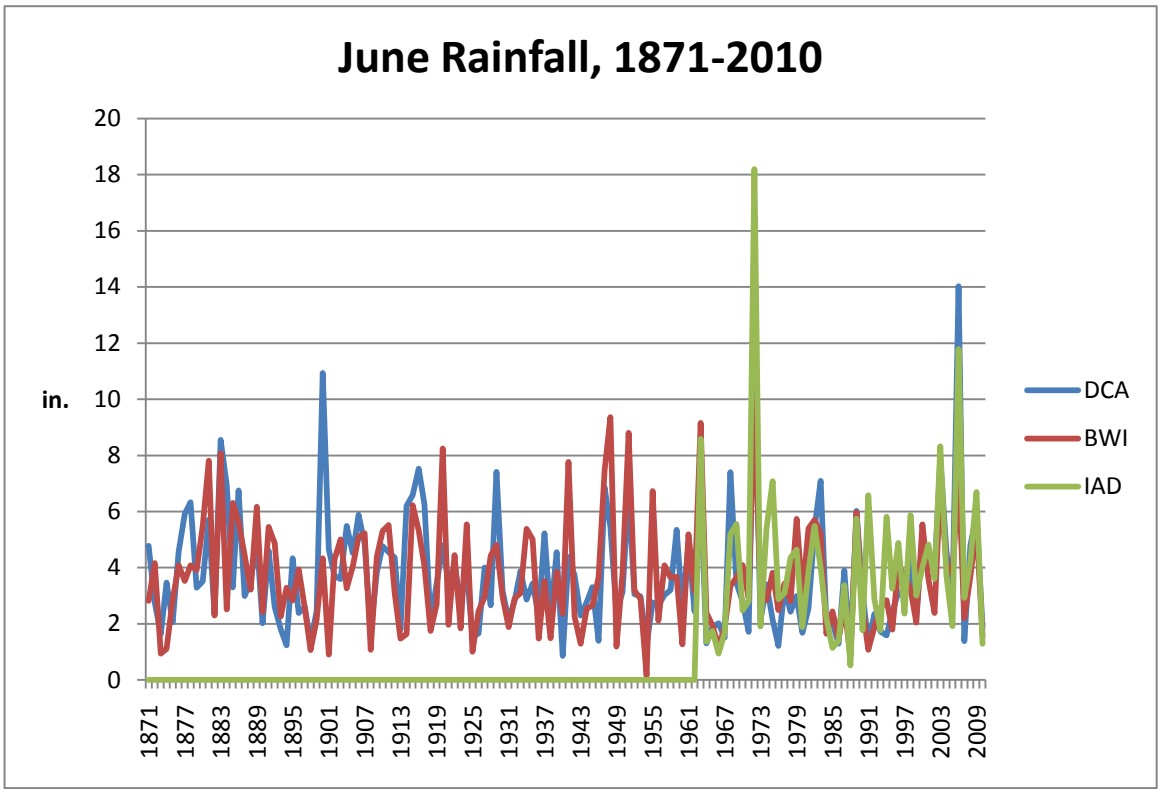
1961
1967
1973
1979
1985
1991
1997
2003
2009
DCA
BWI
IAD

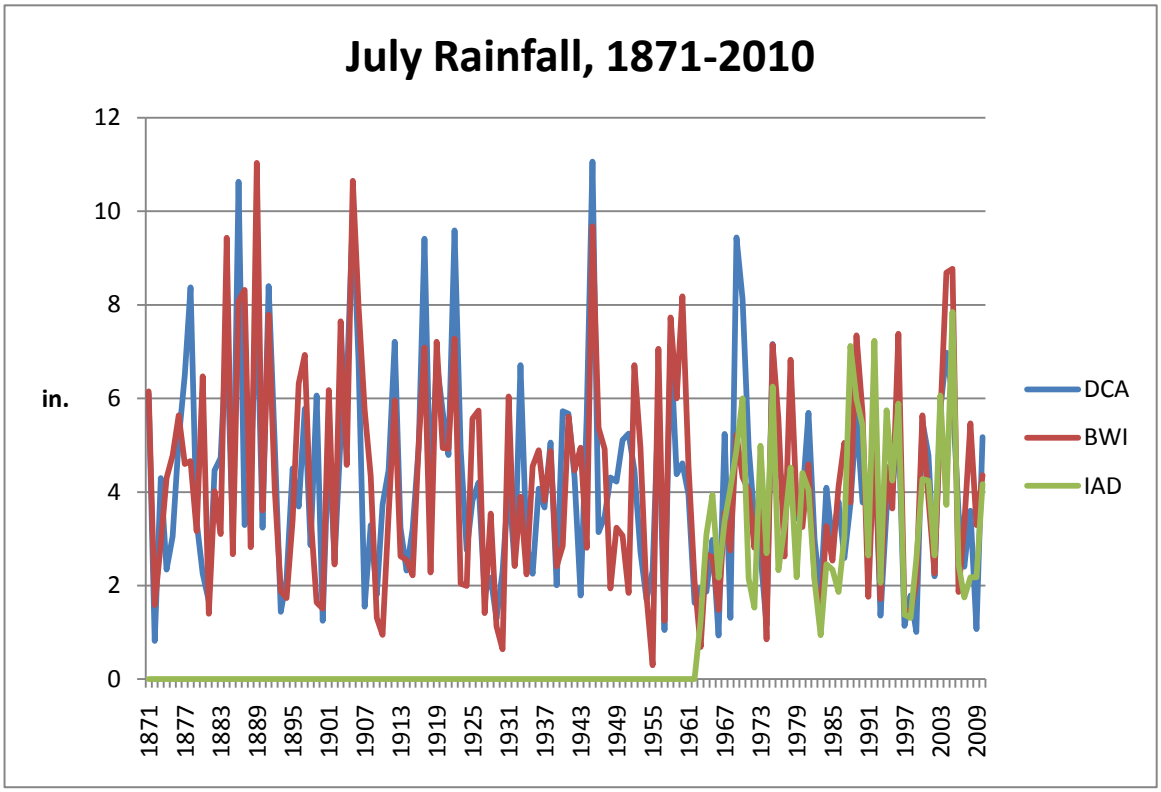
May


May Rainfall, 1871-2010
in.
0
2
4
6
8
10
12
1871
1877
1883
1889
1895
1901
1907
1913
1919
1925
1931
1937
1943
1949
1955
1961
1967
1973
1979
1985
1991
1997
2003
2009
DCA
BWI
IAD

June


June Rainfall, 1871-2010
in.
20
18
16
14
12
10
8
6
4
2
0
1871
1877
1883
1889
1895
1901
1907
1913
1919
1925
1931
1937
1943
1949
1955
1961
1967
1973
1979
1985
1991
1997
2003
2009
DCA
BWI
IAD

July


July Rainfall, 1871-2010
in.
12
10
8
6
4
2
0
1871
1877
1883
1889
1895
1901
1907
1913
1919
1925
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1943
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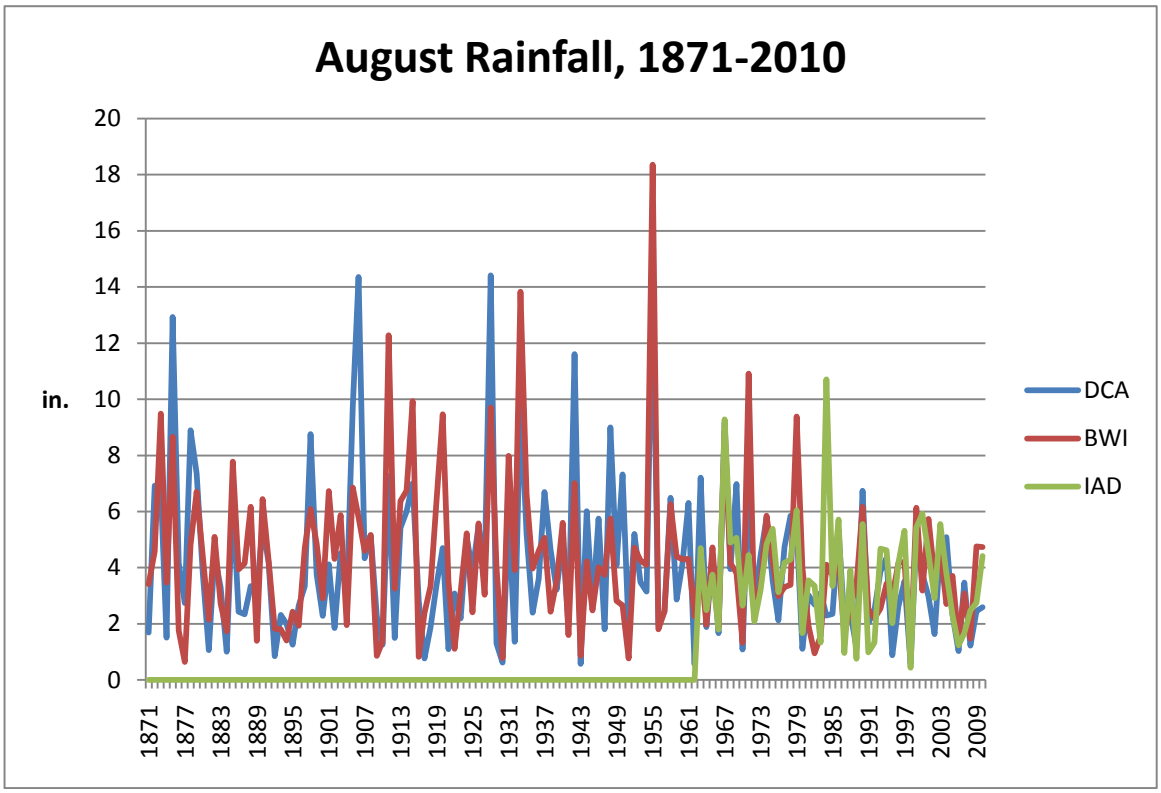
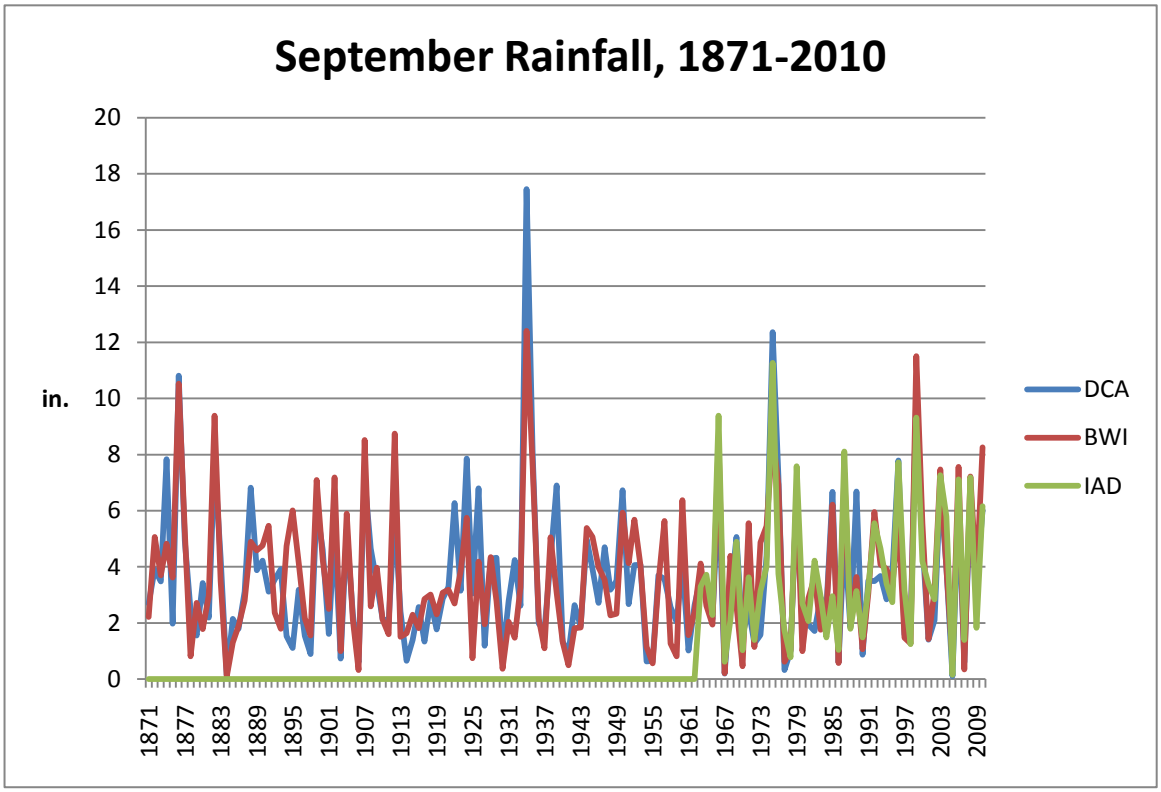
1997
2003
2009
DCA
BWI
IAD

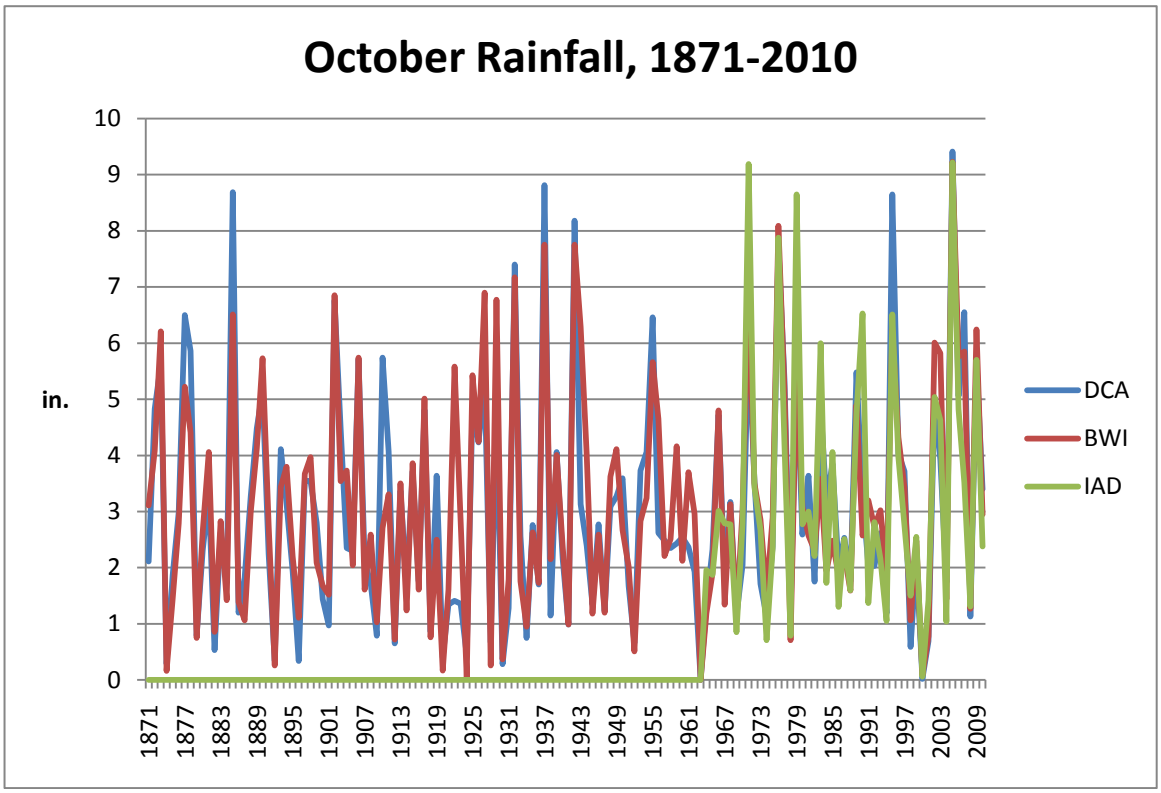
August



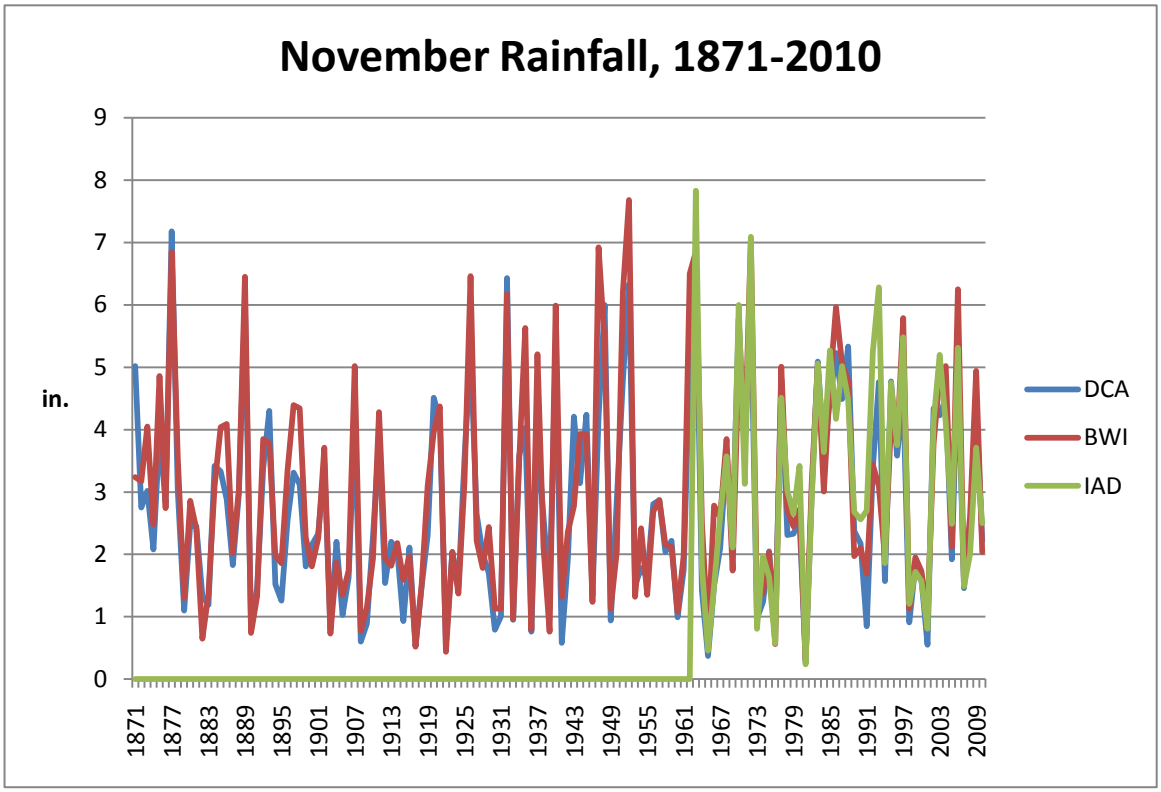
September



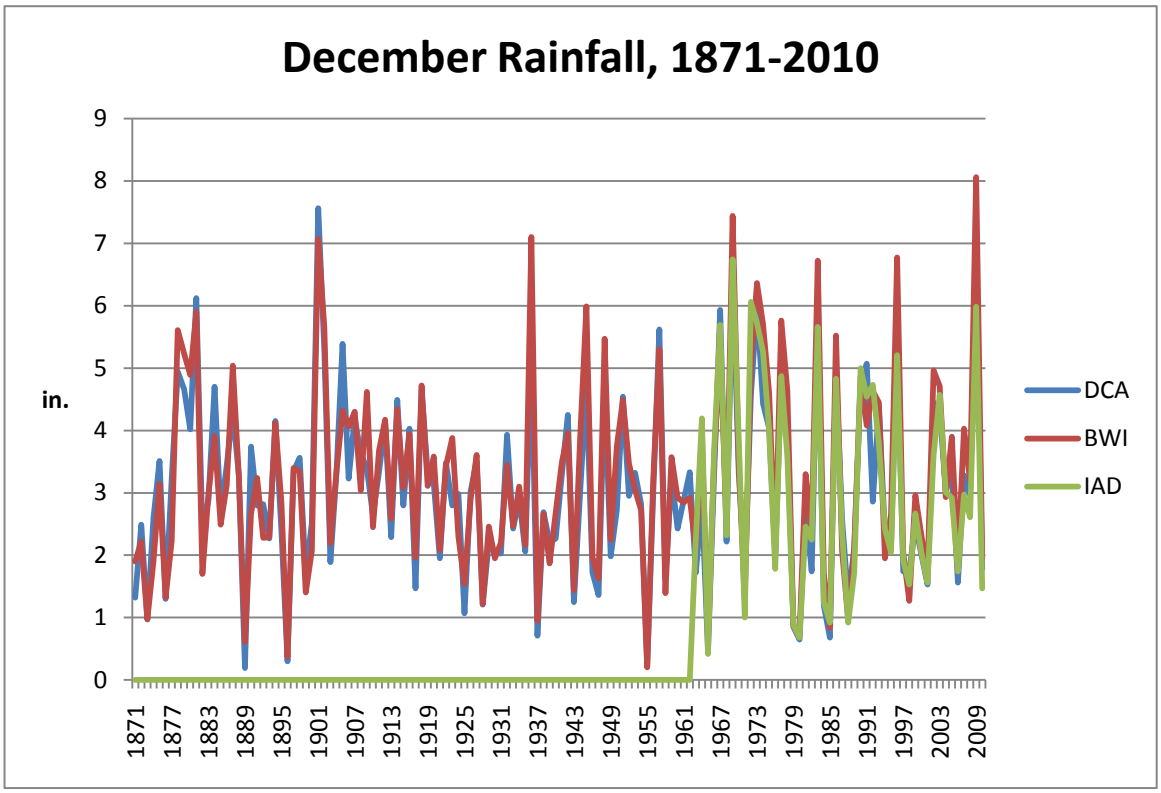
October



November



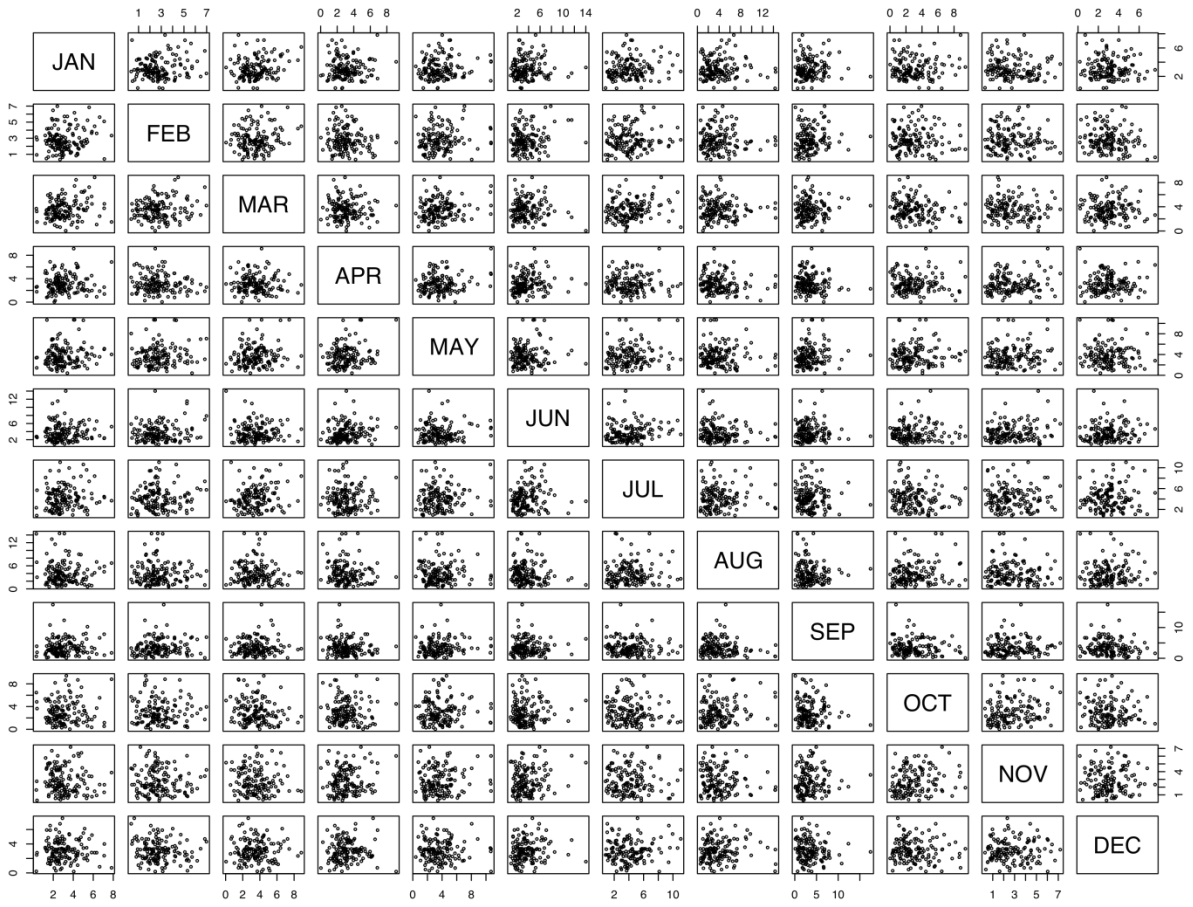
December



Model-Based EDA (Relationships Between Variables)

For brevity, we focus the exploratory data analysis on the data from the DCA weather station. It should be noted that large scale patterns are very similar for the other two stations in the area and most conclusions and results for this station are valid for the other stations as well.

Scatterplot of monthly observations against each other is given below. Here, our purpose is to investigate potential linear or nonlinear patterns that may exist between historic monthly rainfall data.



We also conducted several simple linear regression analyses for the monthly data. For these simple linear regression models, we considered all the possible combinations of monthly data (e.g., each monthly data was regressed on all the other 11 monthly data—in a simple linear regression setting). Results for significant regression analyses are given below

Regression: January on March
coefficient: 0.1632056
p-value < 0.05 (0.02884227)

Regression: March on January
coefficient: 0.2092128
p-value < 0.05 (0.02884227)

Regression: June on November
coefficient: 0.2443279
p-value < 0.05 (0.03100646)

Regression: November on June
coefficient: 0.1361715
p-value < 0.05 (0.03100646)

Regression: October on November
coefficient: 0.2537366

Regression: November on October
coefficient: 0.149278

p-value < 0.05 (0.02168590) p-value < 0.05 (0.02168590)

Significant regressions at 0.05 level: January and March; June and November; October and November.

Research Background and Literature Review

Numerical weather prediction (NWP) models tend to provide forecasts that are often biased or over-predict precipitation accumulation (Berrocal et al., 2008). As a result, several statistical models for precipitation occurrence and accumulation have been proposed in the literature (Stidd, 1973; Bell, 1987, Bardossy and Plate, 1992; and Sanso and Guenni, 2004). Most of these methods make unrealistic assumptions about the distribution of precipitation data which includes many zero values (i.e., no precipitation), with a right-skewed distribution for precipitation accumulations greater than zero. Berrocal et al.(2008) proposes a spatial two-stage method which considers precipitation occurrence first, and then models nonzero precipitation accumulation under the condition that it has occurred. The nonzero precipitation accumulation is modeled using a continuous distribution such as exponential density, gamma density, or the mixture of several densities (Sloughter et al., 2007). We propose a spatio-temporal dynamical model that takes into account both spatial and temporal structure of data in a two stage model. The proposed two stage model consists of an occurrence model (stage 1) which predicts the precipitation occurrence at each location and time point and a precipitation accumulation model (stage 2) conditioned on the outcome of the occurrence model.

There are several examples of related work on developing statistical models for precipitation occurrence and accumulation in the literature (Stidd, 1973; Bell, 1987, Bardossy and Plate, 1992; and Sanso and Guenni, 2004). Most of these methods make unrealistic assumptions about the distribution of precipitation data, which includes many zero values (i.e., no precipitation), with a right-skewed distribution for precipitation accumulations greater than zero.

Stidd (1973) is a pioneer work on deriving climatic expectancies of flood or drought from the mean and variance of a precipitation record. The method is based on the cube root normal distribution of precipitation. This method does not account for spatial and temporal dependence and it provides an exploratory data analysis approach to analyzing precipitation data rather than a statistical modeling attempt. Bell (1987) discusses a model of the spatial and temporal distribution of precipitation that produces random spatial rainfall patterns defined on a grid with each grid point representing the average rain rate over the surrounding grid box. This method is based on a correlated Gaussian random field that exceeds a threshold. The focus of the model is for use in evaluating sampling strategies for satellite remote-sensing of rainfall.

Bardossy and Plate (1992) discuss a multidimensional stochastic model for the spatio-temporal distribution of daily precipitation. The rainfall is linked to the atmospheric circulation patterns using conditional distributions and conditional spatial covariance functions. The model is a transformed conditional multivariate autoregressive model, with parameters depending on the atmospheric circulation pattern. The model reproduces both the local rainfall occurrence

probabilities and the distribution of the rainfall amounts at given locations. However, the methodology does not focus on obtaining predictive distributions of precipitation. Sanso and Guenni (2004) compare ground rainfall with purely deterministic Regional Climate Model (RCM) simulations within a Bayesian framework. The method considers spatial dependence and fits a truncated normal model to the observed ground data to represent spatial variability. The predictive posterior distribution of the spatially aggregated rainfall is obtained and compared to the RCM simulations.

Sloughter et al. (2007) uses Bayesian model averaging (BMA) as a statistical way of postprocessing forecast ensembles to derive predictive probability density functions for weather quantities. Berrocal et al. (2008) proposes a spatial two-stage method which consider precipitation occurrence first, and then model nonzero precipitation accumulation conditioning on the occurrence. The nonzero precipitation accumulation is modeled using a continuous distribution. Our proposed method is an extension of the methodology discussed in Berrocal et al. (2008) to a spatio-temporal setting.

Predictive Statistical Model

We will consider a statistical model that will utilize data for all three stations (DCA, BWI, and IAD). Also, we will adopt a spatio-temporal modeling approach in a Bayesian framework. The spatial aspect of our modeling approach allows for taking into account similarities between values observed at weather stations that are located closer, ultimately allowing for "borrowing strength" across data for weather stations. We develop our model with the intention that it can be easily modified and used for cases where data from more than three stations are available.

The temporal aspect of our model allows us to make realistic assumptions about the data (i.e., data are in form of a time series and thus, should not be considered as independent observations). Our speculation is that, by considering both spatial and temporal structures of the data, our model will be able to produce better prediction than most existing models which use faulty assumptions (such as independence over time and space).

Another aspect of our modeling approach that can potentially strengthen the predictive power of the model is that we consider monthly time series for each month and parameterize a similarity structure for these data across month (e.g., rainfall values for January tend to get more affected by the rainfall values of the past few months). So our model assumes annual (within months variability) temporal effects (i.e., annual trends for each month are accounted for) as well as monthly temporal effects (between months variability).

In the next phase of the project, we will develop this statistical model for the data from all the weather stations in the DC area. The validation of the model will be tested using out-of-sample procedures as well as checking the precision of future predictions.

In particular, the data model is given by

$$\mathbf{z}_t = K\mathbf{y}_t + \varepsilon_t, \qquad \varepsilon_t \sim N(0, \sigma_\varepsilon^2)$$

and the process model is

$$\mathbf{y}_t = \mathbf{H}_{\theta_T}\mathbf{y}_t + \mathbf{H}_{\theta_{T-1}}\mathbf{y}_{t-1} + \eta_t, \qquad \eta_t \sim N(0, \Sigma_\eta)$$

Note this model requires data to be normally distributed. This can be achieved using a transformation of data such as the Box-Cox transformation (DeOliveira et al., 1997).

The proposed dynamical model structure is justified based on the fact that the joint spatio-temporal process can be factored into conditional models based on a Markovian assumption:

$$[\mathbf{Y} \mid \{\boldsymbol{\theta}_t, t = 1, \ldots, T\}] = [\mathbf{y}_0]\prod_{t=1}^{T}[\mathbf{y}_t \mid \mathbf{y}_{t-1}, \boldsymbol{\theta}_t],$$

where the notation [*x*] denotes the probability distribution of a random variable *x*, and the conditional distribution $[\mathbf{y}_t \mid \mathbf{y}_{t-1}, \boldsymbol{\theta}_t]$ depends on a vector of parameters $\boldsymbol{\theta}_t$ which govern the dynamics of the spatio-temporal process.

In the dynamical model defined above, η_t is a spatial error process, and $\mathbf{H}_{\theta_T}$ is the "propagator matrix" which includes parameters that govern the dynamics of the process.

The propagator matrices $\mathbf{H}_{\theta_T}$ and $\mathbf{H}_{\theta_{T-1}}$ can be modeled in a hierarchical fashion in order to obtain estimates of the parameters $\boldsymbol{\theta}_t$. The estimation of the hierarchical model will be done using Bayesian estimation where the posterior distribution of unknown parameters can be obtained using the sampling distribution of data and prior densities of the parameters. Once the estimates of parameters and models states are obtained a predictive distribution can be obtained for locations for which we do not have precipitation measurements (denoted by $\mathbf{Y}^u$ for ungauged locations $s_1^u, s_2^u, \ldots, s_t^u$) described as $[\mathbf{Y}^u \mid \mathbf{Y}, \{\boldsymbol{\theta}_t, t = 1, \ldots, T\}]$.

In general, the estimation of the propagator matrix is often difficult due to its high dimensionality. We efficiently parameterize these matrices based on scientific and intuitive similarity structure between monthly rainfall data. The main assumption we will rely our modeling structure on is that consecutive months tend to have similar total rainfall values. This yields a sparse structure for the propagation matrix:

$$\mathbf{H}_{\theta_T} = \begin{bmatrix} 0 & \beta & 0 & \gamma \\ \gamma & 0 & \mathbf{O} & 0 \\ 0 & \mathbf{O} & \mathbf{O} & \beta \\ \beta & 0 & \gamma & 0 \end{bmatrix} \text{ and } \mathbf{H}_{\theta_{T-1}} = \begin{bmatrix} \alpha & 0 & 0 & 0 \\ 0 & \alpha & \mathbf{O} & 0 \\ 0 & \mathbf{O} & \mathbf{O} & 0 \\ 0 & 0 & 0 & \alpha \end{bmatrix}$$

The proposed structure described above requires estimation of three unknown parameters

$$\theta_T = (\beta, \gamma)', \text{ and } \theta_{T-1} = \alpha'.$$

This sparse structure accounts for the effect of consecutive months (e.g., the rainfall values for January are only assumed to be affected by the values of December through parameter γ, and February through β, as well as, the effect of the values for January of the previous year through parameter α). We will also add extra parameters to this sparse structure based on the exploratory

data analysis done on the data. In particular, we will add two extra parameters to account for potential correlation between monthly total rainfall values of January and March, and June and November. This parameterization is motivated by the exploratory data analysis discussed in the previous section.

Another aspect of the proposed model is the ability to account for the spatial correlation between the rainfall values of the three weather stations. This assumption is accounted for in the covariance structure of the process model (Σ_η). The spatial correlation we consider is based on an exponential covariogram model

$$R(\tau) = \exp(-\tau \| d \|),$$

where the spatial correlation is based on the Euclidean distance (d) and a special range parameter, τ (which governs the strength of spatial correlation over spatial locations). Then, the covariance model can be written as

$$\Sigma_\eta = \sigma_\eta^2 R(\tau) \otimes I_n .$$

Here, the symbol $\otimes$ represents the Kronecker product of the two matrices. The rationale for accounting for spatial correlation is that there is spatial variability between the three weather stations. This spatial variability is shown in the figures shown in the previous section. Although, in some cases, the amount of variability between the three locations is negligible, in certain years for certain months, this variability is significant and should be accounted for. For example, see the plots for January, May, July, and August.

Development of Analytical Tools to Evaluate the Performance of Low Impact Developments in the District of Columbia

Basic Information

Title:	Development of Analytical Tools to Evaluate the Performance of Low Impact Developments in the District of Columbia
Project Number:	2010DC114B
Start Date:	3/1/2010
End Date:	1/28/2011
Funding Source:	104B
Congressional District:	DC
Research Category:	Climate and Hydrologic Processes
Focus Category:	Education, Hydrology, Non Point Pollution
Descriptors:	
Principal Investigators:	Arash Massoudieh, Pradeep K. Behera

Publications

There are no publications.

Development of Analytical Tools to Evaluate the Performance of Low Impact Developments

Progress Report

Submitted to

DISTRICT OF COLUMBIA WATER RESOURCES RESEARCH INSTITUTE

By:

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Catholic University

Dr. Pradeep Behera (co-PI)
Department of Engineering, Architecture & Aerospace Technology
University of the District of Columbia

May 2011

Summary

The goal of this project is to develop an urban watershed and water quality model to assess the impact of construction of various types of Best Management Practices (BMPs) and Low Impact Development (LID) strategies on the loads of various water quality constituents discharging into the water bodies around the District of Columbia. For this purpose an urban watershed model will be developed using the EPA SWMM model for a region at the eastern part of the city of Washington. Loads of TSS, and nutrients will be calculated for three water years including a wet year, a small year and an average year. These simulations will serve as the baseline scenarios. The impacts of various low impact development strategies including retention and detention basins, infiltration ponds, sand filters, rain barrels and green roofs and permeable pavement will then be incorporated into the model. The LID and BMPs will be incorporated as per-area cover and will influence the amount of runoff per area being generated and also in some cases will impact the water quality of the storm runoff.

Objectives

- To evaluate the impact of various scenarios of LID and BMP implementation on the quantity and quality of water discharging into Anacostia River.
- Proposing cost-effective management options for BMPs placement in the District.
- Proposing a decision support system to assist with a phased approach toward TMDL compliance.
- The project will benefit the public health and the water quality by leading to a more sustainable, cost-effective and affordable stormwater infrastructure.

Study Site and Data Availability:

Figures 1-3 shows the locations of the study sites chosen for the research. The location is only composed of that part of eastern Washington, DC that is covered by separate stormwater and municipal wastewater network (Figure 2). This area was selected to avoid the complications associated with the mixing of municipal wastewater with the stormwater. Figure 1 shows the study area in the District of Columbia. The central part of the City of Washington is covered by combined sewer system and the generated runoff in those areas is mostly treated at the Blue Plains wastewater treatment facility except for during the occurance of very large storms when the capacity of the plant is not adequate for the volume of stormwater and municipal wastewater and the water is discharged into the Anacostia River, untreated. There are two areas, one in the east side and the other in the west side of the district that are covered by separate stormwater networks and the stormwater generated in those areas are mainly discharged into the surrounding water bodies. The eastern region is selected for this study. We have gathered most of the data that is needed for the SWMM modeling including precipitation records, and topographic maps

and impervious and pervious areas. We have contacted DCWASA in order to obtain the sewer network map in a GIS compatible format. However our attempts have been unsuccessful so far but we have been promised to be provided with the ArcGIS shape files for the DC sewer network. We currently have a non-GIS map of the sewer system and if we don't succeed in obtaining the GIS maps we will use this map to approximate the sewer network configuration (Figure 4). As for flow, suspended solids and quantity data, we have got some data from the DC Department of Environment DDOE, however there are not adequate amount of data available for the discharge point of the catchment considered for this study. Topographic maps are downloaded in Arcgrid format from the USGS National Elevation Dataset (NED) website. This DEM data has a resolution of 1 Arc seconds (~30m). Rain data is available as hourly precipitation data from Reagan National Airport Station (Figure 5).

Developing the SWMM flow and water quality model and the planned simulations

We are currently at the stage of developing the SWMM model. Due to the delay in the subcontract being issued, the project was started later than planned. A no-cost extension until the end of September 2011 has been approved by DCWRRI and we are planning to finish the model development, calibration and also running several LID and BMP scenarios by that time. Continuous yearly simulations are planned to be performed for baseline and the LID and BMP implementation scenarios. The precipitation from three representative years will be considered for simulation including a wet year, a dry year and an average year. The impacts of various LID and BMP practices will be evaluated for all the three years. An exponential build-up function will be used to model the accumulation of pollutants on the surfaces during the dry periods between events. The range of the parameters of the exponential build up model will be obtained from literature but they will be adjusted during the model calibration. Also an exponential wash-off curve will be used.

The effectiveness of various LID approaches, including several scenarios of installation of bio-retention cells, infiltration trenches, porous pavements, and rain barrels will be studied. LID units will be represented by a combination of vertical layers whose properties are defined on a per-unit-area basis (Rossman, SWMM User's Manual, EPA). The impact of clogging on the long-term performance of porous pavements and infiltration trenches will be considered in the model. The porous pavement scenario will be implemented into the model by considering all or part of the parking lots in the area of study to be made of porous pavement. The impact of transforming the main roads' surfaces to porous pavement will not be studied due to the fact that a cost-effective and structurally durable method of using porous pavement for main roads have not been developed yet and also the impacts of clogging on the long-term efficiency of porous pavement has not been studied rigorously yet.

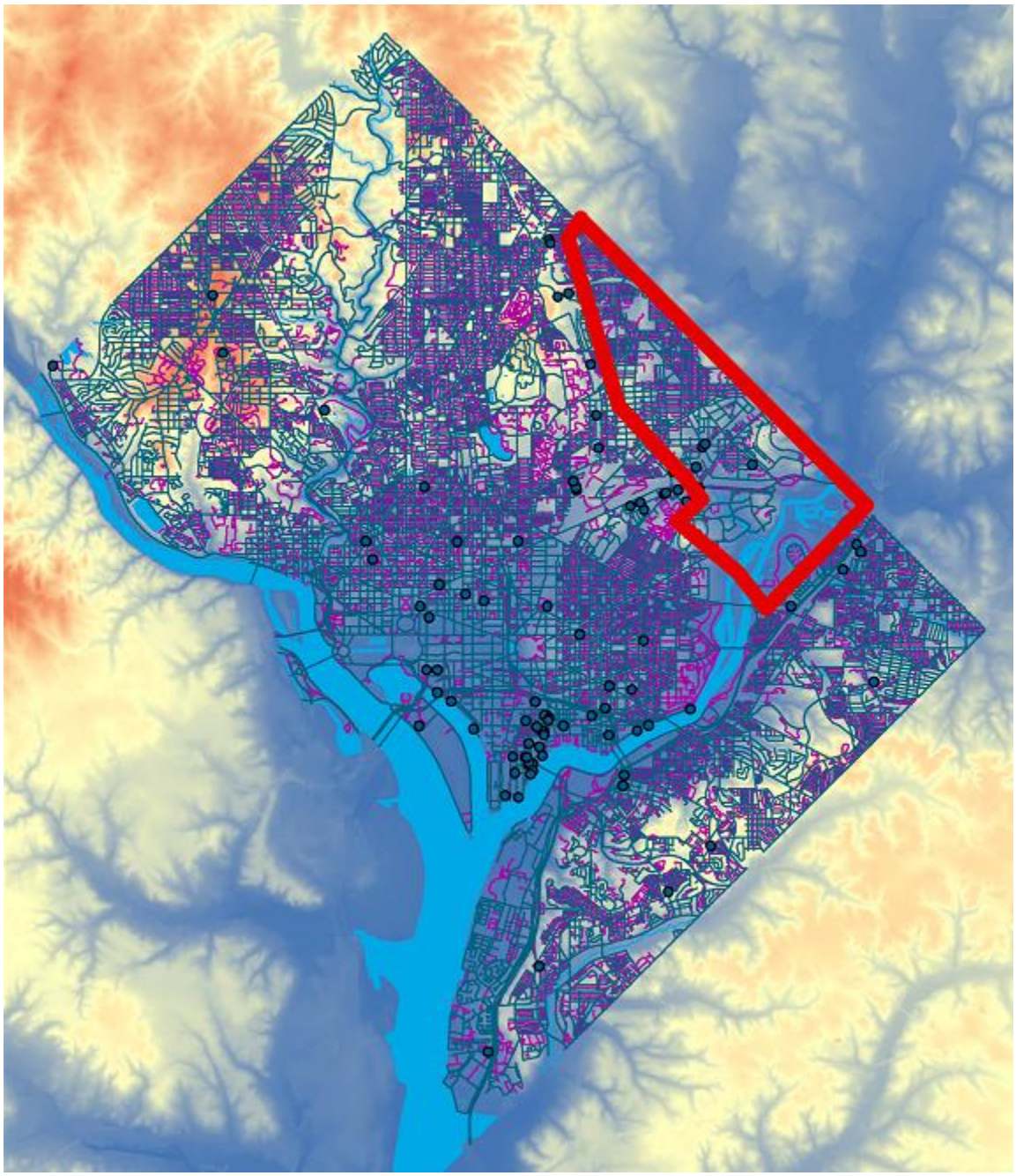


Figure 1: The extents of the study area

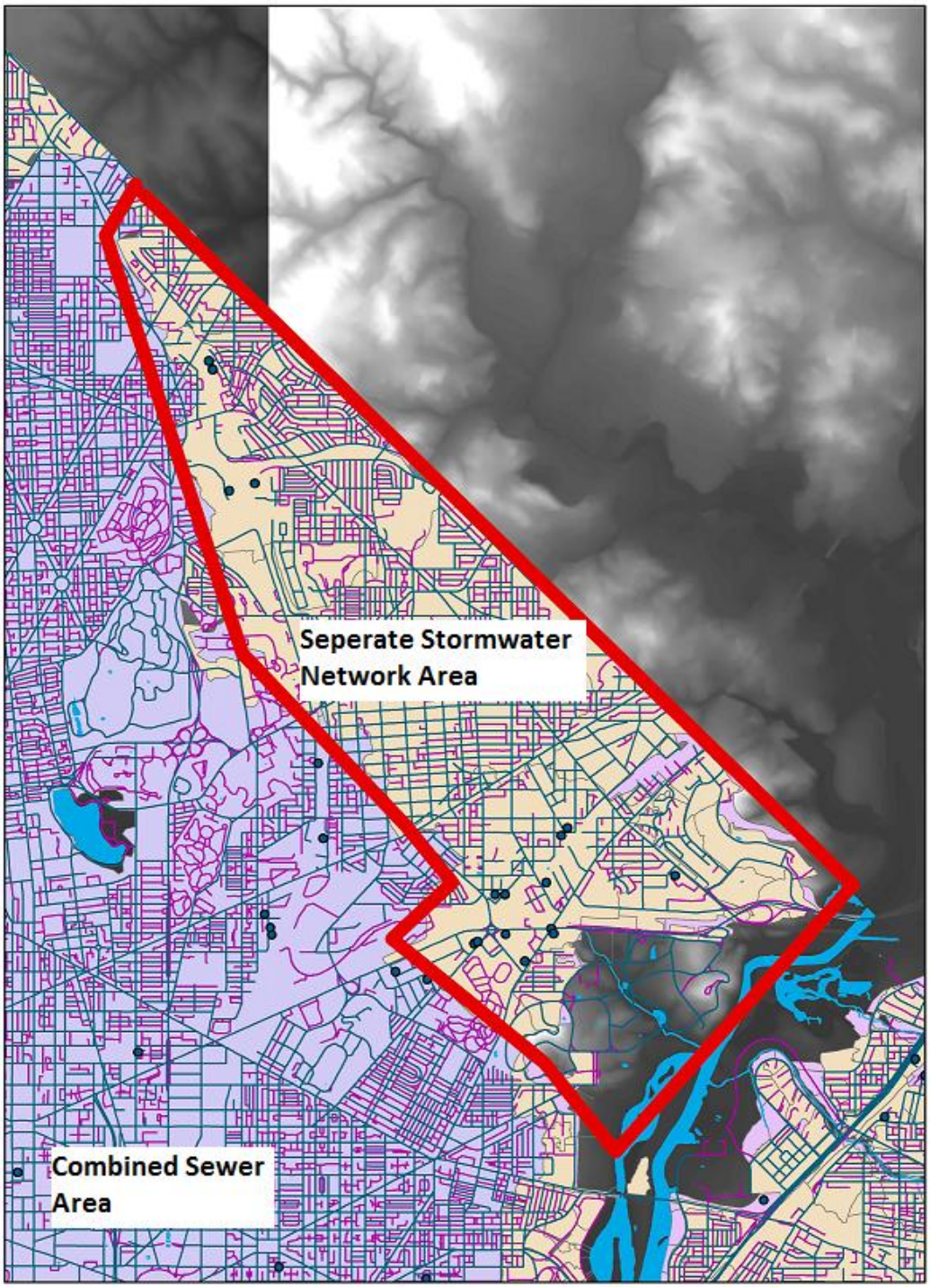


Figure 2: The extent of the study area and the regions of the city of Washington Covered by Combined and separate sewer network

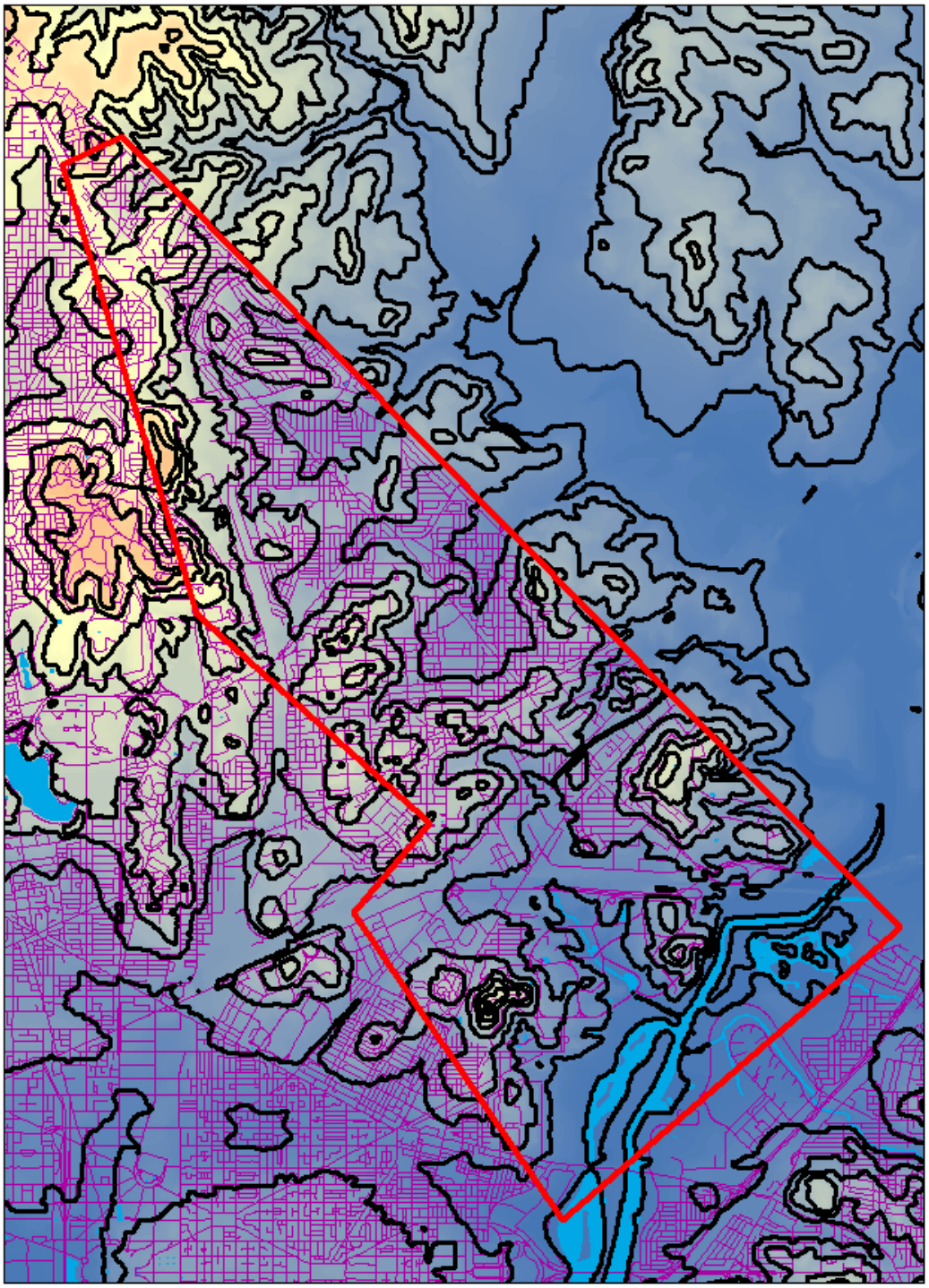


Figure 3: Topographic contour lines of the study site.

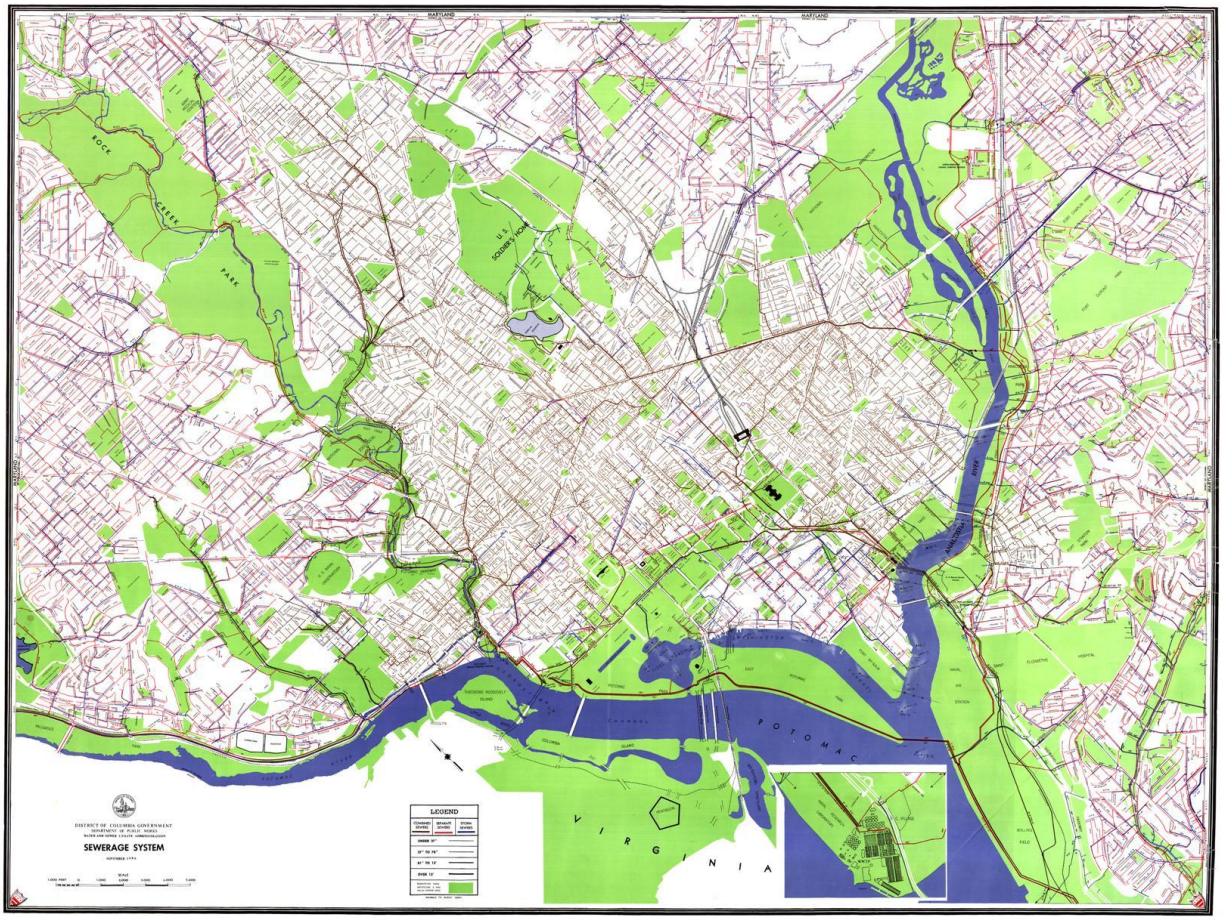


Figure 4: The map of the District of Columbia Sewer network

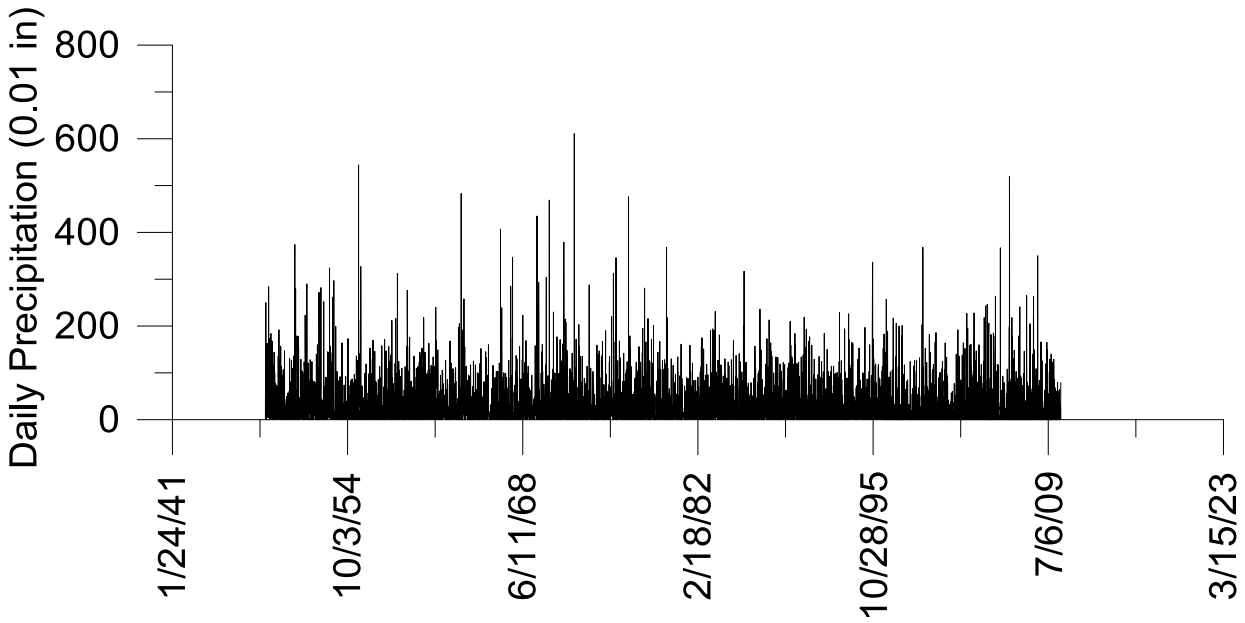


Figure 5: Daily Precipitation data at DCA meteorological station

Current Status of the project

Currently, almost all of the geospatial and temporal data required for the project have been collected and stored in a geo-referenced relational database system using MS ACCESS and ArcGIS. An undergraduate student (Tri Mihn Le) has been hired at CUA and will be assisting fulltime on the project during the summer. He has been trained SWMM and some GIS skills by Dr. Massoudieh. The SWMM model development is in progress.

Publications

Two journal review papers have been submitted partly as a result of this grant. In both papers DCWRRI program have been acknowledged. One of the papers has been accepted and the second one is under review:

Sharifi, S., A. Massoudieh, M. Kayhanian, (2011), A Stochastic Storm-Water Quality Volume Sizing Method with First Flush Emphasis, Water and Environment Research, Accepted.

Sharifi, S., and A. Massoudieh, "A Novel Evolutionary Data-Driven Model Identification Framework Using NSGA-II for the Analysis of Environmental Phenomena", Submitted to Hydroinformatics.

References

Rossman, (2004), L. A., Storm Water Management Model, User's Manual, Version 5.0, Water Supply and Water Resources Division, National Risk Management Research Laboratory, Cincinnati, OH 45268.

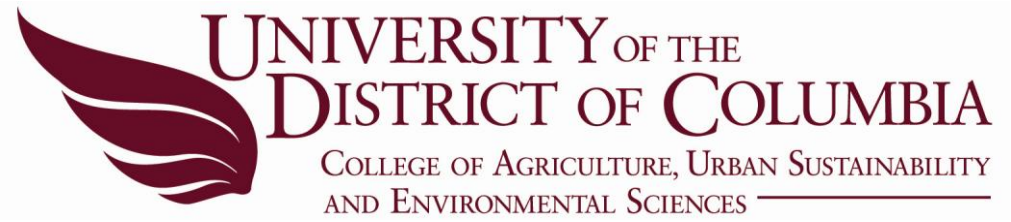
Determination of Seasonal Source Variation of Hydrocarbons, Fatty Acids, Organics and Nutrients in the Anacostia River: Stable isotope Ratios of Specific Compounds

Basic Information

Title:	Determination of Seasonal Source Variation of Hydrocarbons, Fatty Acids, Organics and Nutrients in the Anacostia River: Stable isotope Ratios of Specific Compounds
Project Number:	2010DC115B
Start Date:	3/1/2010
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	DC
Research Category:	Biological Sciences
Focus Category:	Sediments, Toxic Substances, Ecology
Descriptors:	None
Principal Investigators:	Stephen E. MacAvoy

Publications

There are no publications.



Determination of Seasonal Source Variation of Hydrocarbons, Organics and Nutrients in the Anacostia River: Stable Isotope Ratios of Specific Compounds

Progress Report

Submitted to

DISTRICT OF COLUMBIA WATER RESOURCES RESEARCH INSTITUTE

By

Dr. Stephen MacAvoy (PI)
Assistant professor
Department of Environmental Science
American University

May 2011

Progress Summary

A six month no-cost extension was granted March 3, 2011 so the final report of the project will be delivered by October 31, 2011. Water, sediment, and (when possible) invertebrate samples have been collected (in most cases monthly) since April 2010 and have continued through May 2011. We have completed $d^{13}C$ and $d^{15}N$ on organics (sediment and water column particulate organic matter (POM)) from the first 9 months or so of the collections. Hydrocarbons have been extracted from those same samples and have been characterized with the GC/MS. Also, characterization of the geochemistry of Anacostia waters from our field sites has been and continues to be undertaken (analysis of inorganics, including Ca, Mg, Na, S, K, P, B, Ba, Ni, Co, plus nutrients, including NO_3, NH_4, PO_4, and total organic carbon (TOC). The examination and interpretation of our results is ongoing, however I have included in the progress report our initial analysis, which has been presented at the Annual Meeting of the American Geophysical Union, December 2010. These results will be written up as a manuscript for peer reviewed publication summer 2011. We have yet to decide which of our hydrocarbon extracts should be selected for $d^{13}C$ characterization. Generally, only samples with compounds of particular interest (branched or odd chain fatty acids, or petrochemicals for example) should be selected because compound specific isotope analysis is a complex and expensive procedure. We have to send our sediment and POM samples out for $d^{34}S$ analysis. Due to expense, we had to delay this analysis until the funding for the project was in place. We expect to have all the data collected by early fall, and will review what we find in the final report.

Below please find our initial analysis of our results from the geochemical/nutrient work.

Seasonal nutrient dynamics in the Anacostia River (D.C., USA): geochemistry and hydrocarbon biomarkers*

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[2]American University, Department of Biology, Washington DC, 20016

* This paper was presented at the Annual Meeting of the American Geophysical Union, San Francisco, December 2010 B43A-0446 poster session

Abstract

The seasonal biogeochemistry of the urban Anacostia River (Washington D.C. USA) was investigated. Chemical parameters examined include: inorganics (Ca, Mg, Na, S, K, P, NO3, NH4, PO4, B, Ba, Ni, Co); fatty acids and other hydrocarbons; C, N and S stable isotopes; and other water chemistry indicators (hardness, salinity, alkalinity, soluble salts, SAR, TDS). Between April and September 2010, water and sediment were sampled from three tidal freshwater sites along the Anacostia River (UP, MID, and DOWN). Stable isotope analysis of surface sediments revealed a lack of temporal variation in the sources of carbon and nitrogen to the Anacostia. δ15N values ranged from +2 to +6‰, with the most enriched sediment occurring at DOWN (+4 to +6‰). While these values do not reflect sewage inputs, an overall enrichment is observed between spring and late summer, which may indicate microbial activity. δ13C values exhibited slightly more variation and ranged from -30 to -25‰. All sites showed relative depletion in early summer compared with spring or late summer/fall. Water nutrients (NO3 and NH4) demonstrate seasonal fluxes; all sites show a peak in nutrients during early summer (June) and subsequent decline. Overall, NO3 ranges from about 0.2 to 3.3 mg/L and NH4 ranges from 0 to 1.7 µg/L. Preliminary GC-MS analysis of isolated fatty acids does not explicitly suggest bacterial or higher plant dominance in the spring; however, some notable compounds were identified, such as the PAH fluoranthene, naphthoquinone, and testosterone, as well as a number of cholesterols and other steroids. Principle Component Analysis (PCA) of the chemistry data suggests mineral geochemical variables, rather than inorganic nutrients, are the driving forces of observed trends.

Introduction

The Anacostia River is a major waterway, encompassing 440 km^2, located in Washington, D.C. It is also one of the nation's 10 most contaminated rivers, containing sewage, metals, PAHs, and PCBs, and has been cited by the EPA as a "major area of concern" for the Chesapeake region (Maa 2008). Several studies have examined heavy metal geochemistry in the river, but its biogeochemical processes remain largely unstudied (MacAvoy *et al*. 2009). This paper examines nutrient dynamics, organic material sources, and microorganism community makeup, as well as the seasonal trends in these parameters.

Objectives

This research seeks to elucidate seasonal nutrient dynamics and organic material sources of the Anacostia River by addressing the objectives: 1) Determine if seasonal component to water nutrient concentrations and sources exists, and 2) Identify biogeochemical controls within the river and discern which geochemical and nutrient variables are driving those controls.

Methods

Sampling was conducted at three sites (UP, MID, DOWN) along a downstream gradient originating in Bladensburg, Maryland (Plate 2). Water column and sediment samples were collected in triplicate from each site on a once monthly basis, starting in April, 2010. Water samples were immediately filtered onto GFF once in lab, while replicates were sent to Cornell's Nutrient Analysis Lab for analysis of inorganics (Ca, Mg, Na, S, K, P, NO3, NH4, PO4, B, Ba, Ni, Co). Sediment samples were dried for 72 hours at 60°C.

Extracted sediment samples and water column particulate organic matter (POM) were sent to UC Davis' Isotope Analysis Facility for ^{13}C and ^{15}N isotope analyses using a PDZ Europa ANCA-GSL elemental analyzer interfaced to a PDZ Europa 20-20 isotope ratio mass spectrometer. Fatty acids were extracted from GFFs and sediment via Soxhlet extraction followed by saponification. FAMEs were analyzed using a Thermo Polaris Q GC/MS. A Principle Components Analysis (PCA) was applied to nutrient variables to elucidate relationships of covariance within the dataset (Dennis *et al.,* 1995).

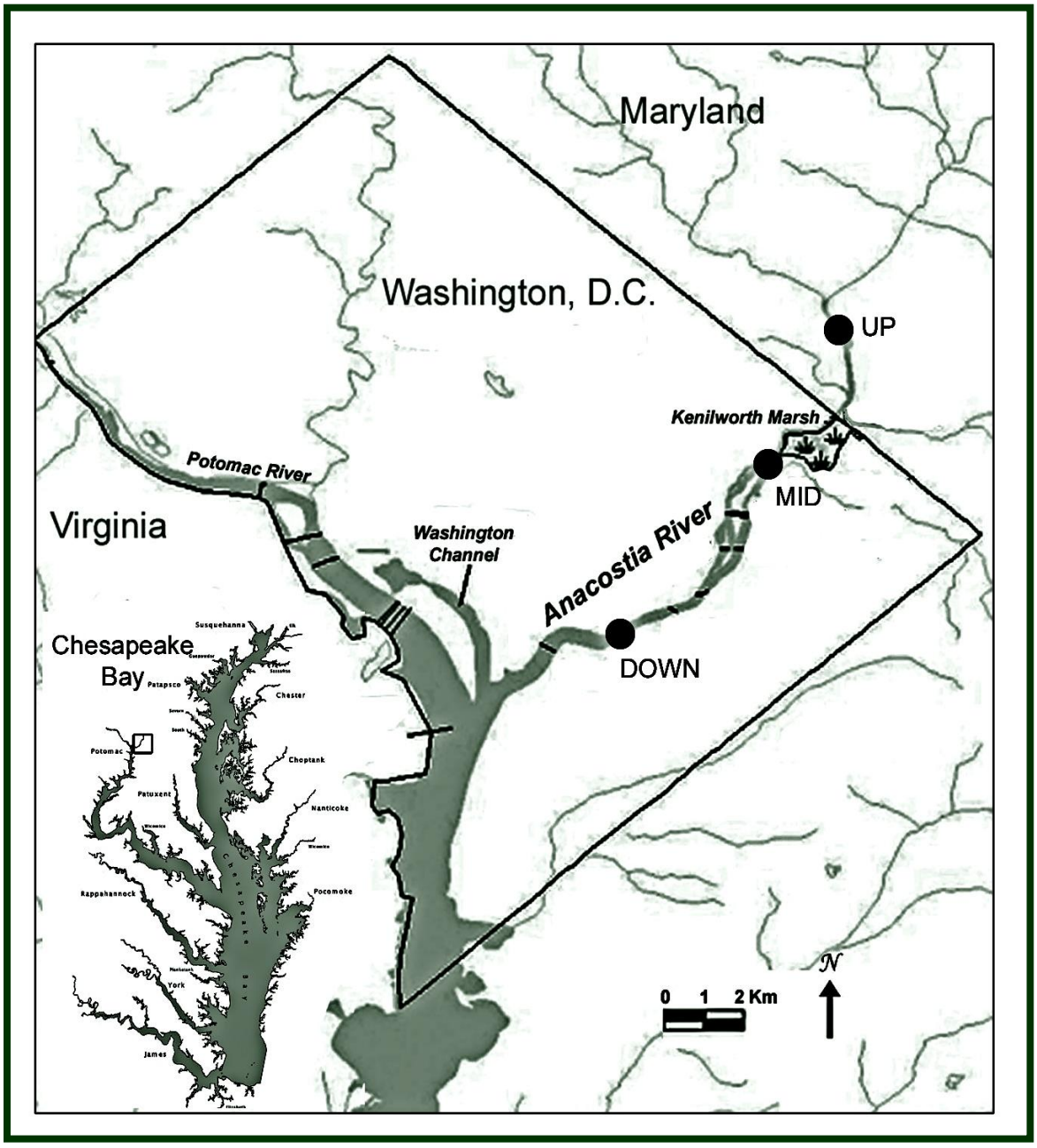
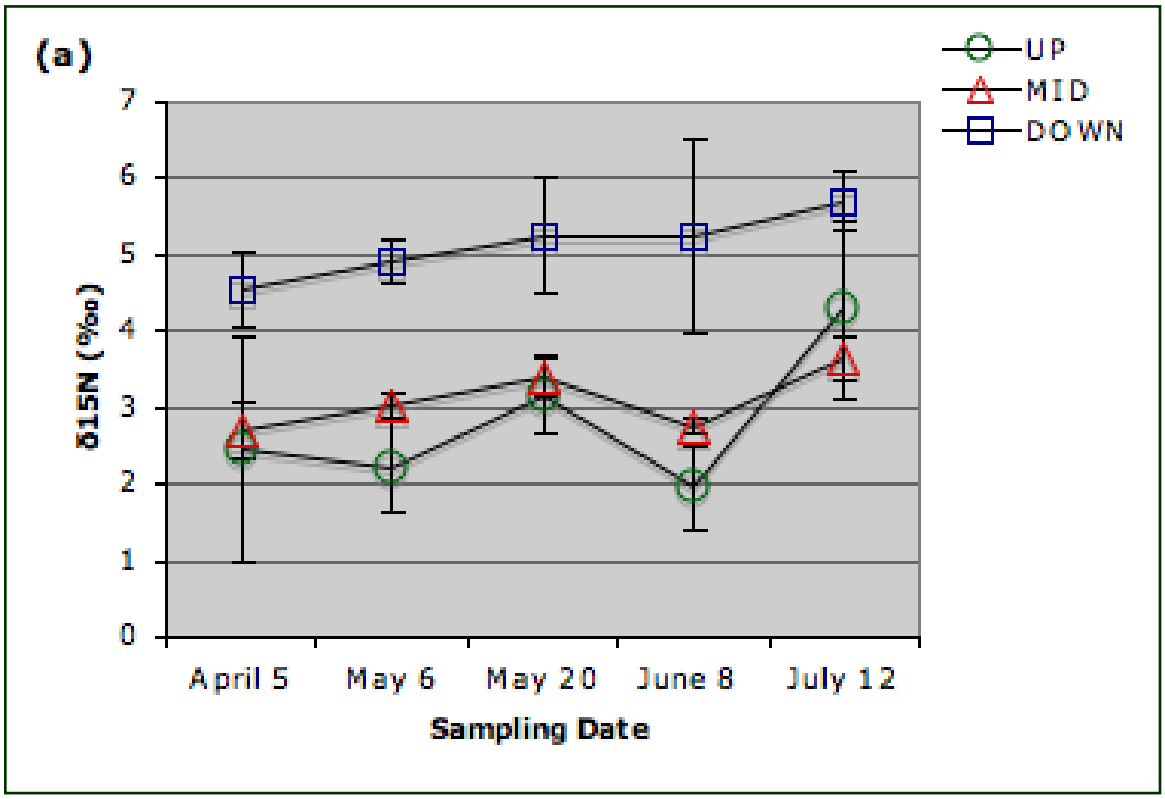


Plate 1. Site map.

Figure 1 Sediment Nitrogen (a) and Carbon (b) Isotope Values over Time: (a) δ15N values are observed to increase from April to July at all sites. Sediment at DOWN shows the most enriched isotope signature, which could reflect its proximity to a combined sewage outflow. Overall, sediment is less enriched than would be expected if sewage is a source; N source appears to be autochthonous (b) δ13C shows similar trends at all sites, and becomes more enriched from ate May to September. Values range from -25‰ to -30‰, and are not reflective of a terrestrial source.



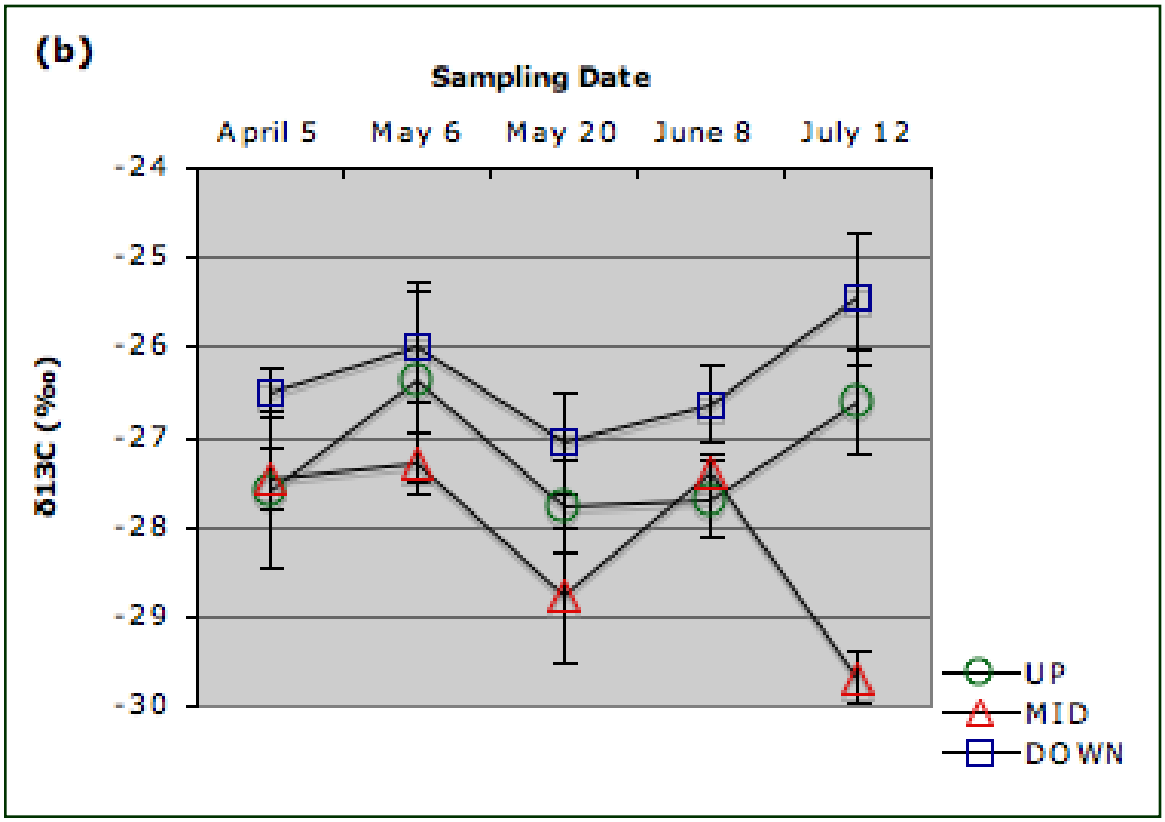
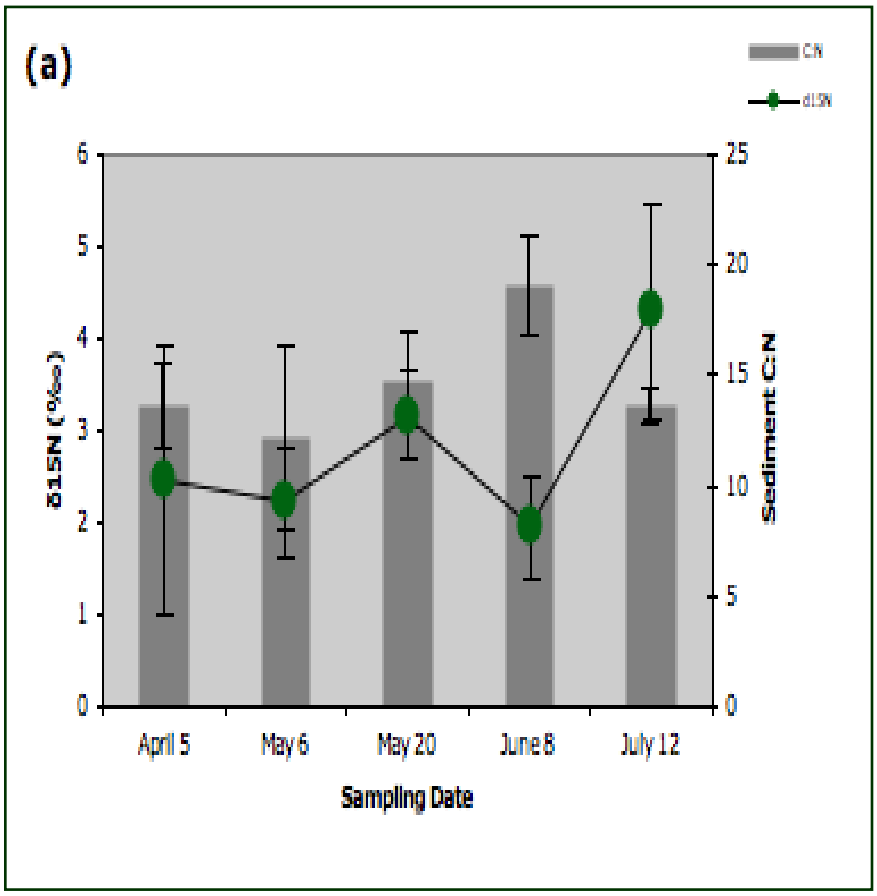
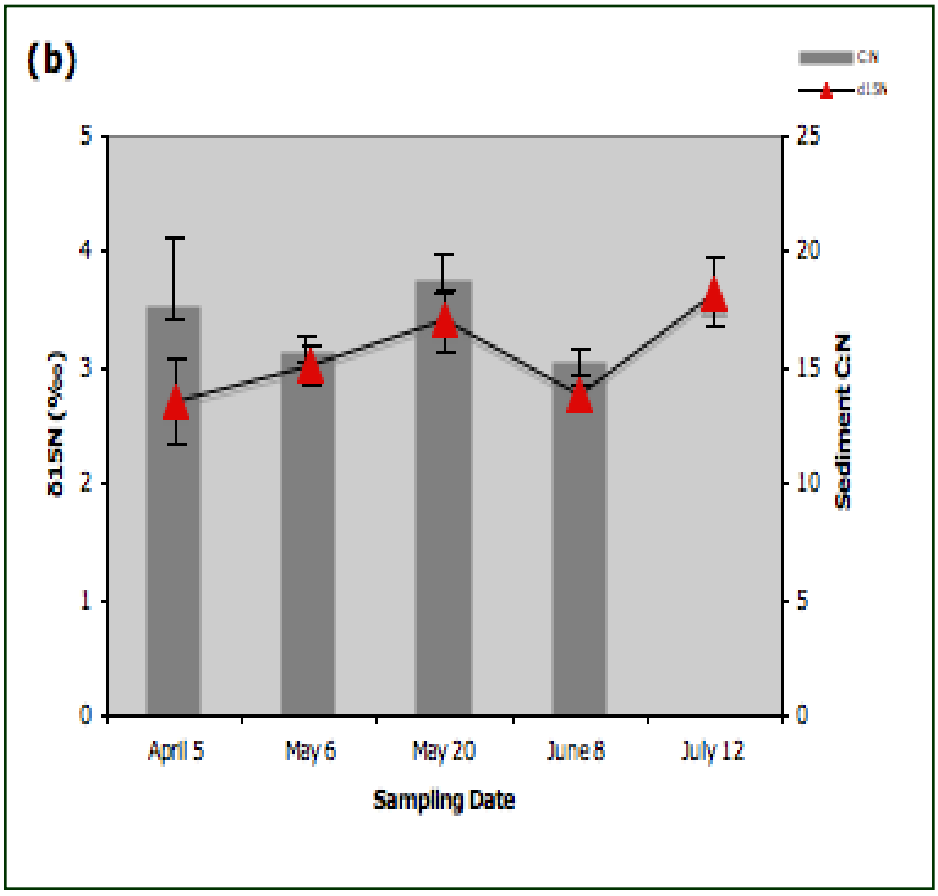

(b)
Sampling Date
April 5
May 6
May 20
June 8
July 12
-24
-25
-26
-27
-28
-29
-30
δ13C (‰)
UP
MID
DOWN

Figure 2 Sediment δ15N and C:N over Time at (a) UP, (b) MID, and (c) DOWN: (a,b,c) C:N is relatively constant over time at all sites, ranging from about 14 to 20. At all sites, sediment nitrogen is becoming more enriched between spring and late summer, reflective of increased in microbial activity. (c) DOWN shows the most nitrogen enrichment, with δ15N values range from +4 to +6‰.




(b)
C:N
δ15N
5
4
3
2
1
0
25
20
15
10
5
0
δ15N (‰)
Sediment C:N
April 5
May 6
May 20
June 8
July 12
Sampling Date

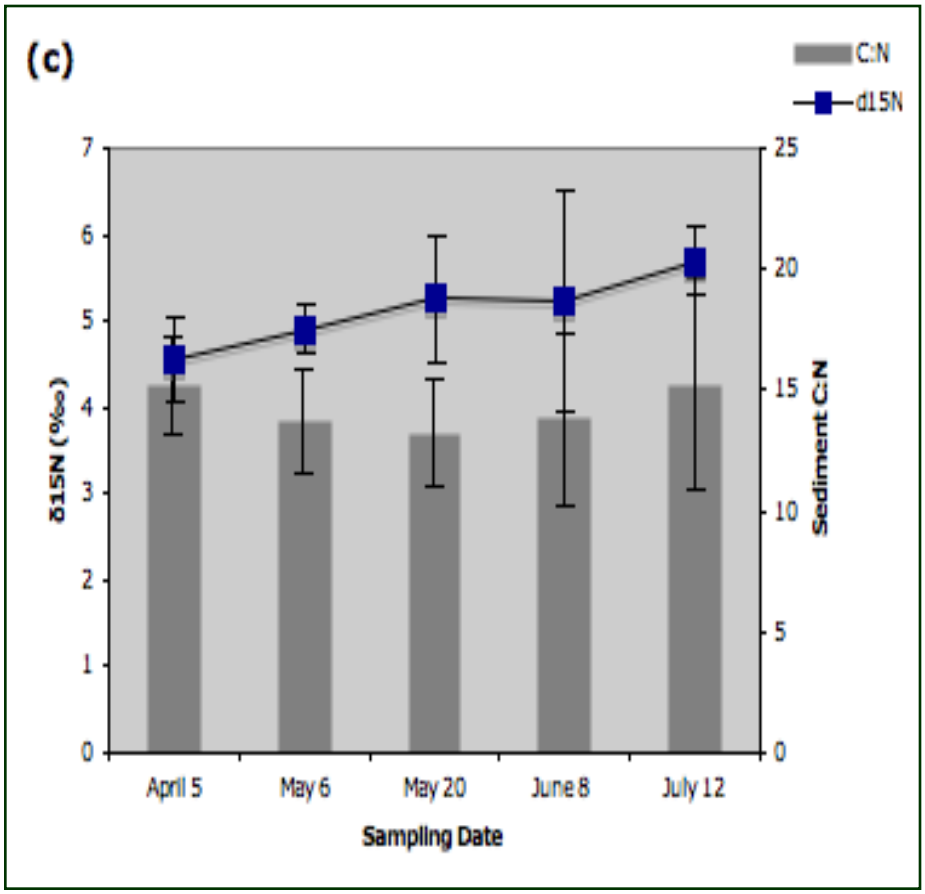
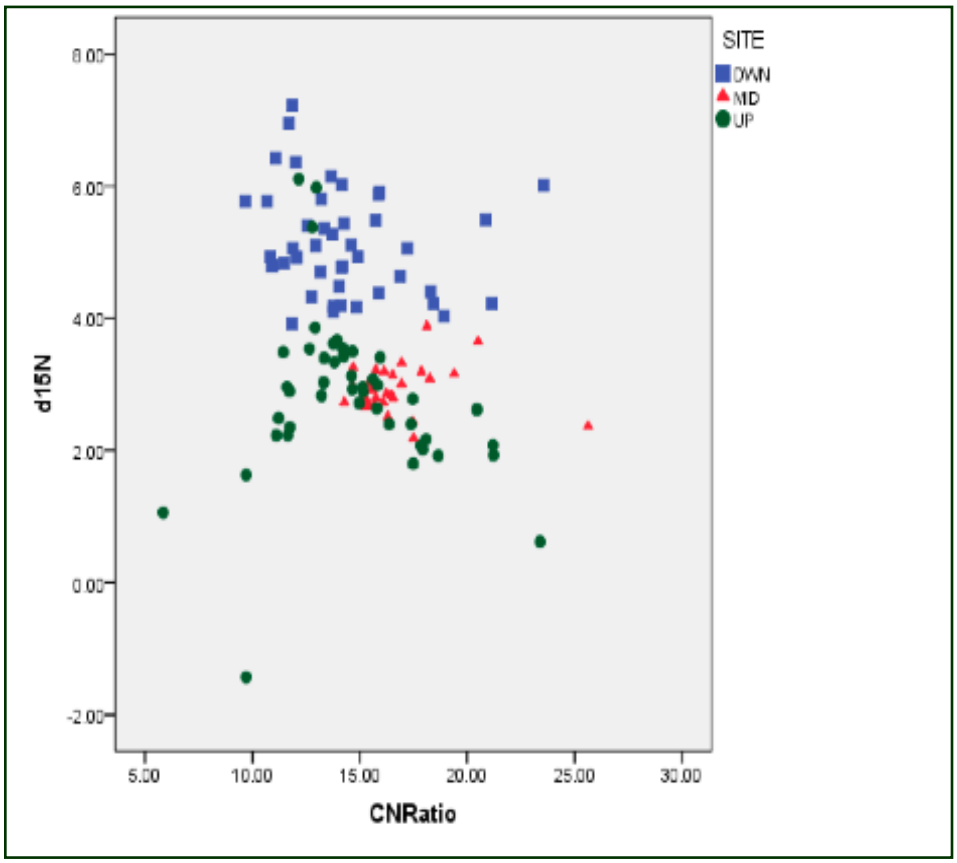
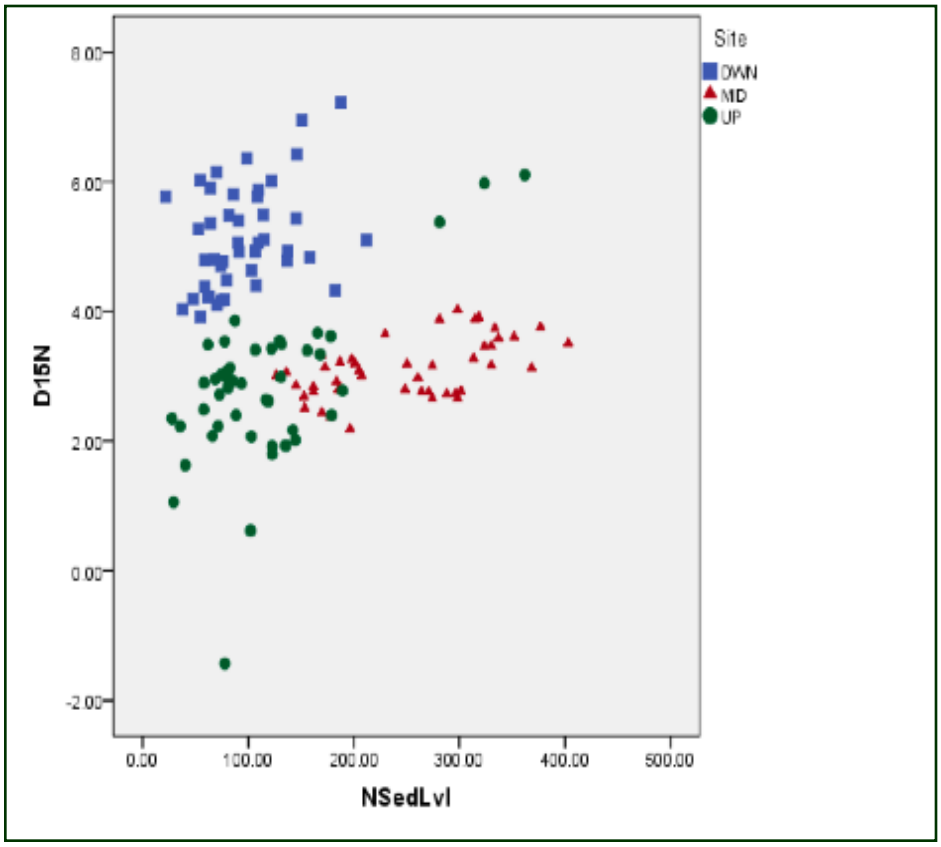

(c)
C:N
d15N
δ15N (‰)
Sediment C:N
0
1
2
3
4
5
6
7
0
5
10
15
20
25
April 5
May 6
May 20
June 8
July 12
Sampling Date

Figure 3 δ15N versus C:N (a) and Soil [N] (b) shows Clustering by Site: clustering in figures 3 (a) and (b) suggests that sediment [C] is highly variable between sites UP and DOWN.

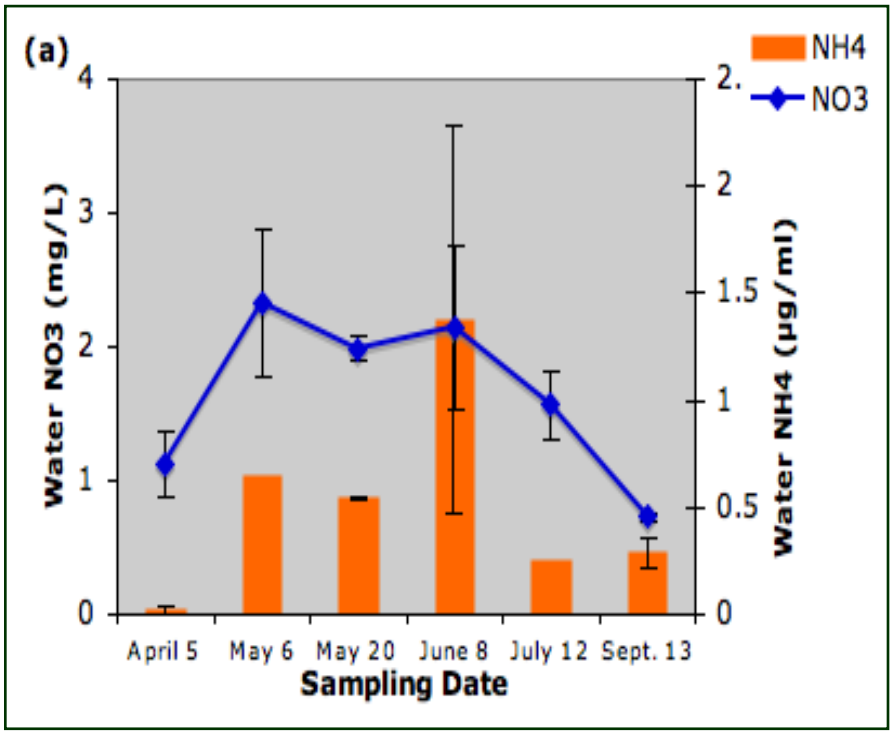


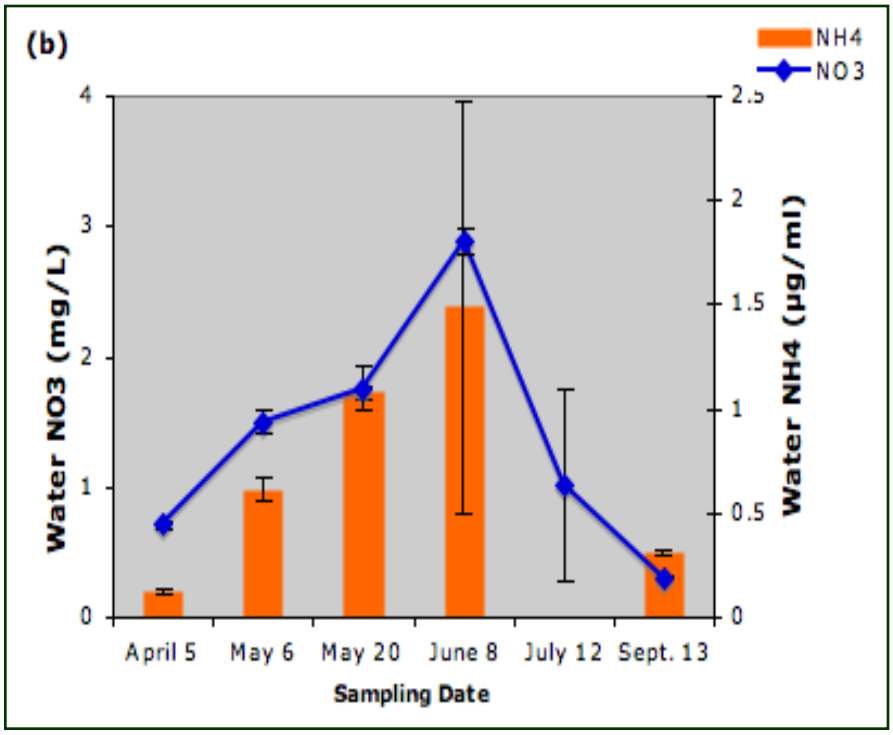
3a.


Site
DWN
MID
UP
D15N
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
100.00
200.00
300.00
400.00
500.00
NSedLvl

3b.

Figure 4 Water Column Nitrogen (NO3 and NOH4) Trends over Time: At (a) UP, (b) MID, and (c) DOWN. Nutrient levels are within similar ranges at all sites and are variable across the time span of sampling. (b) a gradual increase in both parameters is exhibited at MID, with a peak in June and subsequent decline. (c) a pulse of NO3 is seen in May, uncouple with any NH4 increase.




(b)
NH4
NO3
Water NO3 (mg/L)
Water NH4 (µg/ml)
0
1
2
3
4
0
0.5
1
1.5
2
2.5
April 5
May 6
May 20
June 8
July 12
Sept. 13
Sampling Date

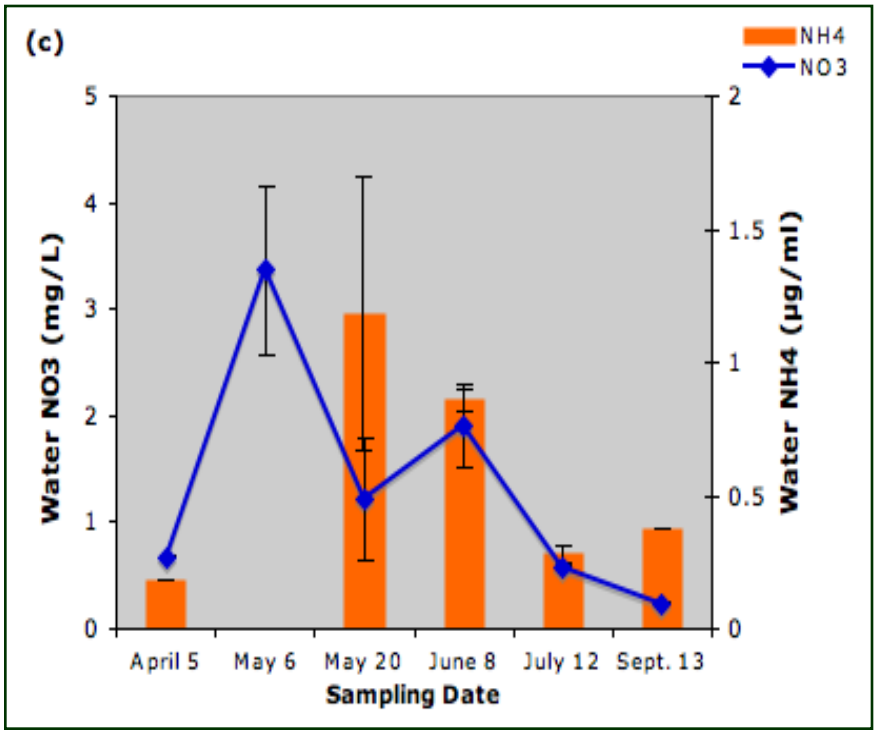
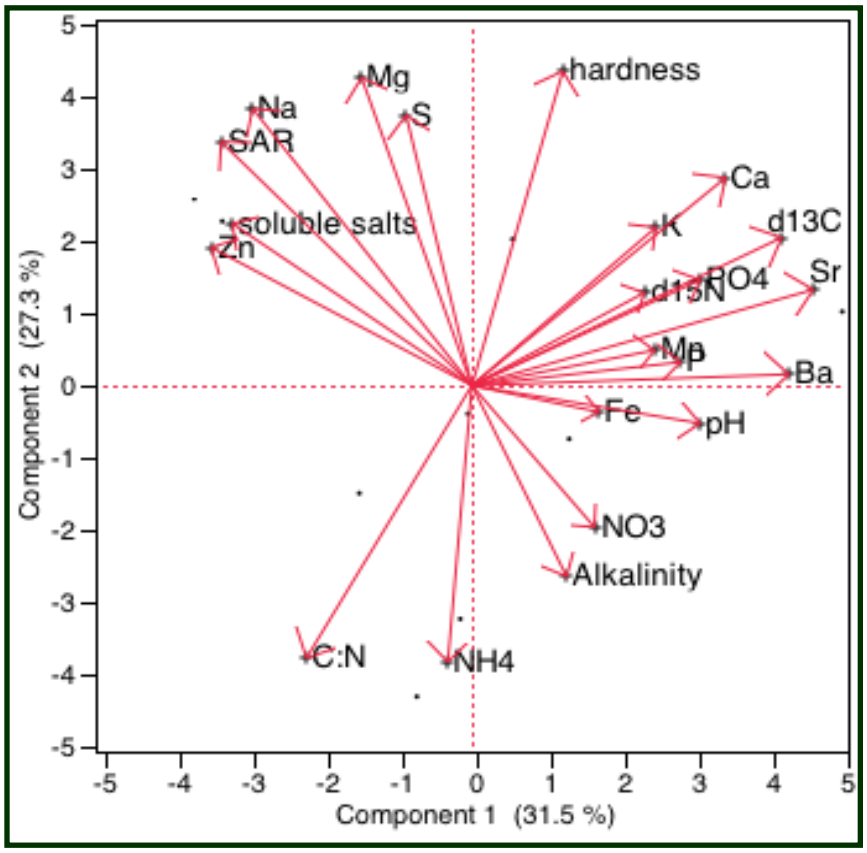
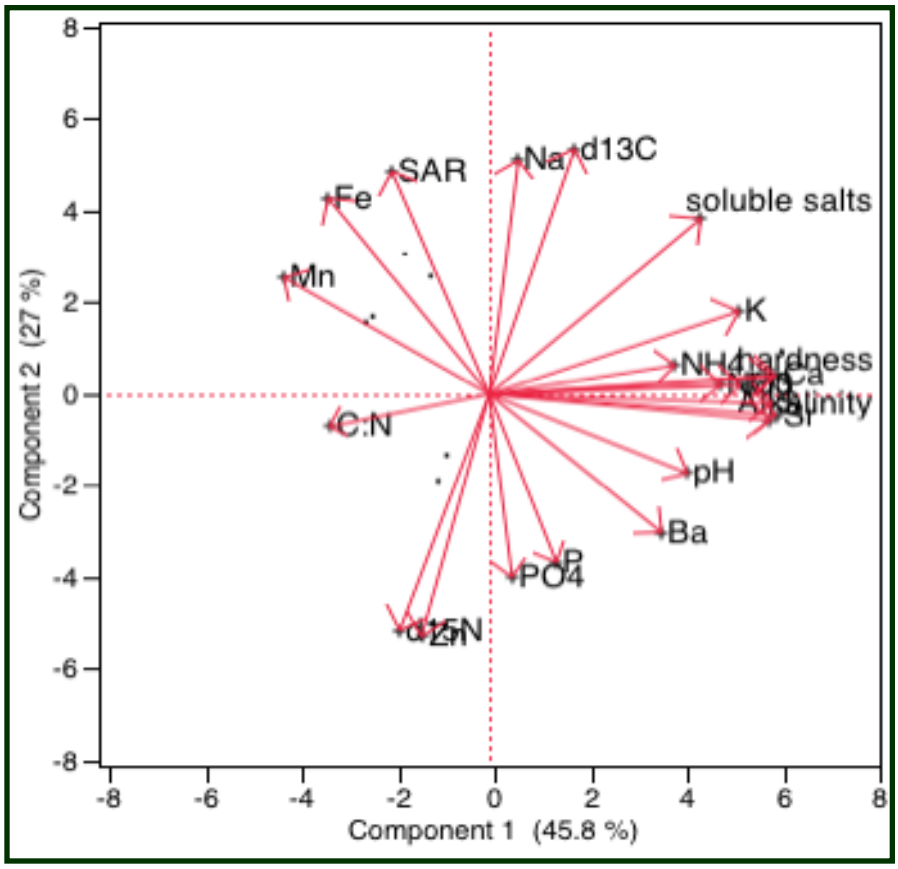

(c)
NH4
NO3
Water NO3 (mg/L)
Water NH4 (µg/ml)
0
1
2
3
4
5
0
0.5
1
1.5
2
April 5
May 6
May 20
June 8
July 12
Sept. 13
Sampling Date

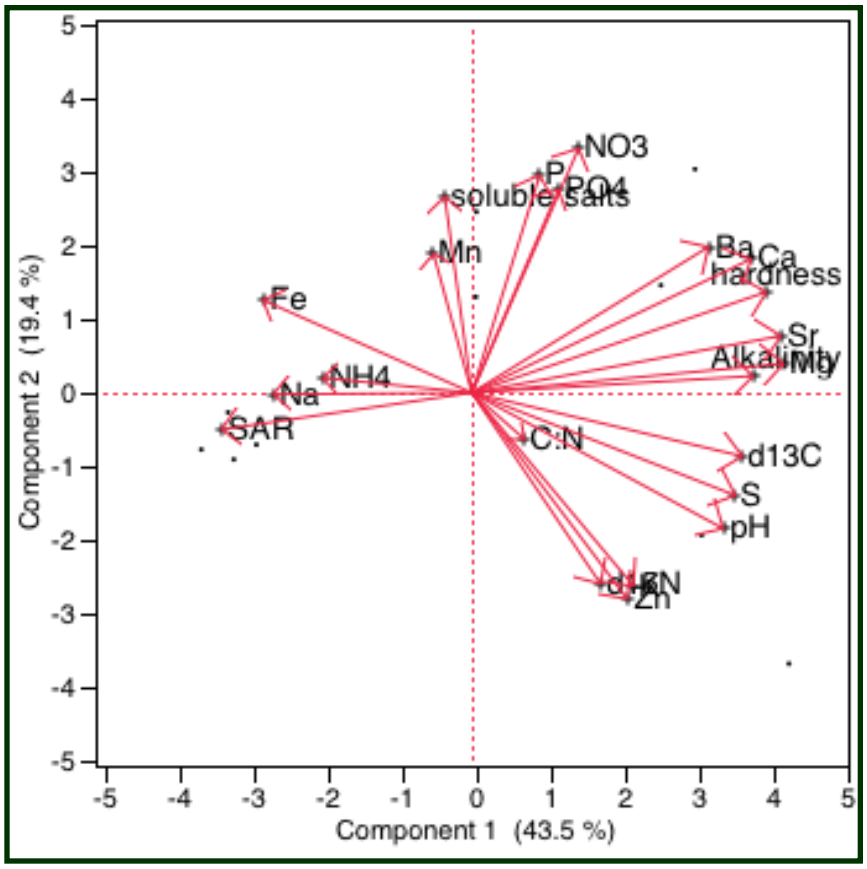
Figure 5 Biplots of PCA at UP (a), MID (b), and DOWN (c): PCA including all water and sediment parameters reveals that each site has distinct controls. There appears to be a strong geochemical control to explain most of the dataset (PC1), while PC2 highlights nutrient drivers such as δ15N and C:N. (b, c) there is a strong correlation between Zn levels and δ15N at both sites MID and DOWN. (a, c) at UP and DOWN δ13C is strongly associated with geochemical variables.



5a.


Component 2 (27 %)
Component 1 (45.8 %)
SAR
Na
d13C
Fe
soluble salts
Mn
K
hardness
Ca
Alkalinity
Si
C:N
pH
Ba
P
PO4
d15N
Zn
8
6
4
2
0
-2
-4
-6
-8

5b.



5c.

Conclusions

1) A seasonal component is present in water nutrient concentrations; however variation is sediment organic sources (δ15N, δ13C, C:N) appears more closely associated with site rather than collection date.

2) δ13C (-25 to -30‰) are representative of autochthonous production.

3) δ15N values ranged (+2 to +6), but UP showed the most enrichment (+4 to +6). Values are not reflective of sewage inputs. δ15N values also show a gradual enrichment from April to July, which may suggest the increase is bacterial mobilization.

4) C:N ratios of between 13 and 19 suggest autochthonous sources of sediment organics.

5) Heterogeneity between sites values is highlighted in Figure 1(a) and Figure 4. PCA reveals strong geochemical (mineral) involvement in PC1 and more nutrient involvement in PC2. Each site is seen to have distinct biogeochemical controls (Figure 5).

Acknowledgments

The authors would like to thank the Cosmos Club Foundation and WRRI/USGS proposal number for partial funding of this study.

References

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Dennis, T. E., S. E. MacAvoy, et al. (1995). "The association of water chemistry variables and fish condition in streams of Shenandoah National Park (USA)." *Water Air and Soil Pollution* **85**(2): 365-370.

Maa, J. P. Y. (2008). "Sediment erosion characteristics in the Anacostia River." *Journal of Hydraulic* E*ngineering-Asce* **134**(8): 1102-1109.

MacAvoy, S. E., E. C. Ewers, et al. (2009). "Nutrients, oxygen dynamics, stable isotopes and fatty acid concentrations of a freshwater tidal system, Washington, DC." *Journal of Environmental Monitoring* **11**(9): 1622-1628.

Speciation of Some Triorganotin Compounds in Anacostia and Potomac River Sediments using NMR Spectroscopy (Phase II)

Basic Information

Title:	Speciation of Some Triorganotin Compounds in Anacostia and Potomac River Sediments using NMR Spectroscopy (Phase II)
Project Number:	2010DC116B
Start Date:	3/1/2010
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	DC
Research Category:	Water Quality
Focus Category:	Sediments, Water Quality, Toxic Substances
Descriptors:	None
Principal Investigators:	Xueqing Song

Publications

There are no publications.

Speciation of some tributyltin compounds in Anacostia and Potomac River sediments using ^{119}SnNMR spectroscopy

Final Report

Submitted to

DISTRICT OF COLUMBIA WATER RESOURCES RESEARCH INSTITUTE

By:

Dr. Xueging Song (PI)
Associate Professor
Chemistry Department
University of the District of Columbia

February 2011

Abstract

The presence of triorganotin in sediments has been regarded as long-term threat to marine and estuarine environments due to its persistence and toxicity to marine organism, such as oysters and fish. Tributyltins were used in antifouling paints on ship hulls because of its strong biocidal effect. These applications are inevitably associated with triorganotin releases into the surrounding water, where it accumulates in suspended matter and in sediments. The overall objective of this research project was to investigate the environmental speciation of tributyltin compounds that are leached from antifouling paints into DC waterways, such as the Anacostia and Potomac Rivers, as a function of pH and to determine the transformation through interaction with the river sediments. The speciation of three tributyltin compounds (TBTs) -- tributyltin chloride (TBTCl), Bis(tributyltin) Oxide (TBTO) and tributyltin acetate (TBTOAc) under varying pH conditions (5, 7 and 9) -- was studied by NMR spectroscopy in both anaerobic and aerobic Anacostia River sediments. The results from this study will provide individuals and/or government agencies interested in water quality and planning of Anacostia and Potomac rivers with knowledge of the fate of these triorganotins once they are leached into these rivers. This information will enable those making decisions about the water quality to better assess the long term impact of these chemicals on the aquatic environment. In addition, understanding the long term environment effects of these compounds, particularly on the fish population in the Anacostia and Potomac rivers is critical, since many of the fish taken from these rivers are consumed.

Objectives

The overall objective of this research project was to investigate the environmental speciation of tributyltin compounds that are leached from antifouling paints into DC waterways, such as the Anacostia and Potomac Rivers, as a function of pH and to determine the transformation through interaction with the river sediments. Speciation of triorganotins is of major concern due to their species-specific toxicity. Tributyltins were used in antifouling paints on ship hulls because of its strong biocidal effect. These applications are inevitably associated with triorganotin releases into the surrounding water, where it accumulates in suspended matter and in sediments. These compounds have been found to be toxic to other non-targeted marine organism, such as oysters and fish. The species that were produced as a result of these interactions were determined using NMR spectroscopy. Compared with other analytical methods, such as derivatization, pressurized liquid extraction, liquid chromatography – inductively coupled plasma mass spectroscopy, and Mossbauer spectroscopy, NMR spectroscopy offers an advantage in that it permits direct observation of the interaction between the triorganotins and the sediments.

Introduction

The Anacostia River and Potomac River are two major waterways located in the District of Columbia. Each year these rivers play host to extensive recreational activities for the residents of the metropolitan area. Two classes of pollutants that find their way into Anacostia and Potomac rivers, as well as other waterways that have high boat traffic, are tributyltins (TBTs) and triphenyltins (TPTs) since they are the toxic additives added to antifoulant marine paints. [1] Marine paints are used to inhibit the attachment of barnacles, sea grass, hydroids and other marine organisms to the bottom of ships and other submerged marine structures. Organotin marine paints contain as much as 20% by weight of antifoulant.[1] One mode of entry these triorganotins into the various waterways is through their release from vessels and underwater structures, such as harbors, estuaries, marinas and bays, than in open waters. The use of triorganotin compounds in the United States has been restricted by the Organotin Act which prohibits the use of organotin-based paints on vessels smaller than 25 meters. [2] However, vessels larger than 25 meters may still use marine paints containing organotins and a number of these larger vessels still travel these rivers, particularly, the Anacostia River where a naval shipyard is located.

Studies have shown that these organotin compounds still possess a major threat to the aquatic environment even after government regulations have restricted their use. [3,4] In the aquatic environment, triorganotin compounds are known to have low aqueous solubility and mobility, and exhibit strong binding to sediments. These compounds are therefore easily absorbed by particular matter in water, which upon settling to he bottom, can be incorporated into the sediment.[5] Any disturbance of the sediment will permit the direct and continuous re-introduction of the organotins back into the water column, where they can have adverse effect on non-targeted species such as crustaceans and fish. [6]

The presence of triorganotin in sediments has been regarded as long-term threat to marine and estuarine environments due to its persistence. Understanding its fate in the environment is therefore of primary importance to prevent its migration. TBT and TPT sorption were found to be reversible, indicating that contaminated sediment may release triorganotins to overlying waters following sediment disturbance.[7] Hence, the approach to understand the conditions affect the mobility of tin becomes a significant. While there have been numerous speciation studies of organotin compounds in various bodies of water around the world, there have been no similar

extensive studies in DC waterways. While most investigators have focused on the determination of organotin species and their concentration in the environment, only a few studies has been initiated to study the interactions of the organotins with sediments. Thus, a study of the speciation of triorganotins in the sediments of Anacostia and Potomac rivers as a function of pH to evaluate their interaction with sediments would be essential for the understanding of the effects of triorganotins on the aquatic environment. The results from this study will alert those responsible for water quality to the long term impact of these hazardous chemicals and, therefore, allow them to plan accordingly. The results from this study will provide individuals and/or government agencies interested in water quality and planning of Anacostia and Potomac rivers with knowledge of the fate of these triorganotins once they are leached into these rivers. This information will enable those making decisions about the water quality to better assess the long term impact of these chemicals on the aquatic environment. In addition, understanding the long term environment effects of these compounds, particularly on the fish population in the Anacostia and Potomac rivers, is critical since many of the fish taken from these rivers are consumed. Consuming large amounts of these fish could have an adverse impact on the health of individuals since triorganotin are known to have mammalian toxicities.

There are numerous analytical procedures in the literature for the determination of organotin compounds. Two recent reviews [8,9] have indicated that the method most employed for the quantitative determination of organotin species in sediments involves some types of derivatization of the organotin species followed by species detection. For example, the determination of organotin by gas chromatography (GC) involves four steps: (1) extraction/concentration; (2) derivatization (hydridization or alkylation); (3) separation; and (4) detection. [8] However, strong interaction between triorganotins and sediments can bias the results.[9] Furthermore, the accuracy of butyl- and phenyltin determination is hampered by the lack of certified reference materials.[9] It would be more advantageous to examine the original organotin species than to study their derivatized analogs, since metals and any organic species contained in the sediment can interfere with the derivatization of the organotin species.[10-12] Mossbauer spectroscopy has been used in this lab to directly examine the original species in sediments.[13-15] However, two unsolved problems in the speciation of organotin using Mossbauer spectroscopy make it difficult to get accurate information on the structure of the organotin species in sediments. First, due to low resolution of the Mossbauer spectrometer towards tin, to

get a perfect Mossbauer spectrum, enough triorganotin compounds (0.1 g) have to be spiked with the sediment (100 g). In order to get a sediment sample close to nature, it usually will take at least 1 month to prepare a sample. The interaction between the unknown organic species contained in the sediments and the triorganotins will normally result in more than more organotin species in the sediments, it is not possible to differentiate these similar organotin species by using Mossbauer spectroscopy only.

A method that would eliminate this problem is NMR spectroscopy, since this method would allow direct examination of the organotin species in the sediments at a very low concentration. Lower concentration of tin in sediments would be environmentally closer to the natural sediment samples. The use of NMR spectroscopy for the elucidation of the molecular structure of the organotin compound is well documented in the literature.[16] Specially, $^{117/119}$Sn NMR provides a probe of the tin atom that is sensitive to oxidation number and the ligands around the tin atom. It has been established that the coordination number of the tin atom is related to the ^{119}Sn Chemical shift. For trialkyltin complexes, four coordinate tin has 119Sn chemical shift ranging from about +200 ppm to -60 ppm, five coordinate tin from -90 to -190 ppm, and six coordinate tin from -200 to -400 ppm. [16] For butyltin complexes, tributyltins with a coordination number 4 or 5 around tin atoms has ^{119}Sn chemical shift in the rang 200ppm to 60 ppm, di butyl tin with a coordination number of 6 or even higher has ^{119}Sn chemical shift in the rang -80ppm to -400 ppm, Small change of the coordinate environment to the tin atom will sensitively be reflected on the ^{119}Sn NMR. Therefore, ^{119}Sn NMR is an ideal analytical tool to record the complicate interaction between the triorganotin complexes and the sediments.

Methods and Materials

Triorganotin Compounds

Tributyltin chloride (TBTCl) and *bis*-tributyltin oxide (TBTO) were obtained from M & T Chemicals, Inc., Rahway, NJ, USA. Tributyltin acetate (TBTOAc) were purchased from Gelest, Inc., Tullytown, PA. All the compounds contained the normal abundance of ^{119}Sn and were used as received without further purification to spike the sediment samples.

Collection of Sediments

Sediment samples were obtained as grab samples from the Anacostia River (Latitude: 38^{o} 52' 17" N; Longitude: 77^{o} 00'18''W) in the DC metropolitan area. The samples were kept frozen

until they were ready to be spiked. Aerobic sediments were prepared by allowing the anaerobic sediments to dry in air. The color of the sediments changed from black/greenish to black to brown.

Speciation Studies

The pH of the deionized water was adjusted to the desired values with either HCl or NaOH solutions prior to the addition of the triorganotin compounds and sediments. The anaerobic sediments were thawed in water to prevent oxidation. The following procedure was used in all experiments. Five g of aerobic or anaerobic sediment were spiked with 50 mg of the tributyltin compound. The mixture was then covered with 100 mL of deionized water. The mixture was shaken mechanically in a closed vessel in the dark for two weeks at room temperature and remained in the dark at room temperature for an additional week. The sediment samples will then be collected by gravity filtration and extracted with three portions of 15 mL of dichloromethane. The combined dichloromethane layer will be concentrated to about 5 mL using rotary evaporator and then sent for ^{119}Sn NMR analysis.

^{119}Sn NMR Analysis

All NMR measurements were made on a Varian Unity Inova 500 MHz spectrometer. Sample and instrument temperatures were controlled at 298 K. Proton-decoupled ^{13}C and ^{119}Sn spectra were acquired with WALTZ decoupling. ^{119}Sn chemical shifts were referenced to tetramethyltin externally. To identify the organotin species present, the experimental spectra were compared to spectra of known organotin compounds. Spectra of the pure compounds were recorded and used for comparison.

Results and Discussions

For preliminary studies, 8 sediment samples spiked with TBTs were prepared. The chemical shifts (□) for the sediments spiked with TBT compounds at different pH are listed in Table 1. Typical spectra for the spiked aerobic and anaerobic sediments are shown in Fig. 1-8.

The preliminary data also indicated that changes in the pH values did not affect the decomposition of the tributyltin compounds in the same sediments. For example, TBTCl spiked with same Sediments at pH 5 (Fig 1) and 7 (Fig 2) shows very similar pattern in NMR spectra. However, different patterns were observed in NMR spectra for TBTs in anaerobic and aerobic

sediments samples. Compared with Fig 31 (aerobic sample at pH 7), anaerobic TBTOAc sample was decomposed more at same speciation time (2 weeks) Except the major signal from un-decomposed hydrated TBT, two signals at 105 (medium) and -341 (weak) ppm were also observed as shown in Fig 4. This would suggest that the organisms in the sediments are responsible for the decomposition of the TBTs. Since anaerobic and aerobic sediments have different organism composition, different pattern of decomposition are observed. This decomposition was also clearly shown in the ^{1}H NMR of TBTOAC samples. The typical acetate CH_3 proton with chemical shift around 2.1 ppm is missing in the $^{1}HNMR$ spectrum (Fig 5). The multiplets from 0.8-1.7-ppm are ascribed for butyl group in the sample. There are no other protons in the sample except typical protons from water around1.6 ppm. Only very weak signals in the range of 0-400 ppm were observed which are ascribed to decomposition of the TBTs in sediments. This indicated that two weeks duration was not long enough to decompose TBTs in sediment.

For these reason, further studies have focused on the anaerobic and aerobic samples spiked in 2 weeks and 8 weeks at pH 7. Total 12 sediment samples spiked with TBTs were prepared. The chemical shifts (□) for the sediments spiked with TBT compounds at different pH are listed in Table 2 for TBTCl, TBTO and TBTOAC.

The ^{119}Sn NMR parameters indicated that all TBTs, TBTOAc(□: 118 ppm), TBTCl(□: 141 ppm) and TBTO(□: 89 ppm) were easily converted to other butyltin species in sediments. When compare with pure TBTs, no sediments samples have chemical shifts same as the pure one. This may be due to the formation of hydrated tributyltin complexes in sediment samples. Most of the hydrated TBT remained unchanged during the two weeks speciation. This is based on the observation that the major peaks around 158 ppm remain as medium to strong in the ^{119}Sn NMR spectra. This hydrated tributyltin species could be $Bu_3Sn(OH_2)_n^+$.

The equations shown in scheme 1 account for the possible mechanism of the formation of the hydrated tributyltin species:

$$Bu_3SnOAc + H_2O \rightleftharpoons Bu_3SnOH + HOAc$$

$$Bu_3SnOSnBu_3 + H_2O \rightleftharpoons 2Bu_3SnOH$$

$$Bu_3SnOH + H^+ \rightleftharpoons Bu_3SnOH_2^+$$

$$Bu_3SnOH_2^+ + £¨n\text{-}1)H_2O \rightleftharpoons Bu_3Sn(OH_2)_n^+$$

Scheme 1

It was also found that the tributyl hydroxide (TBTOH) and hydrated tributyltin species $Bu_3Sn(OH_2)_n^+$ in sediments will further decompose to more unknown tributyltin species if enough time is given for the speciation. As shown in Fig 6 and 7, TBTOAC was converted to hydrated TBTs, then this hydrated TBT was converted to two major unknown species with chemical shift around -11ppm and-109 ppm. Possible structures for these two unknown species could be $Bu_3Sn(OH_2)2^+$ (-11ppm) and $Bu_3Sn(OH_2)_3^+$ (-109 ppm) .

$$Bu_3SnOH_2^+ \rightleftharpoons Bu_3Sn^+ + H_2O$$

$$Bu_3Sn^+ + CO_3^{2-} \rightleftharpoons (Bu_3Sn)_2CO_3$$

$$Bu_3Sn^+ + HS^- \rightleftharpoons Bu_3SnSH$$

$$Bu_3Sn^+ + S^{2-} \rightleftharpoons Bu_3SnSSnBu_3$$

Scheme 2

Chemical shifts in 60ppm to 200 ppm are typical for four coordinated tributyl tin. Most of the samples have several minor peaks other the major peak around 157 ppm. This is indication of the formation of the Bu_3Sn^+ cation in the decomposition process, minor species could be formed with different anions such as carbonate, sulfide and hydrogen sulfide. The peaks from 70-90 ppm could be assigned to tributyltin sulfides while the peaks around 110ppm could be assigned to tributyltin carbonate (Scheme 2).

Chemical shifts around -340.9 ppm is an indication of dealkylation to di or monobutylatin species, though the amount of decomposition is low as the signals around -341 ppm are all very weak (Fig. 7). This would suggest that dealkylation of TBT takes a longer time than 8 weeks in sediment samples. A Comparison of the strength of signal of dealkylation species and

undecomposed TBT species revealed that only less than 5% was decomposed to less toxic DBT or MBT. This is different from the conclusion we made in the studies on the speciation of triorganotins using Mossbauer Spectrometry when all the TBT were shown in Mossbauer spectra to convert to other hydrated TBT species. This would suggest that NMR spectroscopy is more sensitive spectrometer for detection of organotin species than Mossbauer spectrometer.

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Table 1. ^{119}Sn NMR chemical shifts for TBTs spiked with sediment samples from the Anacostia River.

TBTs	pH	Speciation Duration	Sample type	Chemical shifts	
				200 to 60 ppm	0 to -400 ppm
TBTCl	7	2 weeks	Anaerobic	157.0 (medium) 109.9 (medium) 107.3 (strong) 95.1 (weak) 76.9 (medium) 76.6 (medium) 64.3 (medium)	-11.4 (weak) -109.1(weak)
TBTCl	5	2 weeks	Anaerobic	158.0 (strong) 107.8 (medium) 110.7 (weak) 77.1 (weak)	
TBTCl	Pure			85	
TBTO	7	2 weeks	Anaerobic	156.0 (medium) 105.2 (strong)	-109.1(weak) -340.9 (weak)
TBTO	Pure			141	
TBTOAc	7	2 weeks	Aerobic	157.1 (strong)	
TBTOAc	7	2 weeks	Anaerobic	156.0 (medium) 105.2 (strong)	-340.9 (weak)
TBTOAc	7	4 weeks	Anaerobic	157.5 (strong)	-340.9 (weak)
TBTOAc	7	8 weeks	Anaerobic	156.1 (medium) 109.6 (medium) 106.8 (strong) 76.3 (medium) 63.8 (medium)	-11.4 (weak) -340.9 (weak)
TBTOAc	Pure			118	

Table 2. ^{119}Sn NMR chemical shifts for TBTOAc spiked with Anaerobic and Aerobic sediment samples from the Anacostia River at pH 7.

Sample type	Speciation Duration	Chemical shifts	
		200 to 60 ppm	0 to -400 ppm
TBTCl (Aerobic)	2 weeks	158.0 (strong) 107.8 (medium) 110.7 (weak) 77.1 (weak)	
	8 weeks	158.0 (medium) 107.8 (medium) 110.7 (weak) 77.1 (weak)	-11.4 (weak) -109.1(weak)
TBTCl (Anaerobic)	2 weeks	157.0 (medium) 109.9 (medium) 107.3 (strong) 95.1 (weak) 76.9 (medium) 64.3 (medium)	-11.4 (weak)
	8 weeks	157.2 (weak) 109.5 (medium) 108.1 (medium) 95.7 (weak) 77.5 (medium)	-11.4 (medium) -109.0(weak)
TBTCl		85	
TBTO (Aerobic)	2 weeks	156.4 (medium) 105.3 (strong)	-340.9 (weak)
	8 weeks	156.2 (medium) 105.6 (strong)	-11.5 (minor) -340.9 (weak)
TBTO (Anaerobic)	2 weeks	156.0 (medium) 105.2 (strong)	-109.1(weak) -340.9 (weak)
	8 weeks	156.7 (medium) 105.4 (medium)	-109.1(weak) -340.9 (weak)
TBTO		141	
TBTOAc (Aerobic)	2 weeks	157.1 (strong)	
	8 weeks	157.5 (strong) 109.6 (medium) 106.8 (strong) 76.3 (medium)	-11.5 (weak) -340.9 (weak)
TBTOAC (Anaerobic)	2 weeks	156.0 (medium) 105.2 (strong)	-340.9 (weak)
	8 weeks	156.1(medium) 109.6(medium) 106.8 (strong) 76.3 (medium) 63.8 (medium)	-11.4 (weak) -340.9 (weak)
TBTOAc		118	

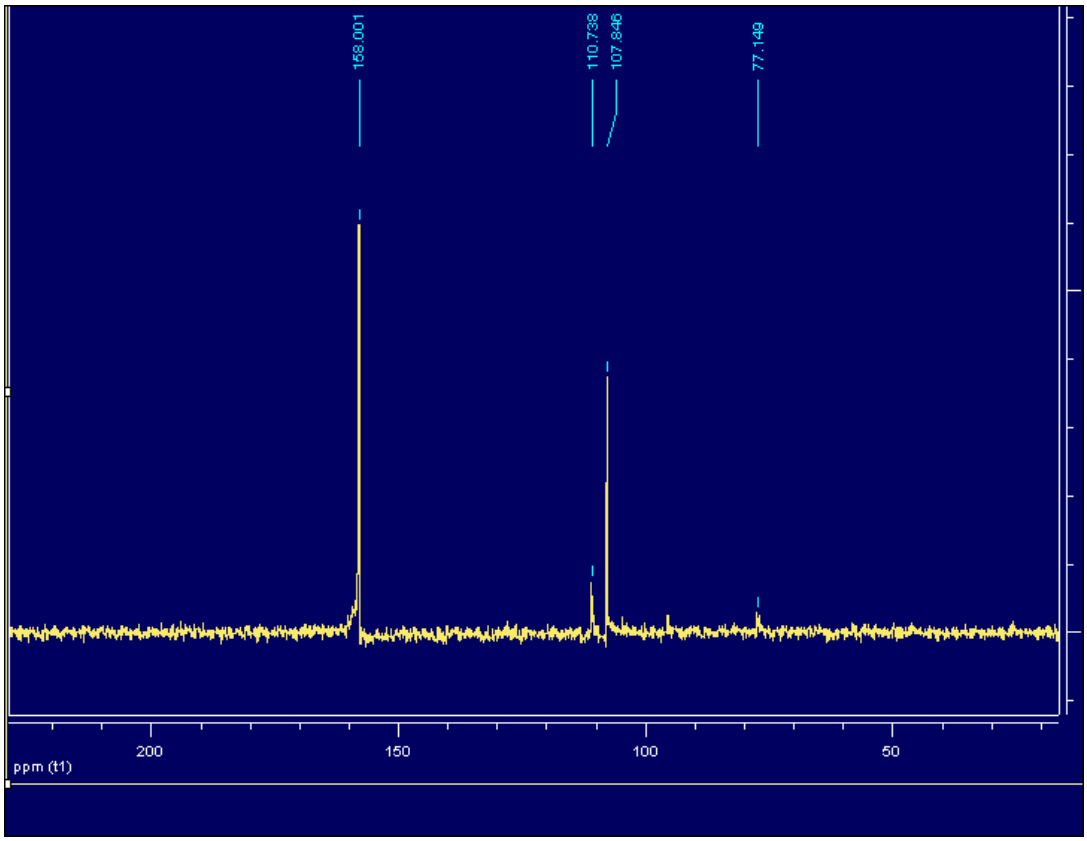

Figure 1. ^{119}Sn NMR spectra of tributyltin chloride (TBTCl) in spiked anaerobic sediments from Anacostia River at pH 5. (Speciation time 2 weeks)

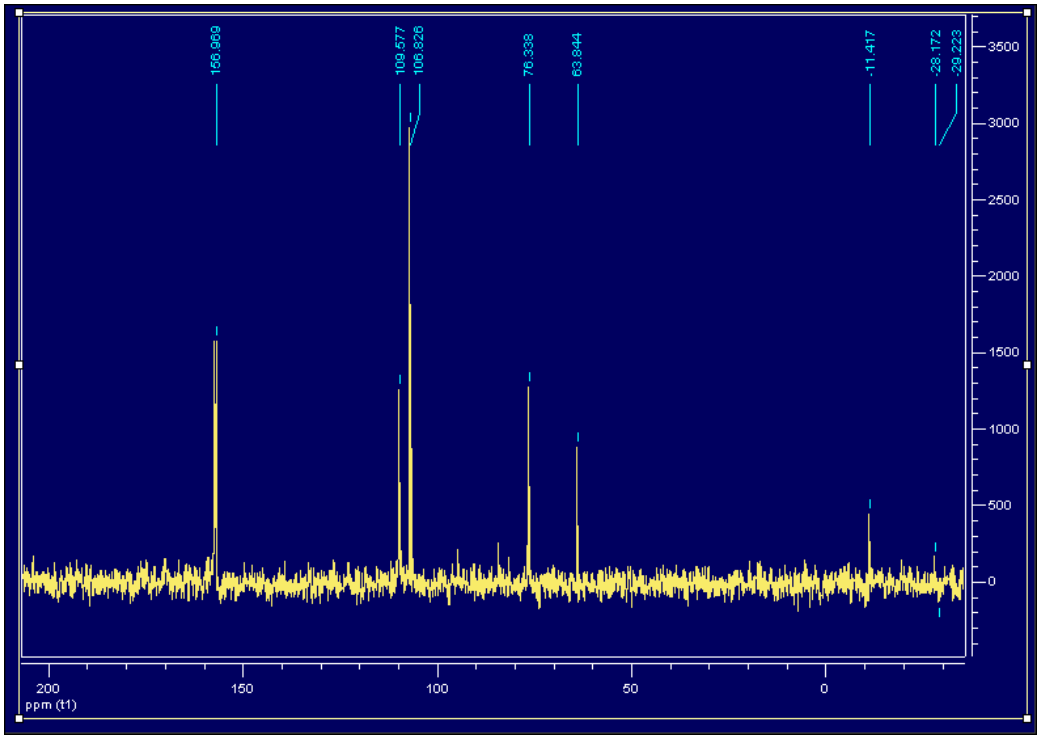

Figure 2. ^{119}Sn NMR spectra of tributyltin chloride (TBTCl) in spiked anaerobic sediments from Anacostia River at pH 7. (Speciation time 2 weeks)

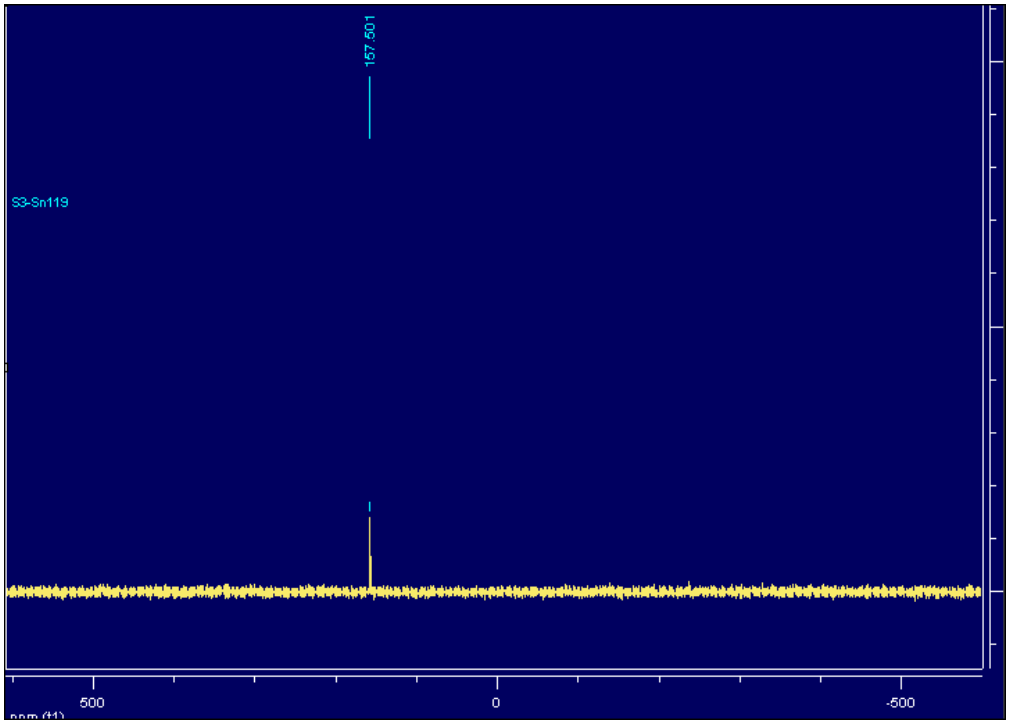

Figure 3. ^{119}Sn NMR spectra of tributyltin acetate (TBTOAC) in spiked aerobic sediments from Anacostia River at pH 7 (speciation time 2 weeks).

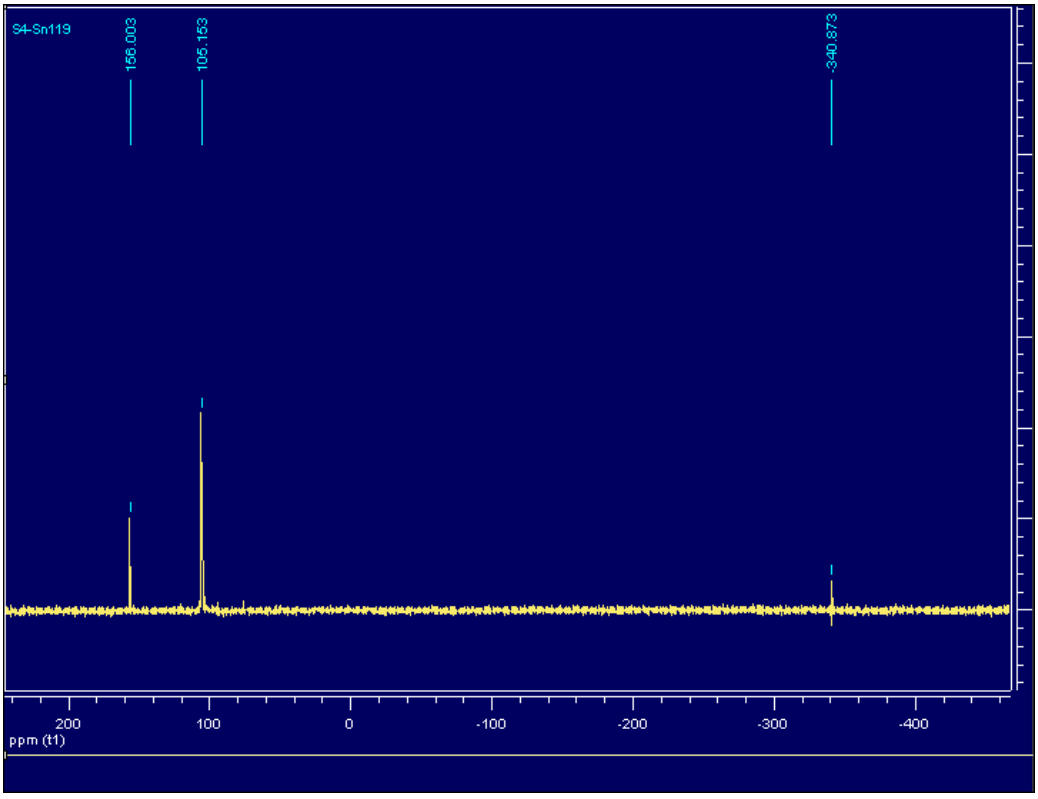

Figure 4. ^{119}Sn NMR spectra of tributyltin actate(TBTOAc) in spiked anaerobic sediments from Anacostia River at pH 7. (Speciation time 2 weeks)

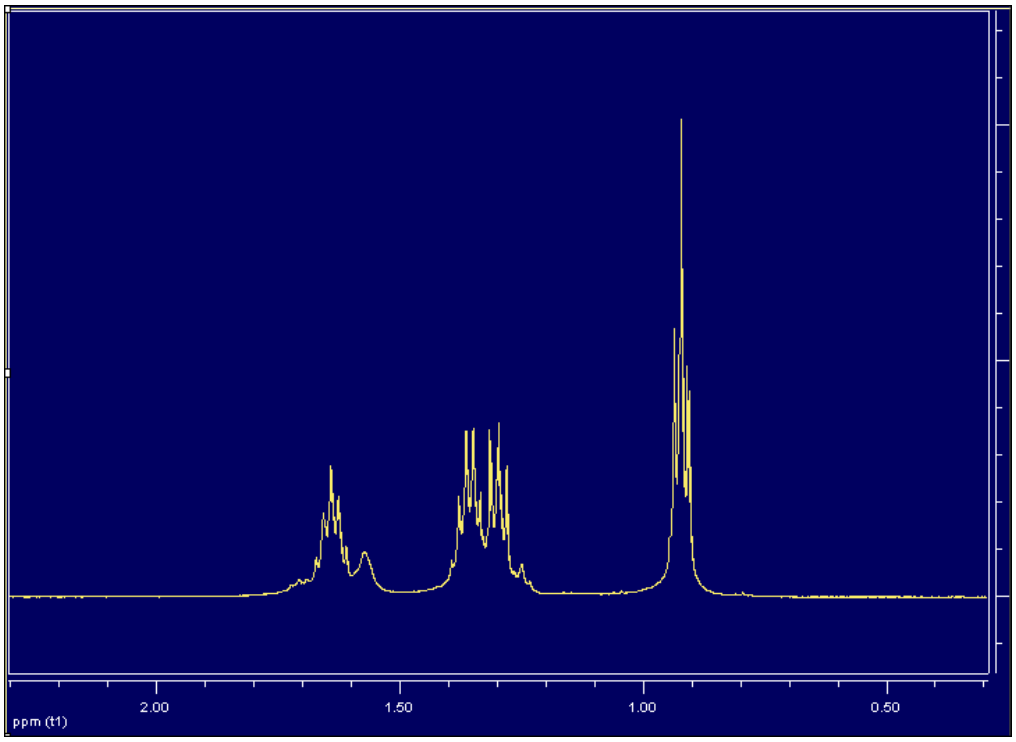

Figure 5. Typical ^{1}H NMR spectra (tributyltin acetate (TBTOAc) in spiked anaerobic sediments from Anacostia River at pH 7).

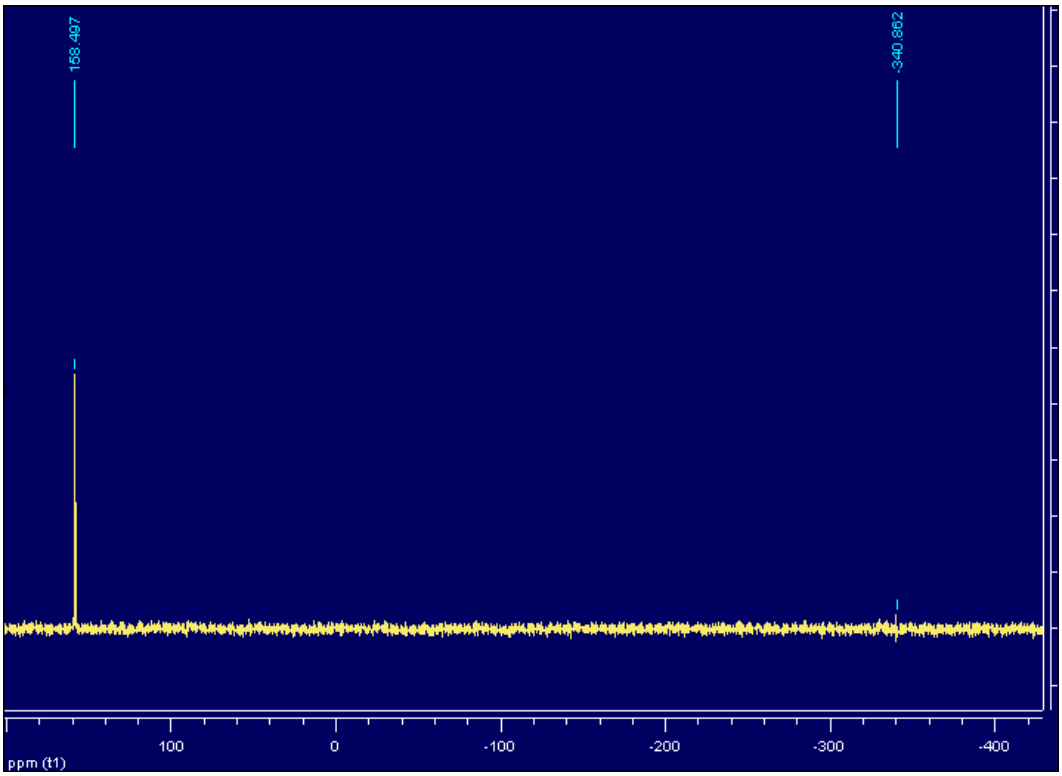

Figure 6. ^{119}Sn NMR spectra of tributyltin actate(TBTOAc) in spiked anaerobic sediments from Anacostia River at pH 7. (Speciation time: 4 weeks)

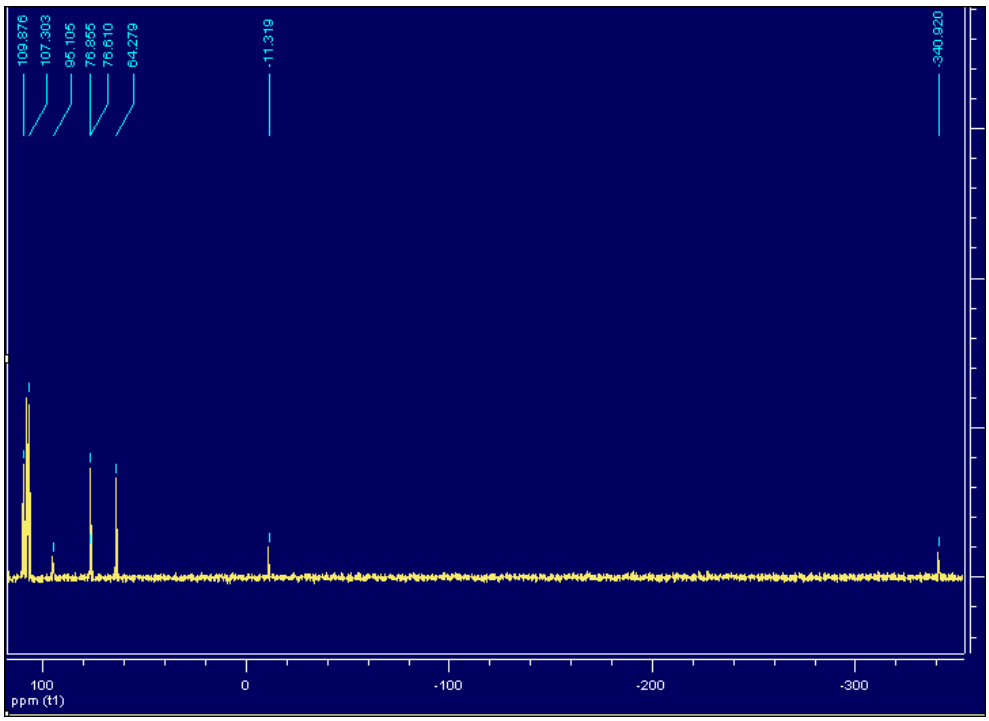

Figure 7. ^{119}Sn NMR spectra of tributyltin actate(TBTOAc) in spiked anaerobic sediments from Anacostia River at pH 7. (Speciation time: 8 weeks)

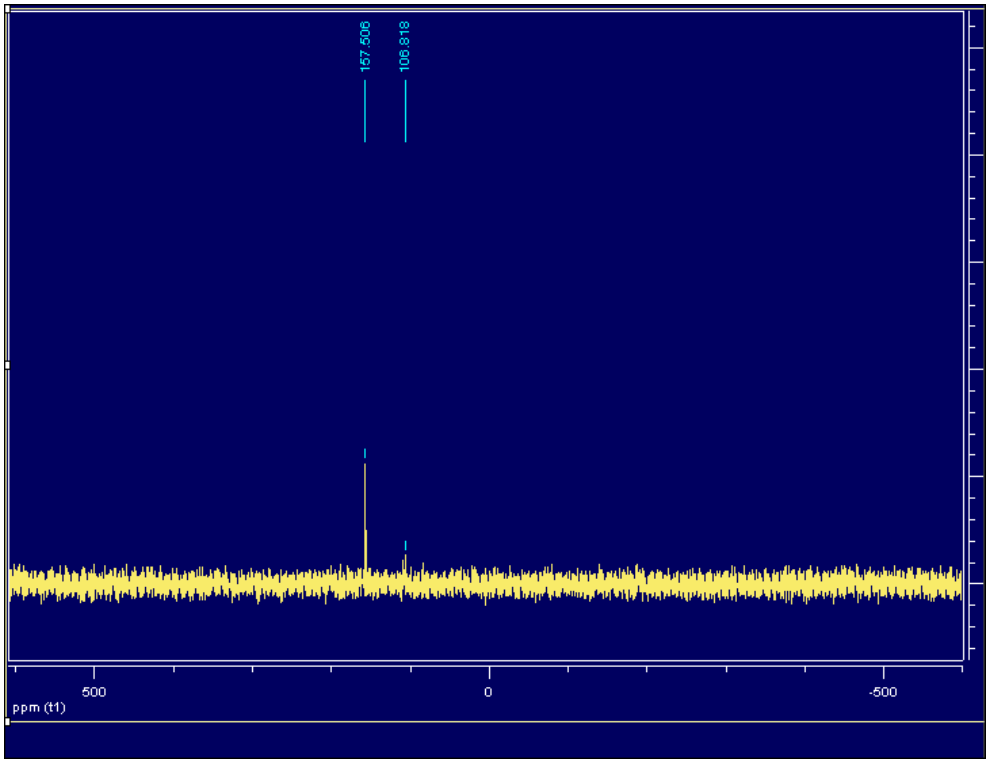

Figure 8. ^{119}Sn NMR spectra of bistributyltin oxide (TBTO) in spiked anaerobic sediments from Anacostia River at pH 7. (Speciation time 2 weeks)

Comparing Clam Active Biomonitoring and POM Passive Monitoring for DC Watershed Contaminant Point Sources

Basic Information

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

Active (ABM) and Passive (POM) Chlordane Monitoring in the Anacostia River Watershed (MD)

Final Report

Submitted to

DISTRICT OF COLUMBIA WATER RESOURCES RESEARCH INSTITUTE

By:

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May 15, 2011

Abstract

This 2010 research project focused on high chlordane contamination in the upper Sligo Creek Park (MD) watershed of the Anacostia River (MD/ DC), using active biomonitoring (ABM) with translocated freshwater clams *Corbicula fluminea*, passive monitoring with polyoxymethylene strips (POM) and fish and sediment analyses. At the downstream site (SCF) sediment chlordane was 4X the Canadian standard for protection of wildlife. Technical chlordane levels in Blacknose Dace minnows and in ABM clams at four weeks were statistically equal and exceeded (5X) the US Fish and Drug Administration (USFDA) standard for fish consumption. Chlordane by ABM and POM increased significantly (1.5X) from two to four weeks deployment. No difference in chlordane uptake was found among small and large clams. ABM chlordane was less at the five sites monitored upstream from site SCF. The USFDA standard was exceeded at all but one site. At the Sligo Creek sites above Route 193 (SC1, SC2, SCB, SCH) minnows were absent and at site SCB the ABM clams initially died. At site SCF the chlordane measured by ABM was higher than measured by POM but after adjusting for weight more chlordane was adsorbed by POM than by clams. High chordane at sites was accompanied by high heptachlor epoxide and dieldrin which were the only other pesticides detected.

Introduction

The freshwater Anacostia River is a tributary of the freshwater Potomac River and has a 126 square mile watershed in DC and MD. Although the Anacostia is currently the subject of major plans to address stormwater, sediment, nutrients and trash (ARP 2010) it is better known for its toxic pollutants that rate it one of three Areas of Concern in the USEPA/NOAA Chesapeake Bay Program (Chesapeake Bay Program 1999) and listed among America's 10 worst rivers. Over 60% of the resident fish have tumors (PAHs) (Pinkney et al. 2000) and the sediment is toxic and lacking many benthic species found in the nearby Potomac (Phelps 1985, Phelps 1993). The Anacostia has a fishing advisory for PCBs and pesticides (DC Department of Health 2006) with TMDLs for PCBs and Trash and is developing programs for control of stormwater, nutrient and suspended sediment (ARP 2010).

The 10 km tidal Anacostia River was extensively studied from 1999 to 2002 by an EPA/NOAA partnership (AWTA 2004) which considered contaminated tidal sediments as the major source of fish and benthos contamination (SRC 2000, NOAA 2002, AWTA 2004, EPA 2009). However the Anacostia Restoration Plan (NOAA 2002, ARP 2010) was unable to include data on toxic sources in the free-flowing Anacostia watershed.

Active biomonitoring from 1999 to 2010 used iterative active biomonitoring (ABM) where *Corbicula* clams translocated to 52 Anacostia watershed sites were analyzed for EPA Priority Pollutants including 18 polycyclic hydrocarbons (PAHs), 28 polychlorinated biphenyl congeners (PCBs), 6 Aroclors, 21 pesticides, and five metals

(Cd, Cr, Cu, Fe, Pb) plus technical chlordane, percent water and percent lipid. These studies found sections in five of 12 Anacostia subwatersheds with PCB, chlordane and PAH totals exceeding levels found in the tidal Anacostia and USFDA standards for fish consumption (Phelps 2011).

In addition to fish, clam and ecosystem contamination, polluted sites in the free-flowing watershed could be sources of the tidal Anacostia contaminated sediments. Organic contaminants like PAHs, PCBs and pesticides are transported by association with suspended sediment particles, and particles from runoff have been found with much higher pesticide concentrations than consolidated sediments due to short-term mixing disequilibria (Bergamaschhi et al. 2001). The recent Anacostia Restoration Plan (ARP 2010) suggested watershed contaminants would be controlled as a result of stormwater control. However this could not apply to toxics from ongoing point and legacy sources of PCBs, PAHs and Chlordane in watershed streams.

Water contaminants can be measured both directly and indirectly. Direct water measurement of low levels of toxic contaminant is the best but also difficult and expensive. Indirect or passive samplers are preferred because they can use accumulators containing a lipophilic solvent like hexane or a solid like polyoxymethylene over a period of time. Active biomonitoring uses bioconcentration over time by living organisms (often molluscs) either in situ or translocated. Active and passive monitoring have different purposes and can give different results (El-Shenawy et al. 2010). Passive indirect monitoring can be easier, used under more circumstances and related in the laboratory to contaminant concentrations in water. Active biomonitoring requires living organisms that have limits but gives information on actual bioavailability and life-stage sensitivity under environmental variables such as salinity, temperature and suspended organic material including additional sources of contaminants such as particulate food (Phelps 1979, Phelps et al. 1985a, Phelps et al. 1985b, Phelps and Mihursky 1986, Phelps and Hetzel 1987, Phillips 1987.) Active biomonitoring with molluscs has been used worldwide for biomonitoring of toxic pollution (Crawford and Luoma 1993, Colombo et al. 1995, DeKock and Cramer 1995,

Sligo Creek is a large subtributary of the Northwest Branch which has 42% of Anacostia river flow (Fig. 1). Complete ABM Sligo Creek EPA Priority Pollutant scans in 2007 and 2009 found chlordane as the major contaminant, with concentrations increasing going upstream to the Main Branch site SCF (Fig. 1) (Phelps 2008, Phelps 2010). Chlordane is a complex manmade pesticide once used for termite control and banned since 1988. Chlordane has high toxicity including neurological effects and is called a PBT (Persistent Biological Toxic) that accumulates in animal tissue and increases up the food chain, with toxic environmental effects. Its high chlordane was accompanied by high heptachlor epoxide and dieldrin. The current plans for Sligo Creek do not address its toxic contaminants (Sligo Action Plan 2009).

Materials and Methods

Chlordane monitoring in upper Sligo Creek began July 2010 by collecting Blacknose Dace minnows at site SCF (Fig. 1) using a permitted square meter minnow net. The minnows were frozen, picked up by TestAmerica (Baltimore), and sent to the TestAmerica Laboratory of Burlington VT for pesticide analysis. *Corbicula* clams for the ABM translocation studies were collected on 7/5/10, 8/24/10, 9/10/10, and 10/3/10 from the shoreline sandy sediment at the Potomac River reference site of Fort Foote (FF) 5 km below the Anacostia confluence. A subsample of the first clam collection (7/5/10) received complete EPA Priority Pollutant analysis. The collected clams were kept cool and dry and placed in plastic-coated wire mesh cages (raccoon protection) on the stream bottoms at Sligo Creek sites within four hours. All ABM clam deployments were analyzed for 21 pesticides plus technical chlordane at two two weeks unless otherwise specified, and had continuous temperature monitors (Tidbit) attached. Alpha and gamma chlordane are part of the EPA Priority Pollutant scan. Technical chlordane, which was analyzed separately, includes several additional chlordane compounds and is used by the US Food and Drug Administration (USFDA) for fish consumption advice.

The furthest downstream Sligo Creek site (SCF) was the sampling location for Blacknose Dace minnows and sediment (SSCF, Table 1, Fig. 1, Fig. 2)). ABM at SCF compared chlordane accumulation among small clams (13 – 18mm, SCFCS) and large clams (22 – 40mm, SCFCL) (Fig. 2, Table 1). The ABM/POM study at site SCF had four 1" x 4" polyoxymethylene (POM) strips wrapped in wire mesh with two placed in the cages with clams for two and four weeks (SCFC2, SCFC4, POM2a, POM2b, POM4a, POM4b). Dr. Upal Ghosh of the University of Maryland Baltimore Campus (UMBC) supplied the POM strips and analyzed them for alpha and gamma chlordane (Phelps 2010).

The uppermost possible Sligo Creek ABM was at the headwater site (SCH) and located just below the junction of a large community stormwater drain and a smaller side drain (Fig. 1). The ABM sites in the upper Sligo Creek were in order going downstream: SCH, SC1, SC2, SCB (bridge) above Route 193, and SCH3 below Route 193, then site SCF (Fig. 2). Sligo Creek at Route 193 had large apartment buildings and a pond with a dam.

Results and Discussion

The sediment sample collected at site SCF was sandy gravel (18% water) with 0.22% carbon. The sediment technical chlordane of 36 ug/Kg (dw) was 4X the Probable Effects Level of 8.87 ug/Kg for freshwater sediment (Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. 1999) and exceeded the NOAA SQUIRT table Upper Effects Threshold for chlordane effects in freshwater sediment biota (30 ug/Kg) (NOAA) (Table 1). When SCF sediment chlordane is normalized to organic carbon its concentration is 1600 ug/Kg C, similar to chlordane levels in Anacostia tidal sediments (NOAA 2002). This suggested Sligo Creek as a potential ongoing source of chlordane–contaminated sediment to the Anacostia tidal region. ABM also found similar high chlordane levels in the Riverdale East subtributary of the Northeast Branch which is another possible source of contaminated sediments (Phelps 2005, Phelps 2008).

Blacknose Dace minnows at site SCF had technical chlordane of 1500 ug/Kg, which is 5X the USFDA standard for fish consumption (300 ug/Kg) and statistically the same as four-week clam chlordane (1300 ug/Kg) (Table 1). A USGS 1992-1995 National Water-Quality Assessment survey found technical chlordane in native bivalves at freshwater sites averaged one-third of fish chlordane (Wong et al. 2000). Small and large clams deployed for two weeks had statistically similar concentrations of technical chlordane, averaging 1020 ug/Kg, which is 3.4X the USFDA standard for fish (Table 1).

Technical chlordane by ABM exceeded the USFDA standard for fish consumption at all sites except site SCH3 below the pond and dam at Route 193. Since clams at site SCF had higher chlordane levels than at upstream sites SCF may have had an additional source of chlordane (Fig. 2). SCF was located just below the entrance of a large drain from a nearby suburban area.

At Site SCB the first set of deployed clams on 9/17/10 was found dead after the two week deployment. The attached TidbiT showed the clams were not out of water. The second SCB deployment on 10/17/10 had 100% clam survival. Electrofishing on 10/28/2011 by the Maryland Department of the Environment (MDE) found many Blacknose Dace minnows at SCF but all sites above Route 193 (SCH, SCH1, SCH2, SCB) had only a few tolerant sunfish (Fig. 2). MDE will analyze those fish for chlordane. *Corbicula* clams are tolerant of high pollutants (Dougherty and Cherry 1988) and chlordane was significantly higher at SCF than all upstream sites, so high chlordane was probably not the cause of SCB clam death. The absence of fish and the one-time SCB clam death suggested an upstream cause of intermittent toxicity. The Friends of Sligo Creek website (http://www.fosc.org/SWMap17.htm) describes a large underground stormwater storage facility constructed under the Arcola Elementary School playground near site SCH. Underground water can become deoxygenated from organic matter and bacterial action (pers. information, Maryland Department of Natural Resources, MDDNR). Intermittent toxicity in Upper Sligo Creek could result from the slow release of anoxic stored water from the stormwater storage facility. The dam at Route 193 would block upstream migration and restoration of the Blacknose Dace minnow population. Similar underground stormwater storage facilities are being proposed. Putting a small waterfall at the outlets could restore proper oxygen levels if necessary (MDDNR).

In this study both passive (POM) and active (ABM) monitoring showed a chlordane increase of 1.5X from two to four weeks deployment. The averaged chlordane by POM was 34% of clam ABM (Table 1). A similar ABM/POM study for PCBs in Lower Beaverdam Creek was carried out with Dr. Ghosh in 2009 (Phelps 2010). POM chlordane is reported in units per dry weight and ABM chlordane is traditionally reported in units of tissue wet weight (80% water). In the present chlordane study, if alpha and gamma chlordane were reported in dry weight units for both ABM and POM, POM would average 3.5X ABM chlordane levels. In the earlier ABM/POM study of PCBs in Lower Beaverdam Creek, total PCB levels by POM averaged 2X total ABM PCBs when measured by dry weight (Phelps 2010). This shows a difference among PCB and chlordane pollution measured by POM and ABM monitoring. Both PCBs and Chlordane are PBT contaminants with serious effects on downstream environments and higher organisms like birds. All of Sligo Creek is being seriously contaminated by its upstream

chlordane sources. Monitoring by ABM is only the first start in addressing Sligo Creek toxic pollution but it does identify the major contaminants and possible sources. Further steps need to include developing a chlordane TMDL and possible sequestration measures.

Acknowledgments

Very grateful acknowledgement is made to continuous support from the District of Columbia Water Resource Research Institute towards increasing understanding of the role of the free-flowing Anacostia watershed in Anacostia River toxic pollution. Many thanks are due to the many students who participated in this research. Special thanks go to Earl Greenidge who was essential to the successful continuation and completion of this work.

Table 1. Chemical and physical data at Upper Sligo Creek monitoring sites.

SITE	SLIGO CREEK LOCATION	DATE COLL.	CHLORDANE ng/Kg, gamma	alpha	gamma +alpha	technical	GPS northing	westing
SCH	Headwater	7/22/10	17	27	44	300	39.042721	77.039543
SCH1	Below SCH	10/17/10	46	72	118	710	39.042202	77.037674
SCH2	Below SCH1	10/17/10	20	39	59	370	39.041154	77.035698
SCB	Bridge	10/17/10	63	77	140	830	39.040127	77.034332
SCH3	Below bridge	10/17/10	10	19	29	150	39.042721	77.029850
SCFCS	*Small clams	9/7/10	110	58	168	940	39.024777	77.030157
SCFCL	*Large clams	9/7/10	140	77	217	1100	"	"
SCF2	*Clams 2 weeks	9/24/10	100	53	153	845	"	"
SCF4	*Clams 4 weeks	10/9/10	160	81	241	1300	"	"
SCF	*Fish	7/2/10	100	190	290	1500	"	"
POM2A	*POMa 2 weeks	9/24/10	25	20	45	(231)	"	"
POM2B	*POMb 2 weeks	9/24/10	36	25	61	(321)	"	"
POM4A	*POMa 4 weeks	10/9/10	46	34	80	(422)	"	"
POM4B	*POMb 4 weeks	10/9/10	47	36	83	(437)	"	"
SSCF	*Sediment	10/17/10	4	4	8	36	"	"
FF	Reference site	7/5/10	10	19	29	110	38.461694	77.014797

*all at site SCF
( ) estimated

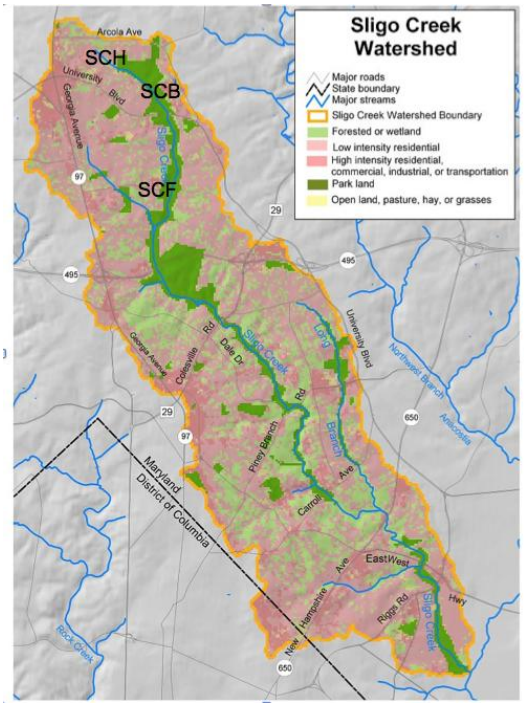

Figure 1. Sligo Creek watershed.

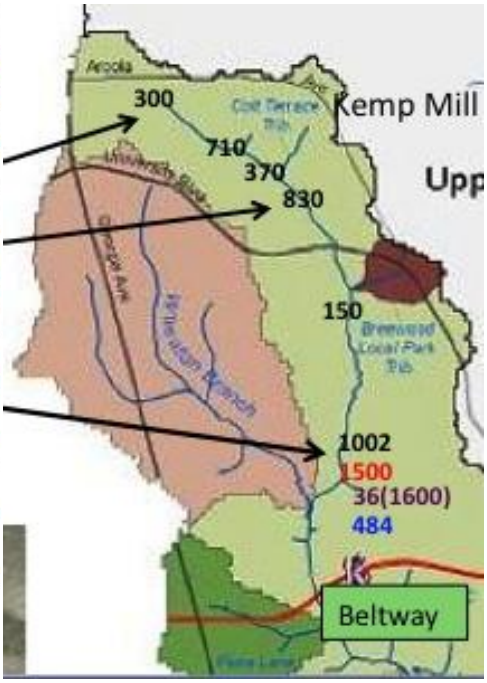

Figure 2. Upper Sligo Creek.

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The Application of Multiple-Antibiotic-Resistance (MAR) Profiles of Coliforms to Detect Sources of Bacterial Contamination of the Anacostia River

Basic Information

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The Application of Multiple Antibiotic Resistance Profiles of Coliforms to Detect Sources of Bacterial Contamination of the Anacostia River

Final Report

Submitted to

DISTRICT OF COLUMBIA WATER RESOURCES RESEARCH INSTITUTE

By:

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May 2011

Abstract

The Anacostia River in Washington, DC has been burdened with the problem of an estimated 2,142 million gallons of sewage overflow per year. Our study is part of a year-long investigation to identify major sources of fecal pollution in the District of Columbia from both combined sewage outlet (CSO) sites and non-point sources (NPS). This project has involved the training and active participation of a least 84 undergraduate students in four classes. Samples were obtained from the outflow of CSOs located in the District from the Northeast Boundary to the Douglass Bridge following precipitation events. The presence of *Escherichia coli* and other coliforms were confirmed and differentiated from other known enteric bacteria using characterization media. Isolates were tested for MAR using a panel of drugs commonly prescribed in clinical and agricultural practice. To determine antibiotic resistance patterns, a two-sided test of binomial proportion and Euclidian metric analysis were used. Isolates from all CSO sources showed significantly greater resistance and higher MAR indices than the NPS sites ($p<0.05$). The highest MAR indices were obtained from outflows from CSO sites 14, 16, 17, 18 and 19. MAR testing has proved to be a quick and reliable measure of identifying the source of fecal contamination and have clearly shown that multiple drug resistance (MDR) fecal coliforms are associated with CSO overflows. Ultimately, our study will provide a comprehensive "before and after" assessment of fecal contamination in the watershed as projected revitalization continues. The continuation of this study is focused on determining antibiotic resistance transfer to environmental sources of *E. coli*, *Enterobacte*r spp. and non-coliform enteric bacteria such as *Salmonella* spp., as well as the impact of MDR organisms and their long-term presence in the watershed. Many isolates were identified as possible Extended-Spectrum β-Lactamase (ESBL)-producing bacteria based on their resistance to cephalosporin drugs and aztreonam. Others were resistant to the new fluoroquinoline antibiotics. These studies point to the critical need to hasten current efforts for the rehabilitation of the river.

Introduction

The Anacostia River is an urban tributary in a highly industrial surrounding, making it a dynamic and unique environment in which to study fecal pollution. It flows approximately 8.5 miles from Prince George's County, Maryland through Washington, D.C., before finally joining the Washington Canal and emptying into the Potomac River. Its watershed covers 176 square miles and contains 13 sub-watersheds. Although encompassed by parkland, the Anacostia is heavily polluted from sediment, toxins, pathogens, and trash (1,2). Public health risks can originate from sewage drainage directly into the river and is caused by fecal coliform bacteria and other pathogens found in the untreated wastewater. The harmful microbes debilitate water quality and create hypoxic conditions, leading to large-scale fish death and deterioration of the local wild-life (2,3). Water pollution is further compounded by the disrepair of the D. C.

combined sewage outlet (CSO) system, much of which dates back to the early nineteenth century (4).

The CSO system carries water runoff and human waste to treatment facilities; however, problems occur when excessive rainfall overwhelms the internal barrier keeping the water runoff and sewage waste separated. When this occurs, wastewater is directed from sewage lines into the river. CSO's account for an estimated 73% of the average annual increase of fecal coliform bacteria along the D. C. region of the Anacostia River, amounting to 348,000 billion Most Probable Number (MPN) fecal coliforms per year (4,5). Washington Suburban Sanitary Commission (WSSC) estimates 75 overflows occur each year, releasing 2,142 million gallons of untreated water into the environment (6).

Fecal coliforms have frequently been surveyed as indicators of the potential presence of human enteric pathogens. Indeed, standards for the District of Columbia are based upon the detection of fecal coliforms (7), although other indicator bacteria, such as the fecal streptococci (reclassified as *Enterococcus*) are favored by other studies (8). Fecal coliforms are gram-negative bacilli able to ferment lactose at elevated temperatures and include species such as *Escherichia coli* and *Klebsiella pneumoniae* (9). Furthermore, the presence of antibiotic resistant coliforms in water samples is a strong indicator of fecal pollution from animal and/or human sources. Recent studies have shown major sources of fecal water pollution can be determined by conducting a Multiple Antibiotic Resistance (MAR) analysis (8,10,11)., or as it is now frequently called Antibiotic Resistance Analysis (ARA). MAR is used to differentiate fecal *E. coli* (and occasionally enteroococci) from different loci by assessing the resistance profiles from bacterial isolates using antibiotics employed for human therapy and livestock maintenance (12,13). The underlying principle is that bacteria in the GI tracts of humans and animals are subjected to different types and dosages of antibiotics which select for flora with specific resistance profiles, or "fingerprints" (12). MAR analysis includes both library-dependent and non-library-dependent approaches for studying and tracking the sources of microbial pollution (called Bacterial Source Tracking, or BST). Each strategy has it own advantages and disadvantages. Several studies, for example, have focused on comparing MAR profiles of *Enterococcu*s isolates to known source libraries for tracking bacterial pollution (14). Our approach, on the other hand, has been to use the non-library approach which has offered more rapid results which are useful where human

health hazards are suspected (15), Few studies have been carried out to determine the variance of MAR profiles of fecal coliforms in this tributary; therefore, our research links pollution-derived coliform levels, antibiotic resistance in mid-summer water samples, and suggests transference of resistance between human and/or animal-derived and natural-source coliforms. This project, above all, has been designed to train undergraduate students in some of the currents methods used to monitor microbial contamination of the nation's waterways and particularly to focus their attention on the remediation efforts for the Anacostia River. Thus, the work described here has been carried out, and in some cases designed, by undergraduate students in our program.

Methods and Materials

The materials and methods used in the research have not differed substantially from the proposal although slight modifications in the proposed procedure have been necessary. While general methods are presented here, a short manual for student instruction was prepared and is presented in Appendix A..

Collection of Samples: CSO sites along the Anacostia River between the 11th Street Bridge and the East Capitol Bridge were chosen for MAR analysis. These sites drain both residential (84%) and mixed commercial areas (16%). In addition, all sampled CSO sites experience overflows during minimal (0.1-0.5 inches) rainfall (6). The non-point source (NPS) samples were collected mid-stream at the M Street Railroad Bridge. Approximately 1 liter of water was collected from each site on June 30th 2010, in duplicate, at each area immediately following a high flow storm event. The samples were stored in sterile plastic collection bottles (Fisher Scientific) at 4^{o}C and were analyzed 24 hours later.

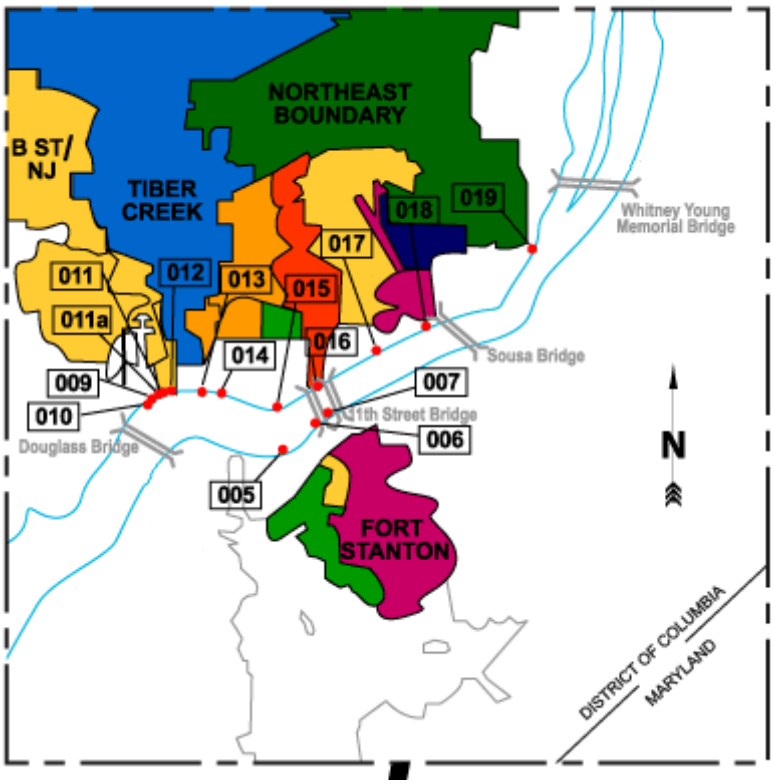

Figure 1: CSO sites on the Anacostia River sampled during this investigation (6)

Isolation, Enumeration, and Identification of Fecal Coliforms: Fecal coliform contamination in each sample was assessed initially by using the Standard Method Analysis recommended by the American Public Health Association (APHA) (16). This method estimates the MPN of fecal coliforms using a standard assay and expressed as MPN /100 mL of water sample. Individual colonies of fecal isolates were obtained based upon sample MPN results: coliform–confirmed water samples were filtered through 0.2 μm pore-sized nitrocellulose filters and the filters incubated on MacConkey Agar plates at 37^{o}C for 48 hours. Lactose-fermenting colonies were further analyzed by replica-plating on Eosin-Methylene Blue, Desoxycholate and Hektoen Enteric agar plates to confirm the isolation of fecal *E. coli*. Fecal coliform isolates were then plated onto antibiotic inoculated LB media and scored according to their resistances to each in order to generate MAR data.

MAR Analysis: The MAR value for a given organism or source relies upon the specific panel of antibiotics which are used for testing. MAR indices were determined using similar patterns to those employed by Kasper, *et al* (15). Isolates confirmed as fecal coliforms were tested for antibiotic resistance on drug-infused LB agar plates of several different antibiotics used for clinical therapy in humans and prophylactic use in livestock (Table 1). Isolates were replica-plated from master plates to each of the antibiotic plates and incubated at 37^{o}C for 18 to 24 hours. Isolates were recorded as resistant to an antibiotic if ≥80% colonial growth was observed. The MAR index for each isolate was calculated using the following relationship: number of antibiotics to which the isolate was resistant / number of antibiotics tested. MAR indices for each sample site were calculated as the number of antibiotics to which all isolates were resistant / (number of antibiotics tested x number of isolates inoculated per site) (15). Significant differences between antibiotic resistance patterns at each site were determined by a two-sided test of binomial proportion ($p<0.05$). Inter-isolate relationships were examined by converting the data to binary code and analyzed by a Euclidian metric, average linked method (DendroUPGMA Program)(12,17).

	Antibiotic Common Name (abbreviation)	Concentrations Used (µg/mL)	Use in Humans	Use in Animals
1.	Nalidixic Acid (Nal)	25.0	Clinical/Disease Control	Restricted
2.	Ampicillin (Ap)	10.0	Clinical/Disease Control	Restricted
3.	Streptomycin (Sm)	12.5	Clinical/Disease Control	Restricted
4.	Ciprofloxacin (Cp)	25.0	Clinical/Disease Control	Restricted
5.	Chloramphenicol (Cml)	25.0	Clinical/Disease Control	Restricted
6.	Chlortetracycline (Ctc)	25.0	Clinical/Disease Control	Disease Control/Feed Efficiency/Growth Promotion
7.	Kanamycin (Kan)	25.0	Clinical/Disease Control	Restricted
8.	Tetracycline (Tc)	25.0	Clinical/Disease Control	Restricted
9.	Oxytetracycline (Otc)	25.0	Clinical/Disease Control	Disease Control/Feed Efficiency/Growth Promotion
10.	Neomycin (Neo)	50.0	Clinical/Disease Control	Disease Control/Feed Efficiency/Growth Promotion

Table 1: **Antibiotic Concentrations and Uses.** Isolates confirmed as fecal coliforms were tested for antibiotic resistance on drug-infused LB agar plates of several different antibiotics consistent with animal and human treatment

Results and Discussion

Undergraduate involvement in the project (individual and class) commenced in late summer 2010 and carried into spring 2011. Two classes were presented with group projects involving some aspect of the work. The first was: "Do We Need Biotechnology?, a part of the Dean's Seminar Series and is attended exclusively by freshmen (science and non-science majors). This year's class, held in the fall of 2010, constituted 18 students, only two of whom were from the D.C. area. The second class was Introductory Microbiology (BiSc 2237 and BiSc 2237W), designed for upper-level undergraduates (juniors and seniors,), which was held in fall 2010 and spring 2011. Each class contained 32 students. Including all participating undergraduate students conducting individual research projects in the laboratory, a total of 84 undergraduates have been actively involved in the water monitoring project. Class work and laboratory exercises relevant to the project included water sampling and testing, determination of fecal coliforms by APHA-recommended procedures (Most Probable Number (MPN) and water filtration techniques), isolation, enumeration and characterization of enteric bacteria (*Escherichia coli, Enterobacter, Salmonella* spp., and *Shigella* spp.) from water and fecal samples, MAR analysis and plasmid DNA isolation procedures.

Comparison of Multiple-Antibiotic-Resistance (MAR) Profiles of fecal *Escherichia coli* at CSO Sites 17 and 18 and a Non-Point Source on the Anacostia River

CSO17 and CSO 18 along the Anacostia River were sampled for this study in the early fall of 2010. Both sites lie between the 11th Street Bridge and the Sousa Bridge. Samples of approximately 1 liter of water were collected three times at each area in September of 2011. The non-point source (NPS) samples were obtained mid-stream near the John Philip Sousa Bridge. The water samples were analyzed as described previously. Briefly, water samples were filtered through a 0.2 μm pore-sized nitrocellulose filters, the filters were then placed on Desoxycholate Agar and further differentiated on MacConkey and Hektoen Enteric Agars. Each plate was incubated at 42.5°C. Suspected fecal *E. coli* isolates were plated on a grid for subsequent MAR analysis. MAR indices were determined by the method of Kaspar et al. (15). Isolates were identified as antibiotic-resistant if growth was identical to that on the MH plate without antibiotics. In comparison to the control plate, if the growth of bacterial colonies of an isolate

was reduced by 20% or more, then the sample was marked as sensitive to the antibiotic. MAR indices for each sample site were calculated as the number of antibiotics to which all isolates were resistant / number of antibiotics tested x number of isolates inoculated per site. Antibiotic resistance patterns at each site were determined by a two-sided test of binomial proportion ($p<0.05$)(15).

The results indicated that isolates from both CSO sites showed significantly greater resistance ($p<0.001$) and higher MAR indices than the NPS sites, with an average MAR index of 0.36±0.04. In contrast, NPS isolates exhibited resistance with an average MAR index of 0.07±0.04 (Figures 2 and 3).

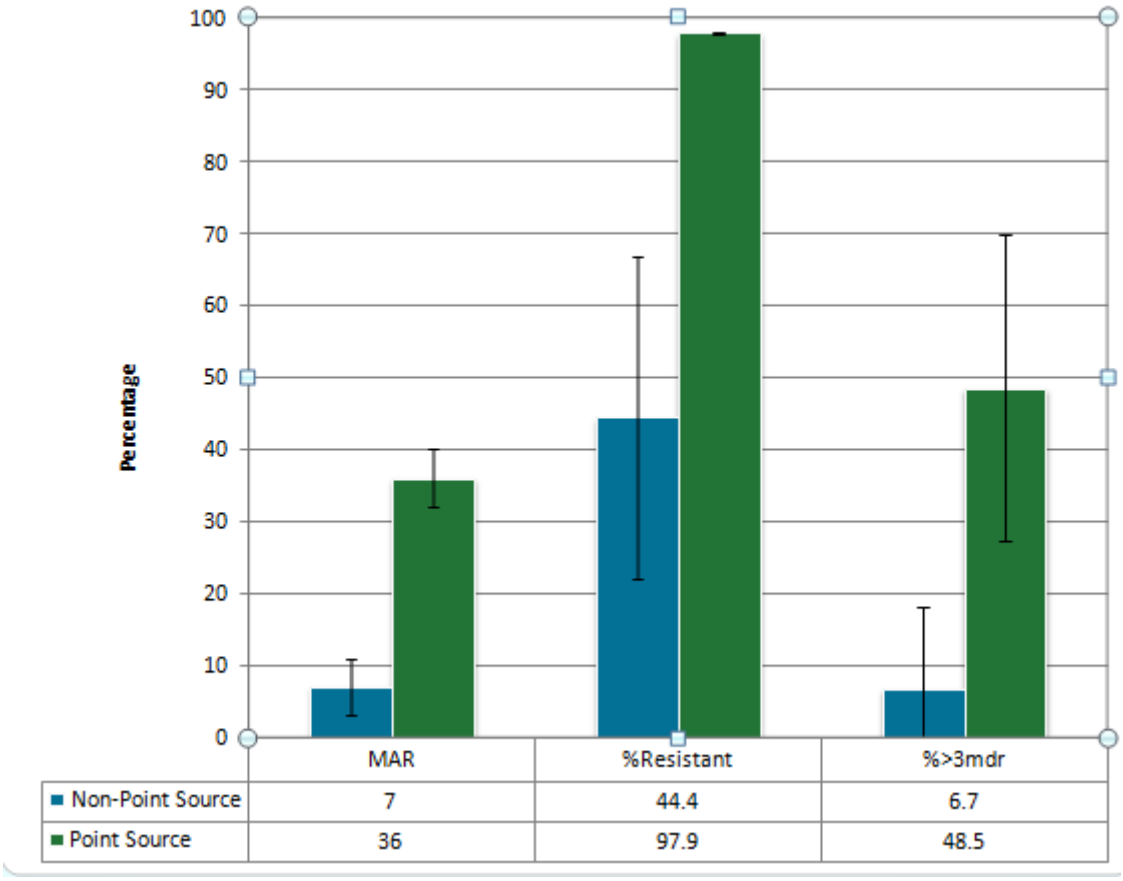

Figure 2: Multiple antibiotic resistance testing for both non-point and point sources. From left to right the bars represent the MAR frequency (number of antibiotic resistant isolates / total number of antibiotics tested), the percent of resistant isolates, and the percent of isolates that had resistances to three or more antibiotics. PS (green bars); NPS (blue bars).

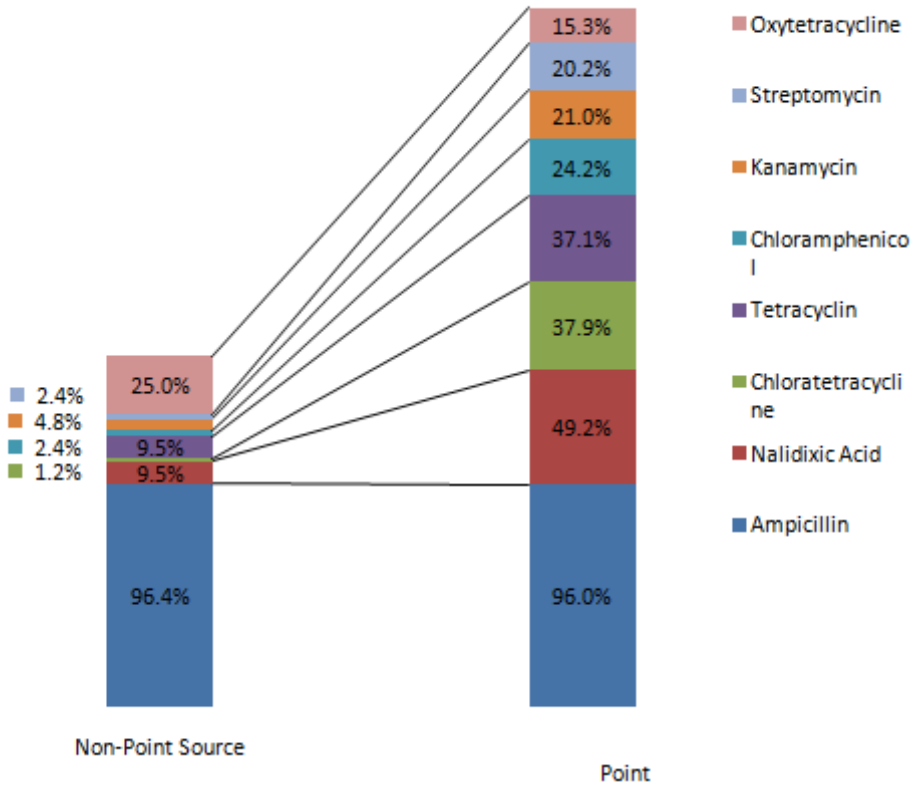

Figure 3: Antibiotic resistance profiles of coliform isolates from PS and NPS sources.

Multiple drug resistance tests also revealed that 81.5% of point source samples showed resistance to multiple drugs compared to 46.3% of nonpoint sources. Point source isolates also expressed resistance to 8 or more different drugs in 7.8% of the samples, an astounding number. Nonpoint source isolates showed varied resistance to no more than 6 drugs in any sampling and only 2.8% were resistant to more than 3. Point source samples showed significantly higher levels of widespread antibiotic resistance than non-point source samples (Figure 4).

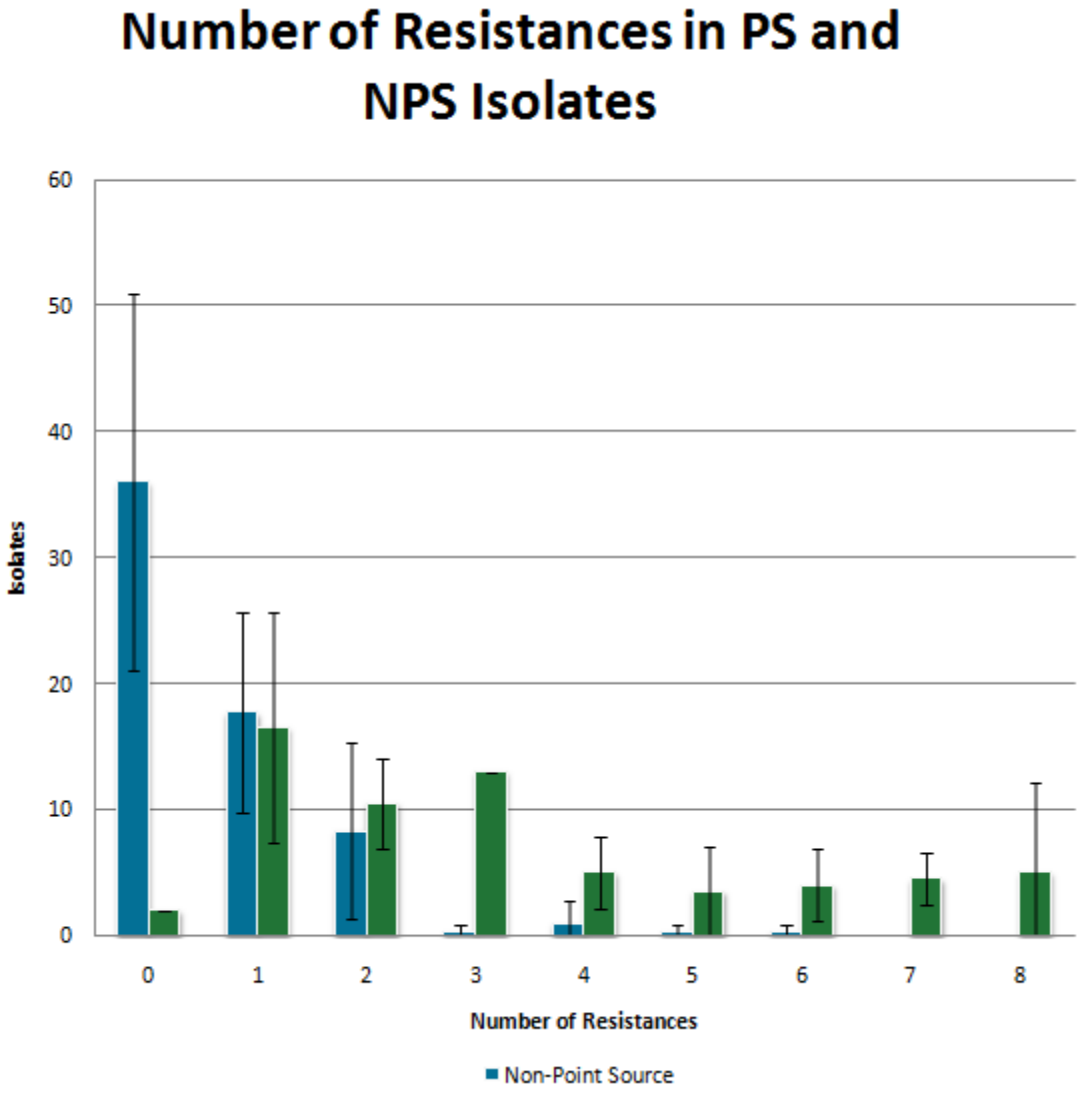

Figure 4: A comparison of the number of antibiotics each isolate was resistant to. Numbers on the x-axis represent the number resistances that each isolate had and the y-axis represents the number of isolates.

The MAR values and patterns of the PS isolates were similar to fecal *E. coli* isolates recovered from raw sewage samples in the D.C. metropolitan area, strongly indicating that multiple drug resistant (MDR) *E. coli* are being directly deposited into the river from these CSO overflows. This portion of the study was carried out by students of the Dean's Seminar Class (Do We need Biotechnology? It was presented as a poster for the George Washington Research Day in March 2011 and later at the Undergraduate Research Symposium in April where it won first prize. The full poster is shown in Appendix B.

Using Multiple Antibiotic Resistance (MAR) Analysis to Identify CSOs as Sources of Fecal *Escherichia coli* Contamination on the Anacostia River

More extensive studies were carried out by undergraduate students engaged in individual research projects in the laboratory throughout the summer and fall of 2010, and continued into the new year. Five CSO sites along the Anacostia River between the 11th Street Bridge and the East Capitol Bridge (CSO's 14, 16, 17, 18 and 19) were chosen for MAR analysis. All sites drain both residential (84%) and mixed commercial areas (16%). In addition, all sampled CSO sites experience overflows during minimal (0.1-0.5 inches) rainfall. The non-point source (NPS) samples were collected mid-stream at the M Street Railroad Bridge. The MAR Index values for all CSO's calculated an average of 52%, significantly higher than the NPS samples calculated at 16% ($p<0.05$). This indicates that the CSO's are major point sources for contamination by fecal *E. coli*. In addition, CSO isolates showed much higher resistance to combinations of antibiotics than NPS isolates. No significant differences in MAR indexes were calculated between each of the CSO sites ($p=0.85$); however, all CSO sites showed a significant difference with the NPS site ($p<0.05$). 98% of isolates from CSO sites were resistant to one or more antibiotics. 83% of isolates from mid-stream samples were resistant to one or more antibiotics. Most importantly, the majority of *E. coli* isolates from CSO sources were resistant to three or more antibiotics.

Site	CSO 14	CSO 16	CSO 17	CSO 18	CSO 19	NPS
MDR	65.7	61.4	74	70.1	82.5	4.2
MAR	52	42	52	46	70	16
n	67	98	115	172	172	154

Table 2 MAR and MDR Index Percent Values for CSO Sites. No significant differences in MAR indexes were calculated between each of the CSO sites ($p=0.85$); however, all CSO sites showed a significant difference with the NPS site ($p<0.05$). 98% of isolates from CSO sites had resistance to one or more antibiotics. 83% of isolates from mid-stream samples were resistant to one or more antibiotics.

Comparative antibiotic resistance profiles of CSO sites showed no significant differences for ampicillin, ciprofloxacin, streptomycin and chlortetracycline resistances. However, isolates from the downstream CSO14, CSO16 and CSO17 sites showed significantly more resistance to naladixic acid, tetracycline and oxytetracycline. Upstream CSO18 and CSO19 isolates showed

significantly more resistance to chloramphenicol. Profiles of isolates from mid-stream (NPS) samples showed similar levels for ciprofloxacin and ampicillin resistances to CSO isolates only. More diverse patterns of antibiotic resistance were seen in the CSO isolates compared to the NPS source. 43 different resistance patterns were seen collectively in the CSO isolates compared to 8 patterns seen in the NPS isolates. These results are shown in detail on the poster display in Appendix C. This presentation was made at the Maryland Water Monitoring Council Conference in Baltimore, Maryland, in November 2010.

Extensive studies were also undertaken on samples obtained from CSO sites 5, 6 and 7 (at the Fort Stanton area on the south-eastern bank of the Anacostia River). MAR and MDR index percent values for each of these CSO sites (27.8%) was significantly lower than for CSO sites 14, 16, 17, 18 and 19 ($p<0.05$) but significantly higher than NPS values ($p<0.05$). Low MAR percent index values were also obtained for CSO 8 (20.5%) and CSO 9 (20.7%).

Overall, our studies indicated that CSO sites, 14, 16, 17, 18 and 19 contribute a significantly greater load of fecal *E. coli* contaminants to the Anacostia River during CSO overflows than the other CSO sites examined in this study. The *E coli* isolates from the Navy Yard and North-East Boundary sites also show a wider variation in antibiotic resistance patterns. One explanation for this wide variation may be due to the exchange of R-factors carried on conjugative R-plasmids. It has been shown that plasmid transference readily occurs among fecal coliforms in the microbial milieu of mammalian GI systems and in stagnant bodies of wastewater (18,19). WSSC has reported that the D. C. region of the Anacostia River is a stagnant water body with a long resting time in these urbanized areas that favors such exchange (5). Consequently, the sluggish flow of the river does not allow for effective aeration of the water. Low O_2 saturation levels as well as high water temperatures likely favor the survival of facultatively anaerobic coliforms, resulting in genetic exchange between particularly virulent microbes and those occurring naturally within the environment (20,21). Future work will focus on these and other CSO sites this summer to confirm the consistency of our results.

There is an effort to remediate the Anacostia River and the watershed that supplies it. However, an aging city sewage system is likely to maintain the current high levels of fecal coliform contamination in the river. Any serious effort to improve the condition of the Anacostia

must be accompanied by careful monitoring of bacterial populations. We believe that using MAR profiles of selected sites on the Anacostia River (CSO and NPS), as we have described here, may be a useful and simple tool for monitoring the rehabilitation of the CSO system.

Studying the Antibiotic "Resistome" of the Anacostia Watershed

It is generally understood that, due to the overwhelming proliferation of antibiotic resistant bacteria, we are now living in a "Post-Antibiotic Era" (22). Microbial resistance to antibiotics now spans all known classes of both naturally-produced substances as well as chemically-synthesized compounds. D' Costa and others (23,24) have argued that studying reservoirs of antibiotic resistant bacteria (in biotic and abiotic sources) could provide an early warning system for the potential transfer of antibiotic resistance genes to clinical isolates. Equally possible is the transfer of resistance genes from clinical pathogens to naturally occurring bacterial populations. It seemed logical, therefore, to extend our work into investigating the MAR spectra of fecal bacteria found in the human and animal sources which contribute to the contamination of the Anacostia River and its watershed.

In these studies, we extended the range of antibiotics used for antibiotic resistance analysis to take into account recent studies which point to new patterns of antibiotic resistance acquisition by enteric bacteria which constitute a public health threat. The additional antibiotics included cefoxitin, aztreonam, piperacillin, oflaxacin and nitrofurantoin. The emergence of resistance to expanded-spectrum cephalosporins has been a major concern and is due to the production of Extended-Spectrum Beta-Lactamases (ESBLs)(25). ESBLs confer resistance to many cephalosporin antibiotics, such as cefoxitin, and related oxyimino-β lactams, such as aztreonam (26). This latter antibiotic is primarily administered intramuscularly due to its inability to pass through the digestive tract unaltered. Resistance to piperacillin, another extended spectrum β-lactam antibiotic, has also raised concerns (27). Dug resistant *E. coli* have been identified in sewage and sludge specimens in Austria and Spain, and recently seen in enteric bacteria isolated from avian sources in Spain and South Africa (28). ESBLs are frequently encoded by plasmid-borne genes. These plasmids responsible for ESBL production frequently carry genes encoding resistance to other drug classes (i.e., aminoglycosides)(29). Resistance to ofloxacin, a second-generation fluoroquinolone, which has been associated with clinical strains of *Mycobacterium tuberculosis*, and has now been noted in among enteric isolates, including *E. coli* (27), In addition, we incorporated nitrofurantoin which is often used to combat urinary tract infections caused by *E. coli*. Rates of resistance to nitrofurantoin in the United States have, until

recently, remained low (0.4 to 0.8%) but clinical isolates resistant to the antibiotic have increasingly appeared over the past few years (30).

MAR Profiles of Coliform and Non-Coliform Bacteria from the Anacostia River and some of its Tributaries in the Anacostia Watershed. Initial results suggest that resistances to some of these "second generation" antibiotics in fecal coliform isolates from some CSO sources are high. For example, in a survey of *E. coli* isolates from CSO 5, 6 and 7, out of a total of 384 individual isolates, 63% were resistant to cefoxitin, 63% to nitrofurantoin and 38% to aztreonam. In a similar study on *Enterobacter* isolates from CSO 19, 91% were resistant to aztreonam, and 39% to nitrofurantoin; all isolates were resistant to cefoxitin and streptomycin (total 128 isolates). Major patterns of antibiotic resistance are shown in Table 4 below: over half of the isolates (54%) were resistant to the combination aztreonam-cefoxitin-streptomycin.

RESISTANCE PATTERN	PERCENT ISOLATES
Az-Ce-St	54
Az-Cef-St-Nf	26.5
Ce-St	15.6
Ce-Sm-Nf	3.1

Table 4: Major resistance patterns seen in *Enterobacter* isolates from CSO 19. Az: aztreonam; Ce: cefoxitin; St: streptomycin; Nf: nitrofurantoin.(n=128.)

MAR Profiles of Enteric Bacteria Isolated from Human Sources. *E. coli*, *Enterobacter* and *Salmonella* spp. were isolated from individual human fecal samples and raw sewage obtained in the vicinity of CSO 19. Isolates were characterized and identified by standard microbiological procedures before being plated onto a grid for subsequent MAR analysis. MAR indices and resistance patterns from individual samples varied considerably; however, sewage isolates exhibited very high MAR indices (>90%) and a wide range of multiple drug resistance patterns. Although this part of the project is still in the preliminary stages, one study on *Salmonella* spp. isolates from raw sewage taken from a sampling point near CSO 19, found that the major resistance pattern was Az-Ce-St, which has also been found in *Enterobacter* isolates from CSO 19 (see Table 4 above). Over 15% of the resistant isolates carried resistances to 9 of the 11 antibiotics tested.

MAR Profiles of Enteric Bacteria Isolated from Animal Sources. Antibiotic resistance analysis was also undertaken on enteric isolates from domestic and wild animals. These included cats, dogs, ferrets, horses and geese.. It has been suggested that wild birds, particularly migratory fowl, may harbor a reservoir of antibiotic resistant bacteria and have the potential to disseminate them over very long distances (32,33). One of our student studies focused on geese because these are common denizens of the Anacostia River and its watershed. Fresh goose fecal samples were collected from the Roosevelt Island area earlier this spring and *Enterobactera* spp. isolates examined by MAR analysis. Our studies showed that goose fecal isolates were far more variable in antibiotic resistance patterns than any other animals tested in this project. The MAR index of the source was 41% (n=64). Most isolates were resistant to the β-lactams, aztreonam, piperacillin and cefoxitin (Figure 5) and carried resistances to multiple antibiotics (Figure 6).

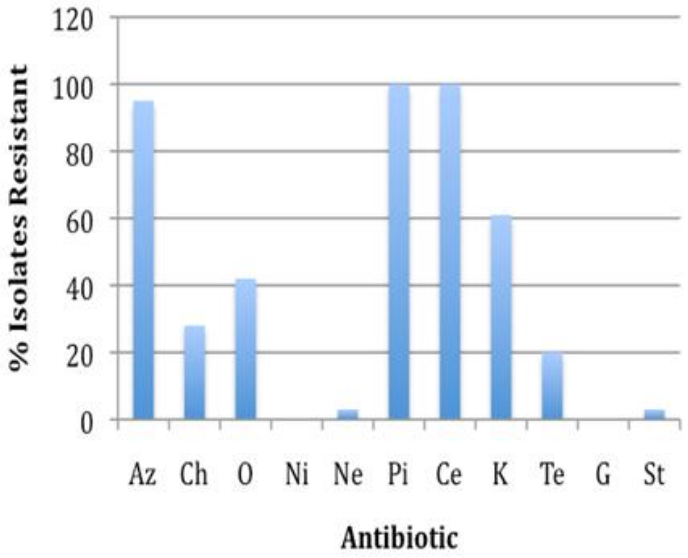

Figure 5: Percentages of individual goose *Enterobacter* isolates resistant to 11 antibiotics. Az: aztreonam; C: chloramphenicol; O: oflaxacin; Ni: nitrofurantoin; Ne: neomycin; Pi: piperacillin; Ce: cefoxitin; K: kanamycin; Te: tetracycline, G: geniticin; S: streptomycin.

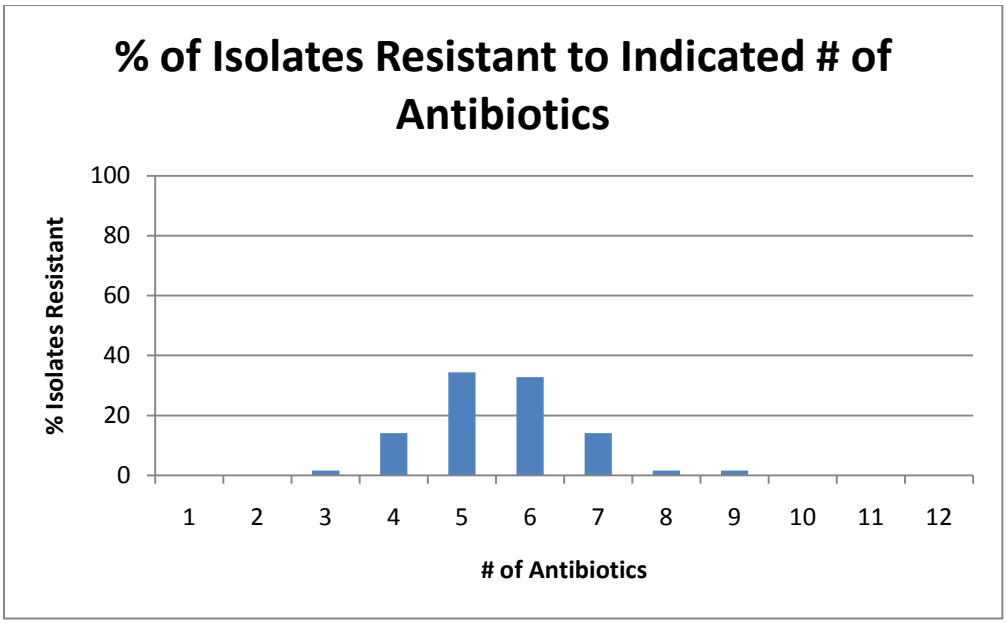

Figure 6: Percentage of individual goose *Enterobacter* isolates resistant to multiple antibiotics

19 different antibiotic resistance patterns were seen among the isolates, the most common depicted in Table 5.

Major Resistance Pattern	% Isolates
Az-Pi-Ce-K	17.2%
O-Pi-Ce	4.7%
Az-Ch-Pi-Ce-K	15.6%
Az-O-Pi-Ce-K	14.1%
Az-Pi-Ce	14.1%
Az-O-Pi-Ce	10.9%

Table 5: Predominant antibiotic resistance patterns in Goose *Enterobacteria*. Antibiotic abbreviations are the same as those in Figure 5.

These studies may be important for identifying sources of fecal coliform contamination of the Anacostia River and its watershed. Geese defecate freely in and around ponds and coastal waterways within their migration paths. Indeed, recent studies have shown that geese and gulls carry more antibiotic resistant coliforms when they nest in urban areas, especially near waste water, or agricultural water. Many of these isolates were found to have antibiotic resistance profiles similar to clinical isolates (31,34), suggesting that they may be potent disseminators of antibiotic resistance determinants (35).

Plasmid DNA Profiles of Multiple Drug Resistant Bacteria. In addition to changes in the selection of antibiotics used for MAR analysis, plasmid DNA isolation is underway to determine the molecular basis of multiple drug resistance seen in many bacterial isolates from CSO sites as well as animal and human sources. It has been well-established that the wide variation seen in antibiotic resistance, especially among Gram-negative bacteria, is due to the exchange of R-factors carried on conjugative R-plasmids (22,24). It has been shown that plasmid transfer readily occurs among fecal coliforms in the microbial milieu of mammalian gastro-intestinal systems and in stagnant bodies of wastewater (18,36). Thus, it is reasonable to hypothesize that the multiple-drug resistance profiles (particularly those which recur frequently) we see in our isolates are a direct cause of fecal contamination by the CSO system throughout the D.C. metropolitan area linked to shared R-plasmids. Furthermore, plasmids are easily transferred between species of bacteria. For this reason, this study was expanded to include other bacteria known to inhabit the intestinal tract such as *Enterococcus faecalis* (another indicator, in addition to *E. coli*, of recent human fecal contamination [8]), *E. coli* O157:H7, and *Enterobacter* spp. (in which the percentages of ESBL producers have risen sharply over the past few years [37]). Additional media and other assays have allowed our students to confirm the source of fecal contaminations, catalogue each isolate by source, and compare singular and multiple drug resistance profiles of the various water samples (NPS and CSO) to raw fecal samples.

The first attempts at plasmid DNA isolation has begun with individual isolates of MDR *E. coli* and *Enterobacter* spp. from water sources, and human and animal fecal samples taken in spring 2011. Plasmid isolation was conducted as outlined by Takahashi and Nagano (38) and the samples electrophoresed on 0.8% agarose gel for 120 minutes at 90 volts. Figures 7 shows some of the initial results. Figure 7 shows profiles of isolates from horses (lanes 6-9) and geese fecal samples (lanes 11-16) and human fecal samples (lanes 18-22) taken from Children's National Medical Center in Washington, D.C. All the horse isolates were confirmed to be cefoxitin resistant isolates. The goose fecal samples were inconsistently drug resistant to all antibiotics tested with no significant resistance pattern observed. Human fecal samples were unanimously resistant to cefoxitin, piperacillin, streptomycin and tetracycline. Similar patterns of plasmid banding (with a predominant band at ~30kbp) was observed

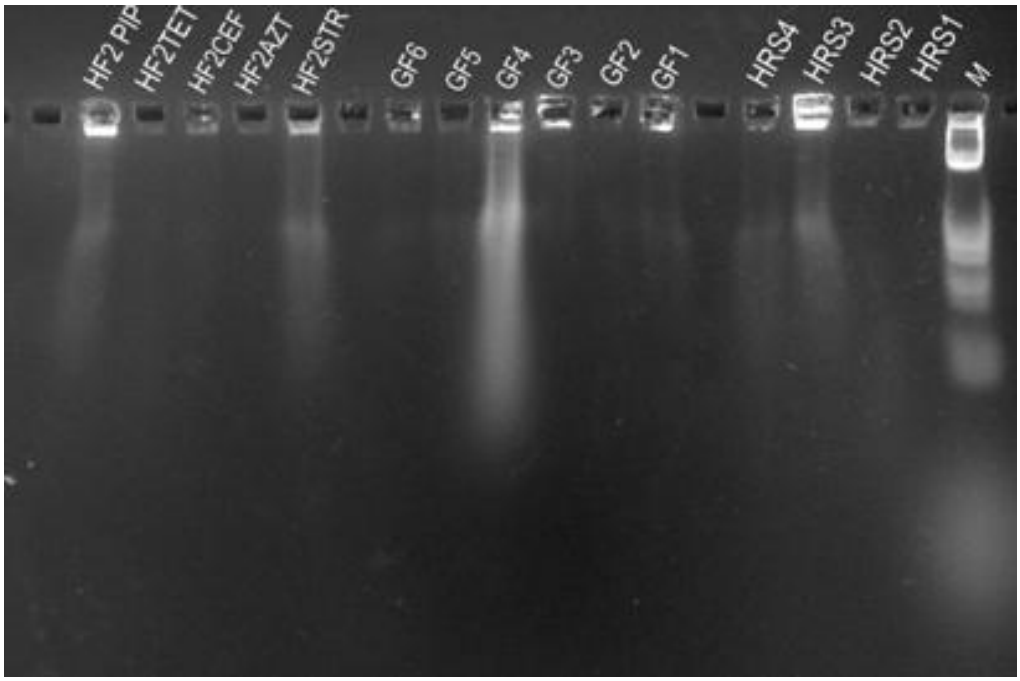

Figure 7. Plasmid profiles of multiple-drug resistant fecal coliform isolates from (L to R) humans (HR). geese (GF) and horse (HR). The single band seen in most profiles was calculated to be about 30 kb in size compared to the standards in lane M.

These investigations will continue this summer. Furthermore, as planned in the Proposal, isolates confirmed for plasmid content will be investigated by resistance transfer testing and plasmid curing (36) to assign resistance genes to plasmid DNA.

Acknowdgments

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38.

Appendix A: Student Manual for the isolation, characterization and MAR analysis of fecal coliforms.

Day 1—Colony Collection

1) Water samples should be processed within 48 hours of collection. Shake acquired water samples vigorously to mix contents that may have settled. Organic material caught in the sample is normal and inconsequential.
2) Use vacuum filtration located next to the fume hood to filter the samples.
    a. Turn on the vacuum in the hood and attach a filtration cup to the filter flask.
    b. Remove the lid of the filtration cup and add desired water volumes
        i. Late Spring—Early Fall: 5-10mL water or one of each
        ii. Late Fall—Early Spring: 20-30mL water or one of each
    c. Filter an additional 10-20 mL of distilled water after the contaminated water.
    d. Dip tweezers in alcohol and remove the filter paper in the cup and place onto plate consisting of MacConkey's agar, grid-side up.
        i. Place it down at an angle to avoid air bubbles and ensure the most contact between the paper and the agar. Using the sterilized tweezers, gently press out any remaining air bubbles.
3) Place topside down in 37C incubator overnight.

    **NOTE: Plates must be read within 24 hours to ensure late sugar fermenting organisms do not influence original results.

Day 2—Master Plates

1) Remove plates from incubator to ensure sufficient growth. If sufficient growth is not observed, it may be necessary to filter a larger volume of water to obtain a higher quantity of colony forming organisms.
2) Using pre-formed grid papers align fresh MacConkey's plates on top of the grid. Mark the bottom of the plates to orient them. This differentiates the first colony to the last colony when you read/compare them at a later date.
    a. Label fresh plates with sample name/number from the filtration plates and [current] date.
    b. Square plates = square grid; round plates = round grid papers
3) Using sterile toothpicks, collect fermenting (red) colonies individually from the filter plates and transfer by pricking gently into the new MacConkey's plates. One colony per square.
4) Place topside down in 37C incubator overnight. These plates will be referred to as the "master plates" and must be read within 24 hours to ensure late fermenting organisms do not contaminate original results.

Day 3—Classification/Characterization by Differentiation Media

1) When you read the previous days plates, note/record the color, shape and other unusual physical characteristics of each colony. Your colonies should be primarily [Lac+] pink→brick red, round formations, and may have a bile precipitate present.

2) Align 8 grid papers one after another. The first placement is your master plate followed by one each of your differentiation media:
    a. Desoxycholate (Desoxy)
    b. Eosin Methylene Blue (EMB; or // label)
    c. Hektoen Enteric (HE)
    d. Simmon's Citrate
    e. MacConkey's (MAC; or / label)
    f. Xylose Lysine Desoxycholate (XLD)
    g. Sorbitol MacConkey's (S. MAC)

Expected Results for *E. coli* (Refer to the Difco Manual):

Desoxy	Red colonies with a surrounding bile precipitate
EMB	Deep red—purple colored colonies with a greenish metal tinge
HE	Large yellow—salmon-pink colonies with bile precipitate
Citrate	No growth: an important test because it distinguishes *E. coli* from *Enterobacter* (which does grow and elicits media color change from green to blue). Change in color should be recorded as positive for *Enterobacter*.
MAC	Pinkish—brick-red colonies and bile precipitate
XLD	Large, flat yellow colonies
S. MAC	Pink—red colonies with bile precipitate; sorbitol non-fermentation is indicative of O157:H7 Enterohemorrhagic *E. coli* [EHEC]

You may also be recommended to carry out the following confirmatory tests on selected isolates:

a. Gram staining;
b. IMVic tests;
c. API test strips for Salmonella/Shigella;
d. TSI agar stabs;
e. LB Salts (6.5%)
    **This test attempts to isolate *Streptococcus faecalis* and growth of mucoidal, round opaque colonies indicates a positive result. Gram stain sample organisms to confirm.

3) Label each plate with the corresponding Master Plate information and [current] date. All plates should be marked and oriented the same direction. Using a sterile toothpick, transfer one colony at a time to each of the plates. Complete one master plate at a time and remain consistently centered for ease of replica plating later.
    a. You only need to use a new toothpick when going from one master plate to another; however you can use one toothpick per master plate across all media.
    b. You will be transferring one colony at a time so that the grids align across ALL media plates. Colony 1 on the mater plate corresponds with colony 1 on the subsequent media plates. It is okay for the same toothpick to go from HE to citrate, etc.
4) Incubate topside down at 37C overnight.

Day 4—Antibiotic Assay

1) Record the results from these plates by noting the appearance of the plates, color changes, any significant patterns and how much growth has occurred. If there are a few colonies, be sure to count them and note this number.
    a. Observe all physical characteristics of each colony individually—color, shape, aggregation, surrounding media, etc. This is important and informative when we consider source contamination of the water sample in addition to the further classification of each colony. You will use the provided media descriptions to organize and clarify or results.
2) Using the original master plates, transfer one colony at a time to antibiotic plates in the same replication pattern used for differentiation. The antibiotics and concentration used are:
    a. Aztreonam: 0.05 μg/mL
    b. Geneticin: 25 μg/mL
    c. Nitrofurantoin: 0.64 μg/mL
    d. Kanamycin: 50 μg/mL
    e. Ofloxacin: 10 μg/mL
    f. Cefoxitin: 0.4 μg/mL
    g. Piperacillin: 25 μg/mL
    h. Streptomycin: 12.5 μg/mL
    i. Neomycin: 50 μg/mL
    j. Tetracycline: 25 μg/mL
    k. Choramphenicol: 25μg/mL
3) Using the same technique and setup as above transfer one colony at a time from the MacConkey's master plates onto the antibiotic plates. You should have 11 antibiotic plates per water sample.
4) Incubate the plates topside down at 37C overnight.

A. Isolation of *E. coli* from anal swabs, animal feces and raw sewage

1) For anal swabs (human and animal).
    a. Take a sample immediately after defecation and swipe directly onto an EMB plate and incubate for 48 hours.
    b. Alternatively, the swab may be placed in 1 mL of EC broth, incubated for 8 to 16 hours at 44.5^{o}C (in a water bath) before plating onto EMB plates.

2) For fecal specimens,
    a. Place approximately 1 gm of material in 10 ml of 1% tryptone broth and shake vigorously to disperse the material. Use sterile glass rod if necessary.
    b. Transfer 1 mL amounts to 5 ml of EC broth and incubate at 44.5^{o}C for 8 to 16 hours. Plate samples (streaking is sufficient) onto EMB plates and incubate at 37^{o}C for 24 to 48 hours.

3) For raw sewage, pipette 1 mL amounts into 5 ml of EC broth and process as described above.

Transfer fermentative colonies (deep red in coloration) to fresh EMB plates and screen for *E. coli* as above.

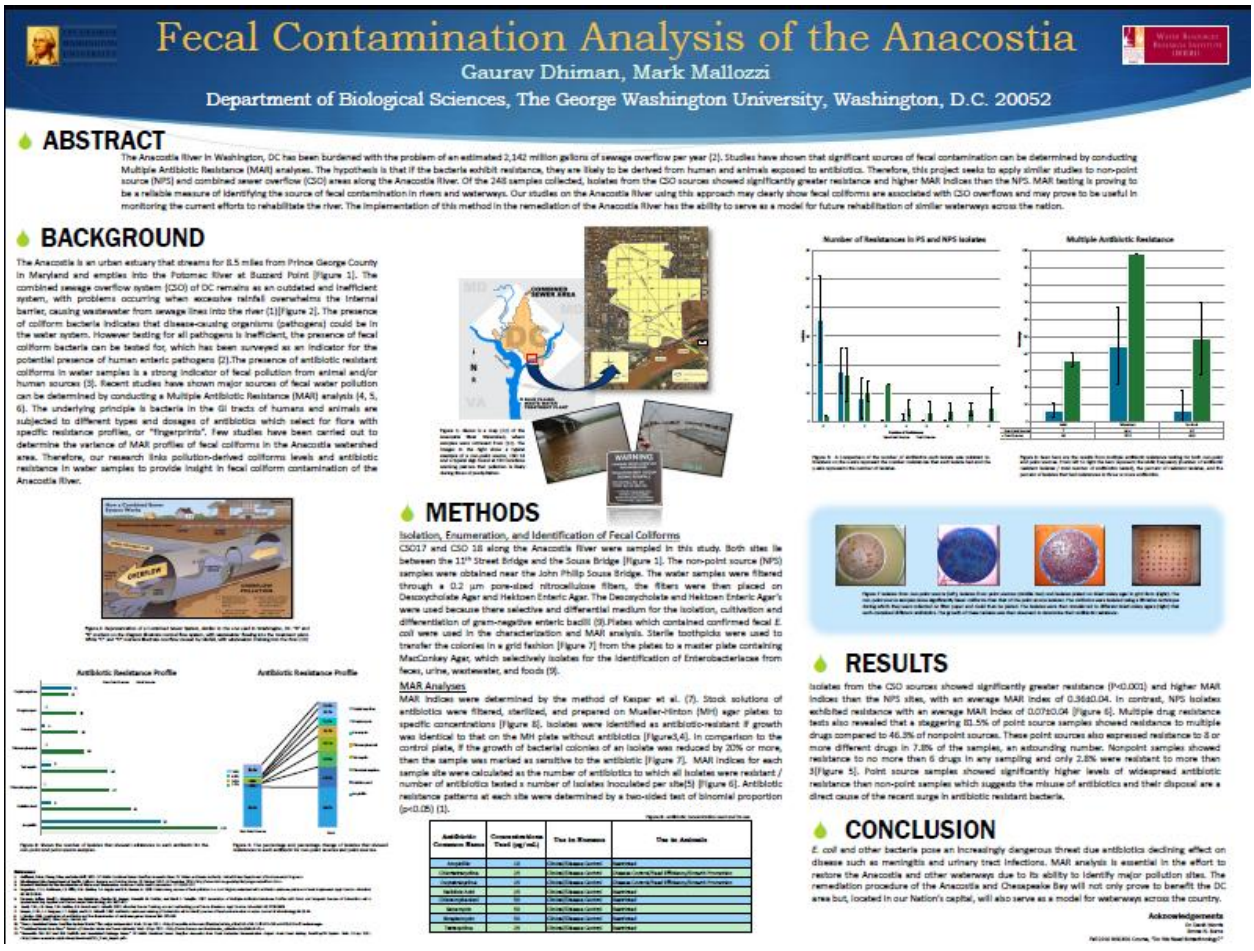
B. <u>Data Calculations and other Schematics</u>

Susceptible: 0→15% growth; Sensitive: 15→79% growth; Resistant: ≥80%

1) For each ISOLATE
    a. Multiple Antibiotic Resistance Index for each isolate calculated as follows:
    MAR Index = (# of colonies grown/total # of AB's tested) x 100 =
    b. Present this information as a bar graph
    c.
2) For each CSO/NPS
    a. MAR Index for each AB calculated as follows:
    AB MAR Index = (total # resistant isolates/total # isolates) x 100 =
    b. Present this information as a bar graph.
    c. Make a chart of the samples/antibiotics and write down the number of colonies that showed growth per total number of colonies poked onto the antibiotic plates.
    a. Note if any plates have turned a greenish color.
    b. In addition, your record will also need to note growth (as +)/no growth (as -) for each colony inoculated onto the plate. This means, for each square AB plate, you will have a series of 64 +/- notations.
    c. You will use the above information later to develop analytical tools such as comparative matrices and isolate "fingerprints" called Dendograms.

Appendix B: Fecal Contamination Analysis of the Anacostia, by Gaurav Dhiman and Mark Mallozzi ("Do We Need Biotechnology?" Dean's Seminar Class).

Presented at the George Washington University Undergraduate Research Symposium. April 25th 2011.



Fecal Contamination Analysis of the Anacostia

Gaurav Dhiman, Mark Mallozzi
Department of Biological Sciences, The George Washington University, Washington, D.C. 20052

ABSTRACT

The Anacostia River in Washington, DC has been burdened with the problem of an estimated 2,142 million gallons of sewage overflow per year (2). Studies have shown that significant sources of fecal contamination can be determined by conducting Multiple Antibiotic Resistance (MAR) analyses. The hypothesis is that if the bacteria exhibit resistance, they are likely to be derived from human and animals exposed to antibiotics. Therefore, this project seeks to apply similar studies to non-point source (NPS) and combined sewer overflow (CSO) areas along the Anacostia River. Of the 248 samples collected, isolates from the CSO sources showed significantly greater resistance and higher MAR indices than the NPS. MAR testing is proving to be a reliable measure of identifying the source of fecal contamination in rivers and waterways. Our studies on the Anacostia River using this approach may clearly show fecal coliforms are associated with CSO overflows and may prove to be useful in monitoring the current efforts to rehabilitate the river. The implementation of this method in the remediation of the Anacostia River has the ability to serve as a model for future rehabilitation of similar waterways across the nation.

BACKGROUND

The Anacostia is an urban estuary that streams for 8.5 miles from Prince George County in Maryland and empties into the Potomac River at Buzzard Point [Figure 1]. The combined sewage overflow system (CSO) of DC remains as an outdated and inefficient system, with problems occurring when excessive rainfall overwhelms the internal barrier, causing wastewater from sewage lines into the river (1)[Figure 2]. The presence of coliform bacteria indicates that disease-causing organisms (pathogens) could be in the water system. However testing for all pathogens is inefficient, the presence of fecal coliform bacteria can be tested for, which has been surveyed as an indicator for the potential presence of human enteric pathogens (2).The presence of antibiotic resistant coliforms in water samples is a strong indicator of fecal pollution from animal and/or human sources (3). Recent studies have shown major sources of fecal water pollution can be determined by conducting a Multiple Antibiotic Resistance (MAR) analysis (4, 5, 6). The underlying principle is bacteria in the GI tracts of humans and animals are subjected to different types and dosages of antibiotics which select for flora with specific resistance profiles, or "fingerprints". Few studies have been carried out to determine the variance of MAR profiles of fecal coliforms in the Anacostia watershed area. Therefore, our research links pollution-derived coliforms levels and antibiotic resistance in water samples to provide insight in fecal coliform contamination of the Anacostia River.

METHODS

Isolation, Enumeration, and Identification of Fecal Coliforms

CSO17 and CSO 18 along the Anacostia River were sampled in this study. Both sites lie between the 11th Street Bridge and the Sousa Bridge [Figure 1]. The non-point source (NPS) samples were obtained near the John Philip Sousa Bridge. The water samples were filtered through a 0.2 µm pore-sized nitrocellulose filters, the filters were then placed on Deoxycholate Agar and Hektoen Enteric Agar. The Deoxycholate and Hektoen Enteric Agar's were used because there selective and differential medium for the isolation, cultivation and differentiation of gram-negative enteric bacilli (8).Plates which contained confirmed fecal *E. coli* were used in the characterization and MAR analysis. Sterile toothpicks were used to transfer the colonies in a grid fashion [Figure 7] from the plates to a master plate containing MacConkey Agar, which selectively isolates for the identification of Enterobacteriaceae from feces, urine, wastewater, and foods (9).

MAR Analyses

MAR indices were determined by the method of Kasper et al. (7). Stock solutions of antibiotics were filtered, sterilized, and prepared on Mueller-Hinton (MH) agar plates to specific concentrations [Figure 8]. Isolates were identified as antibiotic-resistant if growth was identical to that on the MH plate without antibiotics [Figure3,4]. In comparison to the control plate, if the growth of bacterial colonies of an isolate was reduced by 20% or more, then the sample was marked as sensitive to the antibiotic [Figure 7]. MAR indices for each sample site were calculated as the number of antibiotics to which all isolates were resistant / number of antibiotics tested x number of isolates inoculated per site[5] [Figure 6]. Antibiotic resistance patterns at each site were determined by a two-sided test of binomial proportion ($p<0.05$) (1).

RESULTS

Isolates from the CSO sources showed significantly greater resistance ($P<0.001$) and higher MAR indices than the NPS sites, with an average MAR index of 0.36±0.04. In contrast, NPS isolates exhibited resistance with an average MAR index of 0.07±0.04 [Figure 6]. Multiple drug resistance tests also revealed that a staggering 81.5% of point source samples showed resistance to multiple drugs compared to 46.3% of nonpoint sources. These point sources also expressed resistance to 8 or more different drugs in 7.8% of the samples, an astounding number. Nonpoint samples showed resistance to no more than 6 drugs in any sampling and only 2.8% were resistant to more than 3[Figure 5]. Point source samples showed significantly higher levels of widespread antibiotic resistance than non-point samples which suggests the misuse of antibiotics and their disposal are a direct cause of the recent surge in antibiotic resistant bacteria.

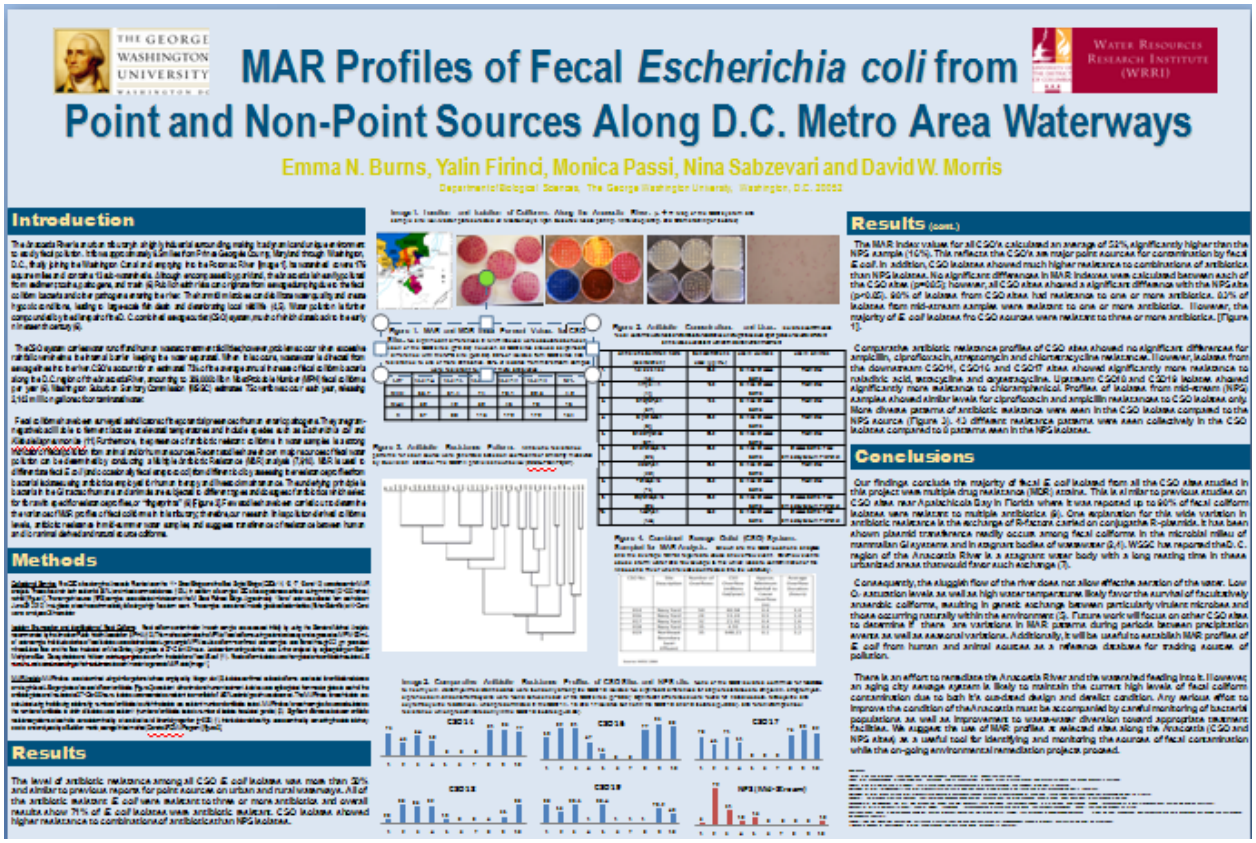
CONCLUSION

E. coli and other bacteria pose an increasingly dangerous threat due antibiotics declining effect on disease such as meningitis and urinary tract infections. MAR analysis is essential in the effort to restore the Anacostia and other waterways due to its ability to identify major pollution sites. The remediation procedure of the Anacostia and Chesapeake Bay will not only prove to benefit the DC area but, located in our Nation's capital, will also serve as a model for waterways across the country.

Acknowledgements

Appendix C: MAR Profiles of Fecal *Escherichia coli* from Point and Non-Point Sources Along D.C. Metro Area Waterways, by Emma N. Burns, Yalin Firinci, Monica Passi, Nina Sabzerai and David Morris.

Presented at the 16th Annual Maryland Water Monitoring Council Conference, November 2010.



Information Transfer Program Introduction

Dr. Tolessa Deksissa and water consultant Dr. Cat Shrier coordinated the 14-week DC Area Water Issues Program (DCAWIP), offered as a pilot program during the fall 2010 semester by the University of the District of Columbia's College of Agriculture, Urban Sustainability and Environmental Sciences (CAUSES). DCAWIP was created to implement a strategic goal of the DC Water Resources Research Institute: to generate greater involvement by students and faculty at all of the area universities in water education programs, as well as that of other DC area water stakeholders; and to develop a network of peer reviewers for DCWRRI-funded research. This multi-disciplinary seminar program featured expert speakers from water organizations and explored numerous aspects of water and watersheds in the DC area. DCAWIP drew an average of 40 attendees per week, indicating a strong interest by participants to come together on a regular basis to learn more about area issues and programs, and to develop opportunities for greater student and other university involvement in the larger community of water professionals.

A new Research Associate was hired to support and strengthen our 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.

DC Water Issues Forum and Water Research Faculty Professional Development Program

Basic Information

Title:	DC Water Issues Forum and Water Research Faculty Professional Development Program
Project Number:	2010DC110B
Start Date:	3/1/2010
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	DC
Research Category:	Not Applicable
Focus Category:	Education, None, None
Descriptors:	None
Principal Investigators:	Tolessa Deksissa, Catherine Shrier

Publications

There are no publications.

DC Water Issues Forum and Water Research Faculty Professional Development Program

Final Report

Submitted to

DISTRICT OF COLUMBIA WATER RESOURCES RESEARCH INSTITUTE

By:

Dr. Tolessa Deksissa (PI)
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February 2011

TABLE OF CONTENT

Abstract

The DC Area Water Issues Program (DCAWIP) was offered as a pilot program during the Fall 2010 semester by the University of the District of Columbia's College of Agriculture, Urban Sustainability and Environmental Sciences (CAUSES). Funded by the US Geological Survey (USGS) through DC Water Resources Research Institute (DCWRRI), this Program was developed with the goal of creating a more cohesive water research community in the DC area. DCAWIP was created to implement some of the measures recently identified in strategic planning activities by the DC Water Resources Research Institute, which had indicated the need for greater involvement by students and faculty at all of the area universities in water education programs, as well as the involvement of other DC area water stakeholders; and for the development of a network of peer reviewers for DCWRRI-funded research.

DCAWIP was a comprehensive set of university events open to all DC Area students, faculty, water managers, and members of the general public who are interested in water. DCAWIP was a multi-disciplinary program, exploring issues related to the science and engineering, policy, and socioeconomic aspects of water and watersheds in the DC area. Every Thursday afternoon for 14 weeks, a seminar series was offered in which speakers from water "stakeholder" organizations provide insightful, practical information about DC water issues and their role in the water community, followed by sponsored refreshments and community-building reception.

Initial speakers included leadership from DC Water, Washington Aqueduct, DC Department of the Environment, Interstate Potomac River Basin Commission, and Metropolitan Washington Council of Governments, provided an introduction to DC area watersheds; water supply, treatment, and wastewater systems; storm water and flooding issues; habitat issues; stakeholders and regional coordination efforts. The middle series of speakers focused on water-related opportunities for educational programs and degrees, jobs, internships, scholarships, volunteering. The final speakers were on topics selected by the "DC Area Water Community" participants," including urban gardening and green spaces; wastewater reuse and communications; and water security issues. Additional events provided included art exhibits, a book signing, a film screening, and a boat tour of the Anacostia River.

DCAWIP drew an average of 40 attendees per week, with at least 30 attendees at all programs, and two programs with attendance of more than 50. The program included interns and volunteer students from UDC, Catholic University, Howard University, the University of Maryland at College Park, George Washington University. Participants registered and submitted evaluation forms and self-identifying data. There was consistent support for reception sponsorships, which was not part of the original proposal budget. The inclusion of food was found to be important both in attracting attendance and in providing opportunities for participants to continue discussion and generate new opportunities for collaboration and understanding. The program created opportunities for collaboration between students, faculty, and staff with area water providers and other water stakeholders, such as the Anacostia Watershed Society, Metropolitan Washington Council of Governments, DC Department of the Environment, DC Water, and Washington Aqueduct.

The DC Area Water Issues Program (DCAWIP) demonstrated a strong interest by students, faculty, staff, and area stakeholders to come together on a regular basis to learn more about area issues and programs, and to develop opportunities for greater student and other university involvement in the larger community of water professionals**.**

1. INTRODUCTION

The DC Area Water Issues Program (DCAWIP) – offered by UDC's College of Agriculture, Urban Sustainability and Environmental Sciences (CAUSES) -- was developed as a pilot program during the Fall 2010 semester. DCAWIP was created as a comprehensive set of university events open to all DC Area students, faculty, water managers, and members of the general public who are interested in water. DCAWIP explored issues related to the science and engineering, policy, and socioeconomic aspects of water and watersheds in the DC area, including the suburban areas of Maryland and Virginia. Funded by the US Geological Survey (USGS) through DC Water Resources Research Institute (DCWRRI), the goal of DCAWIP was to create a more cohesive water research community in the DC area.

1.1. Background

The District of Columbia Water Resources Research Institute (DCWRRI) has taken several steps in recent years to build the capacity of the Institute to fulfill its statutory mandate and its mission to DCWRRI's mission, which is to provide the District of Columbia with interdisciplinary research support to identify DC water resources problems and contribute to their solution. The Institute has also taken steps to address needs identified in prior USGS Evaluation Committees, and to go beyond these requirements to become a "center for excellence" in water research.

In 2009, DCWRRI commissioned Cat Shrier, President of Watercat Consulting LLC, to complete an external review of its Resources and Accomplishments, resulting in a White Paper entitled "DCWRRI Preliminary Inventory and Assessment of Resources and Accomplishments" (updated October 23, 2009), which includes recommendations to address the concerns raised by the Evaluation Committee and in additional communications with USGS.

As noted in this White Paper, while the District of Colombia includes several major universities within an area of roughly 70 square miles, there is no cohesive water research community, nor is there any individual university with a strong and multidisciplinary water research focus. The White Paper and recent USGS evaluations had identified the need for greater involvement by students and faculty at all of the area universities, as well as to involve the DC water stakeholders; and for the development of a network of peer reviewers for DCWRRI-funded research. Individual faculty at DC universities had expressed concerns regarding the need for a greater understanding of proposal expectations for grant funding programs, information on related research underway at other DC universities, and opportunities for the development of multidisciplinary teams to address water resources research. Several DC area agencies and policymakers have expressed a strong interest in developing the District of Columbia as a more sustainable or "green" city, providing leading research and programs on urban sustainability. Stakeholders who comprise the DCWRRI Advisory Board (including Washington Aqueduct; DC Water and Sanitation Authority; Metropolitan Washington Council of Governments; Interstate Commission on the Potomac River Basin; DC Department of Environmental Protection; Friends of Rock Creek; and Chesapeake Bay Foundation) had identified research needs that can be addressed by DC area faculty, as well as the need to develop future employees with an understanding of DC water issues. DC-based federal and local agency personnel, consulting firms and other water professionals, have expressed similar research and hiring needs which can be met, in part, through local university researchers and graduates.

Based upon this information and feedback received from the Stakeholder Advisory Board, DCWRRI staff, and UDC Deans, the DCAWIP proposal was developed by Dr. Shrier and UDC Research Associate (and current Director of the UDC Professional Master's Degree in Water Resources Management) Dr. Tolessa Deksissa as a set of coordinated programs to be funded, in part, through the USGS 104B program, to simultaneously address several of the recommendations identified in the White Paper and in previous evaluations completed by USGS.

1.2. Goal and Objectives

The goal of DCAWIP was to create a more cohesive water research community in the DC area. This goal was to be met through the development of a pilot program consisting of a comprehensive set of university events open to all DC Area students, faculty, water managers, and members of the general public who are interested in water, enabling participants to explore issues related to the science and engineering, policy, and socioeconomic aspects of water and watersheds in the DC area, including the suburban areas of Maryland and Virginia.

Specific objectives include:

- Provide a pilot set of seminars to serve as an "Introduction to DC water issues" with presentation made by stakeholders, hosted at UDC but open to all DC area university students, faculty, and staff, as well as stakeholders and the general public. Incorporate opportunities for participants to talk less formally over a reception.
- Provide information for faculty, students, and staff for information on funding, scholarship, and grant programs.
- Provide opportunities for water tours
- Provide an internship
- Evaluate the pilot programs and review opportunities for a water research symposium and institutionalization of the seminar series

1.3. Scope of Work

DCAWIP was developed to include:

1) a paid student internship
2) a Weekly Seminar Series
3) a Boat Tour of the Anacostia River, as well as art exhibits, a book signing, and film screening
4) Fairs for Students and Faculty to develop Research Opportunities, Scholarships, Grants, Work, and Internships

2. PROGRAM COMPONENTS

2.1. Internship and Student Volunteers

A competitive internship program was announced by Principal Investigator Dr. Tolessa Deksissa and Co-Principal Investigator Cat Shrier, using a list of faculty in water-related disciplines throughout DC. A copy of the internship announcement is provided in **Appendix A.**

After interviewing the respondents, two interns were retained by Watercat Consulting LLC during August 2010 to assist with preparation of the seminar series. Diego Antezana, a Civil engineer student at Catholic University, was offered the internship funded through the original 104B grant, while additional funding was sought for a second intern, Arielle Benjamin, an undergraduate chemical engineering student from Howard University, who was paid by Watercat Consulting for work performed during August 2010. Additional funding support was not found for Ms. Benjamin, who continued as a volunteer until mid-September.

Mr. Antezana, the paid intern, provided program management support including:

- Weekly mailings to the "DC Area Water Community" email list
- Weekly updates of the "DC Area Water Community" email list with new participant from the sign-in sheets
- Coordination with speakers and sponsors
- Setting up registration and overseeing volunteers

- Ordering food and setting up the weekly receptions

Based upon experience acquired during this internship, Mr. Antezana was later able to secure a position with a construction management company.

After the start of the fall semester, funding was also sought for a third intern, Antonia (Toni) Davidson, a professional master's degree student in water resources management at UDC, who worked on weekly surveys of participants in the seminars. Funding was not available for Ms. Davidson. However, Ms. Davidson continued to support the program as a volunteer throughout the semester, as did several other students in the UDC professional master's degree program in water resources management.

Trevor Cone, a master's degree student in water resources engineering at the University of Maryland, also provided volunteer support for registration at the weekly seminar programs and with the post-program survey. Volunteers were identified as "university ambassadors" and their support was critical to the success of the program. The university ambassadors supported program implementation including setup and cleanup of weekly registration and reception.

2.2. Seminar Programs and Speakers

The seminar series was set up as a weekly program offered at UDC, open to all university students, faculty, staff, stakeholders and the general public. The programs were developed to cover a broad array of topics, providing an opportunity for area water stakeholders to "tell their own story," and providing opportunities for a facilitated dialogue between the participants and the speakers, as well as less formal communications over a reception following each program.

The original proposed title of the program was the "DC Water Issues Program." Between the time of the proposal and the start of the program, however, the water utility serving the District of Columbia, the DC Water and Sewer Authority, had changed their "branding" and is now known as "DC Water." DC Water requested that the name of the UDC program be changed. The revised program title, the "DC Area Water Issues Program," proved to be more inclusive, encouraging greater participation by students, faculty, and residents from Virginia and Maryland, including sponsorship by the Maryland Water Resources Research Institute of one of the weekly program receptions, and participation by a UMD university ambassador. Given that DC's watersheds, including the Potomac and Anacostia Rivers, are shared with Virginia and Maryland, and the residents and employees of the region often cross borders between DC, Virginia, and Maryland, this title change and more inclusive approach to the program was fortuitous.

The pilot weekly seminar program was held during the Fall Semester of 2010, and coincided with the launch of the College of Agriculture, Urban Sustainability, and Environmental Sciences (CAUSES). CAUSES provided essential support for the program, including review of program announcements, certificate of appreciation for invited speakers, volunteers, reception sponsors, and exhibitors. CAUSES is a reorganization of related programs at UDC including:

- Three academic programs: (Department of Architecture and Urban Design; Department of Nutrition and Food Sciences; and Department of Environmental Sciences and Urban Sustainability)
- Four research units: (Agricultural Experiment Station (AES, a land-grant unit); Architecture Research Institute (ARI); Water Resources Research Institute (WRRI); and World's River Institute (WRI)
- Four outreach programs: Family and Consumer Sciences & the Center for Nutrition Diet and Health (CNDH); Environment and Natural Resources & the Institute for Applied Urban Agriculture; 4-H and

the Center for Youth Development; and Community Resources and Economic Development and the Center for Cooperatives)

The Fall 2010 semester also featured the launch of the CAUSES graduate Professional Science Master's Program in Water Resources Management – the first graduate program of its kind offered by a historically black college or university (HBCU). The DCAWIP Principal Investigator, Dr. Tolessa Deksissa, is the director of the PSM in Water Resources Management, and several of his students were volunteers and participants in the weekly programs.

To develop a means of announcing and promoting the program, the DCAWIP Directors (PIs) and interns met with the CAUSES Marketing Specialist, Mary Elliot, who reviewed the meeting announcements. Because of new university requirements regarding contact with the press and use of the university brand, the announcements of the program were limited to weekly emails and flyers. Copies of the emails and flyers distributed for the seminar programs are provided in **Appendix B**.

The seminars were held at UDC each week from 4:00-5:30 pm, followed by a reception from 5:30-6:30 pm. Each of the weekly seminars was designed with a similar structure, including:

- An introduction to CAUSES and the DCAWIP by PI Tolessa Deksissa and Co-PI Cat Shrier, respectively
- Announcements of upcoming water-related events and sponsor recognition
- A speaker program
- A facilitated dialogue with the audience (the "DC Area Water Community")
- A sponsored reception, along with related fairs, exhibits, and other activities

The "Water Peace" was added to the program to provide community members with an opportunity to greet one another at the start of each program, and to support open and civil dialogue.

Copies of the seminar programs for each of the seminars are provided in **Appendix C**. Copies of the special programs for film screening and boat tour are provided in **Appendix D**.

The reception sponsorships and the additional events (including a boat tour, film screening, fairs and art exhibits) are discussed in sections 2.2 and 2.3 of this report, respectively.

DCAWIP participants were asked to sign in to registration at each program, and to complete an evaluation form, shown in **Appendix E**.

The seminar topic included the following:

- The first of the weekly seminar programs was held on August 26, 2010. This initial program was developed as a joint kickoff program for the National Capital Region Flood Risk Assessment Program, in order to announce a memorandum of understanding between UDC, the University of Maryland (UMD), and George Mason University (GMU) to pursue research addressing severe flood risks in the DC area. Presentations were given by researchers from UDC, UMD, and GMU on area flood risks and responses. This program was promoted by UMD and GMU as well as UDC.

- The next 7 programs featured speakers from area stakeholder groups, including several members of the DCWRRI Stakeholder Advisory Board, providing an introduction to DC area water issues, including:
    - Getting to Know DC's Water, Watersheds, and Stakeholders
    - Joe Hoffman, Executive Director, Interstate Commission on the Potomac River Basin

- DC Drinking Water Supply Systems and Treatment
  - Tom Jacobus, General Manager, Washington Aqueduct
    Rich Giani, Director of Water Quality Programs, DC Water
- Regional Cooperation: The Anacostia Watershed Restoration Plan
  - Ted Graham, Director of Environmental Programs, Metropolitan Washington Council of Governments
- DC Department of Environment's Water Pollution Control Approach
  - Hamid Karimi, Deputy Director, DC Department of Environment
- Water in DC's History and Culture
  - Jack Wennersten, Author, Anacostia: Death and Life of an American River
  - Commodore Steve Ricks, Chair, Historic Anacostia Boating Association
- DC's Federal Water "Footprint" and Greening the Federal House
  - John Simpson, GSA Office of Federal High Performance Green Buildings
- Water Energy and Power in DC
  - Ernest Jolly, DC Water, Beverly Perry, PEPCO, and Sheila Hollis, Public Service Commission)

- The next three seminars (Seminar 9, 10, and 11) focused on opportunities for university students, faculty, and staff get involved in water by learning about workforce development and jobs training programs; advocacy and volunteer opportunities; scholarships and grant funding programs. During the weekly reception that followed these programs, opportunities were provided for area programs to provide information and sign up DC area water community members for their programs (the "fairs"). The programs offered during these middle seminars were:

  - Water Workforce Development and Green Jobs in DC -- plus water-related green jobs training program fair (*Annette Gantt, Earth Conservation Corps, John Wasiutynski, DC Department of Environment, and Ron Lord, International Association of Plumbers and Mechanical Officials*)

  - DC Area Water Advocacy Roundtable and Film Screening on Global Water Advocacy (*With Dottie Yunger, Anacostia Riverkeeper, Brent Bolin, Anacostia Watershed Society; Irv Sheffey, Sierra Club, Paul Schwartz, Clean Water Action, plus film screening and dialogue with producer/writer/director Jim Thebaut*)

  - Funding Opportunities for Water Research and Education, plus scholarship and grant funding program fair (*Bill Hare, DCWRRI/USGS, Jim Dobrowolski, USDA National Institute of Food and Agriculture; Greg Lank, USEPA "People, Prosperity, and the Planet (P3)"; and Lindsay Birt, Doctoral Candidate and National Academy of Sciences Science & Policy Fellow*)

- The final three program topics were selected with input from the DC Area Water Community, addressing more advanced topics of interest to the participants, namely:

  - Water, Trees, and Gardens in the DC Area (*Sandy Farber Bandier, Master Gardener Program Coordinator, DC Cooperative Extension; and Marcelo Lopez, Wiles Mensch Corporation, on behalf of Casey Trees)*

  - Wastewater Treatment, Reuse, and Communications in DC Area (*Sudhir Murthy, DC Water, and Laurens van der Tak, CH2M HILL)*

- Community-Based Water Resiliency (*Nushat Thomas, US Environmental Protection Agency Water Security Division)*

The final program also featured a presentation by Drs. Deksissa and Shrier on the DCAWIP program results and initial evaluation, and recognition of the speakers and sponsors.
The possibility was explored for offering the seminar with the option to provide university credit, with additional assignments and learning objectives for students. Administrative requirements and deadlines for fall semester courses made this option infeasible. However, there were several university faculties who required or recommended students to attend the seminars as part of their own courses, as well as continuing education credits provided to program participants, including the Master Gardner program offered through UDC's Cooperative Extension program.

2.3. Receptions and Sponsors

One critical element of the program was the inclusion of sponsored receptions after each seminar. The receptions provided opportunities for the audience to have further discussion with the speaker(s), distribute information on local water events, and build stronger relationships within the community. The original seed grant from USGS did not include funds to support the sponsored receptions, but area stakeholders were invited to provide sponsorship support as in-kind support through purchase and donation of Giant supermarket gift cards.

To ensure maximum value of participation for DC Area Water Issues Program (DCAWIP) sponsors, DCAWIP worked with JMT and EBA consulting firms to develop sponsor packages, which included:

- Company name and logo displayed on DCAWIP handouts for the seminar sponsored, and for the all-semester program (see Appendices B and C)
- An exhibit table to pass out company brochures and give-aways (e.g. pens) during the registration and reception
- Discounted parking passes
- Recognition and an opportunity to address the community during the seminar
- Company name and logo displayed on the auditorium screen

Preparation for the weekly reception began on Monday with an estimated cost of the food, paper goods, and inventory of supplies for the upcoming seminar reception. By Wednesday the order was placed by phone to the deli at Giant, located across the UDC campus on Connecticut Avenue. All food was purchased using the Giant gift cards at the time of pickup on Thursdays afternoon. Because the student intern and volunteers picked up the food and set up the receptions, the costs for each reception were minimized.

Reception sponsors included:

- Johnson, Mirmiran, and Thompson (JMT)
- EBA Engineering
- University of the District of Columbia
- Interstate Potomac River Basin Commission
- Metropolitan Washington Council of Governments
- Maryland Water Resources Research Center
- International Association of Plumbers and Mechanical Officials (twice)
- Watercat Consulting LLC
- CH2M HILL

2.4. Tours, Fairs, and Other Events

The weekly seminars and receptions were supplemented with several events designed to encourage greater appreciation for and understanding of DC area water issues.

One of the additional events was a presentation and boat tour, scheduled on November 11, organized on the Veteran's Day Holiday, which fell on a Thursday, when the seminars were otherwise held. The boat tour was organized through the Anacostia Watershed Society (AWS), led by AWS Executive Director Jim Foster, with a presentation and lunch with the AWS staff.

Other events were organized during or after the weekly seminar receptions, including:

- Exhibits of artwork featuring scenes of the Anacostia River by local artist Bruce McNeil.
- A book signing by author John Wennersten of his book, Anacostia: Death and Life of an American River and display of "essential water books" from the book collection of Adam Shrier
- A film screening and conversation by filmmaker Jim Thebaut, Writer/Executive Producer of the Running Dry Film Series, including a 20-minute preview of his film "Running Dry: Beyond the Brink" on the Australian drought and global security issues related to water, and a 5-minute preview of "Running Dry: South Africa" about urban water education. The special program followed the Water Advocacy seminar and reception.
- Multiple "fairs" were offered with tables provided for organizations on green jobs training programs, scholarship and grant funding applications, and volunteer opportunities with water advocacy organizations and gardening programs.

3. EVALUATION OF PARTICIPATION AND OUTCOMES

3.1. Participation Evaluation and Statistics

Participation in each of the seminars was determined by the registration forms and evaluated. The total attendance for each week and sample demographic data of the participants for week one is shown in Figure 1 and Figure 2, respectively.

Attendance ranged from 30 to 80, including speakers, directors, interns, and sponsor. Figure 2 shows the attendance breakdown of attendees based on the sign-in sheets for each week.

- The highest attendance occurred at Seminar 1, where the kickoff for a MOU between UDC, UMD, and GMU was announced to research regional severe flood risks and protections in the National Capital Region (see Figure 1). . The seminar targeted students, faculty, staff, government agency, non-profit, consultants, and other members of the DC community. The demographics of participants on week one is illustrated in Figure 2. The majority of the attendees were students from universities including UDC, Howard, Catholic, UMD, and GWU. The majority of participants were from UDC.

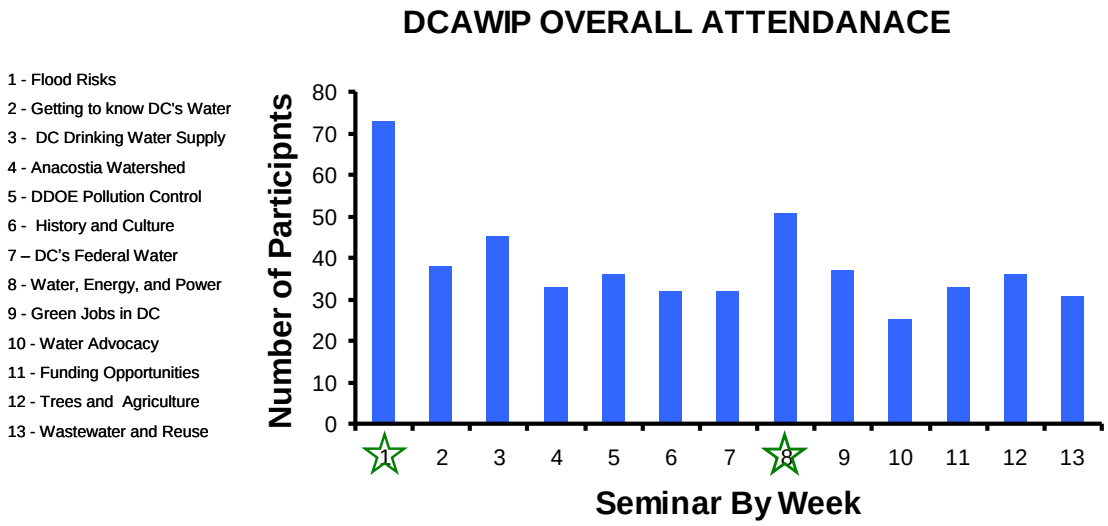


Figure 1. The total attendance for each week: the highest is number was recorded on the 1st (flood risks) and 8th week (DC drinking water supply)

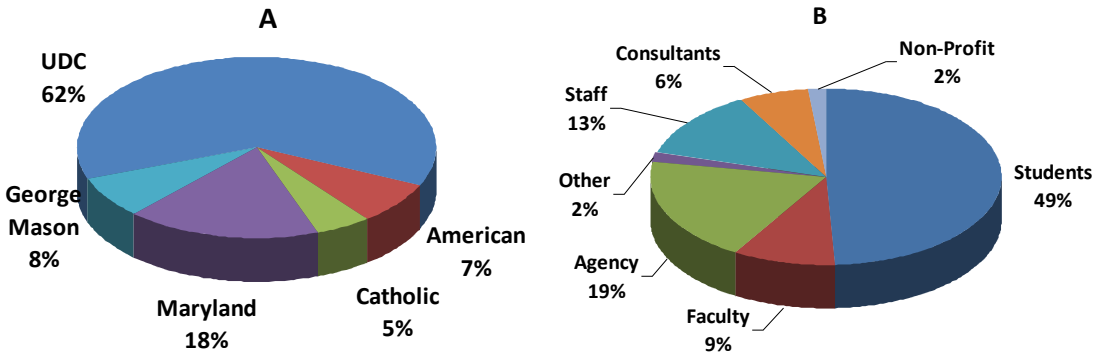


Figure 2. Demographics of participants on the basis of institution (A) and profession (B) on week one

- Seminar 2, Getting to Know DC's Water Resources totaled 39 attendees, a majority of whom were students, with several members of the professional community in attendance, possibly due to outreach to the local chapter of the American Water Resources Association.

- Seminar 3, DC Drinking Water Supply Systems and Treatment attendance improved to 47 attendees and there was a slight increase in both faculty and staff. This seminar also included consulting firm sponsors and outreach to the Chesapeake Section of American Water Works Association. There was a display provided by the sponsors, with "giveaways" (e.g. pens) that attracted additional attendees.

- Seminar 4, Anacostia Watershed Restoration Plan, totaled 34, with a slight increase in staff and faculty, including Dr. Harriet Phelps and others who have been involved in research related to the Anacostia River.

- Seminar 5, Water Pollution Control Approach attendance totaled 36, with a major increase in staff members, tripling the normal weekly attendance. This was the first week that staff out-numbered

student population. We also had increased attendance from government agencies and non-profit organizations.

- Seminar 6, Water in DC's History and Culture attendance totaled 33 members of our water community, and included recreational boaters interested in the Historic Anacostia Boating Association. This program was on a night with major rainfall and some flooding in the streets.

- Seminar 7, Federal Water and Greening the Federal House totaled 33 members of our water community, with peak faculty attendance this week, reaching 8 members. This program was scheduled to coincide with the GreenGov conference of federal agency personnel involved in sustainability efforts at federal facilities. This program was sponsored by the International Association of Plumbing and Mechanical Officials, who subsequently provided a speaker for the Water and Green Jobs Training program.

- Seminar 8, Water, Energy and Power, had the second highest turnout, totaling 51. This program also included discussion from audience members involved in water and energy studies from the Washington Aqueduct and Colorado River Water Conservation District.

- Seminar 9, Water Workforce Development and Green Jobs, was developed to reach out to students as possible to share with them the opportunities available in the DC area to find jobs or volunteer experience. Due to exam week, many of the undergraduate and graduate students typically in attendance were not able to attend this seminar. However, there were several students from jobs training programs hosted at the DC Community College, and more nonprofit community members and professional associations were present. This program also included attendance by EPA staff involved in water workforce development.

- Seminar 10, DC Area Water Advocacy, had 30 people, and also coincided with term papers, so fewer students were able to attend, although there was greater participation from members of water advocacy organizations, including the Anacostia Watershed Society, which led the subsequent Boat Tour and has developed a Watershed Steward Training Program with UDC.

- Seminar 11, Funding Opportunities for Water Research and Education, had 34 participants and speakers, despite the need to change rooms due to a leak in the ceiling, on a night with major flooding in the streets.

- Seminar 12, Water, Trees, and Gardens in the DC Area, including displays from the UDC Cooperative Extensive gardening and ethnic food programs, and attendance by several consultants and federal agency personnel.

- Seminar 13, Wastewater Treatment, Reuse, and Communications in the DC Area, included 37 attendees, including several students who were able to talk with the Director of Wastewater Research for DC Water regarding potential research opportunities.

- Seminar 14, Community-Based Water Resiliency, with 34 attendees, also included a ceremony in which interns, speakers, volunteers, and sponsors were recognized with gift bags.

3.2. Program Evaluations

Evaluations forms were developed initially to support potential for the seminars to be offered for academic credit. Participants were asked to complete forms each week addressing questions including the following:

- Did the seminar meet your learning expectations?
- Was this seminar taught at the appropriate level?
- Did this seminar provide you with new information?
- Will you be able to apply what was learned in your daily practices?

The value of the evaluation forms for all seminars are almost similar and the overall satisfaction of the seminar was rated good and the results for seminar 8 and 9 are shown in Figure 3.

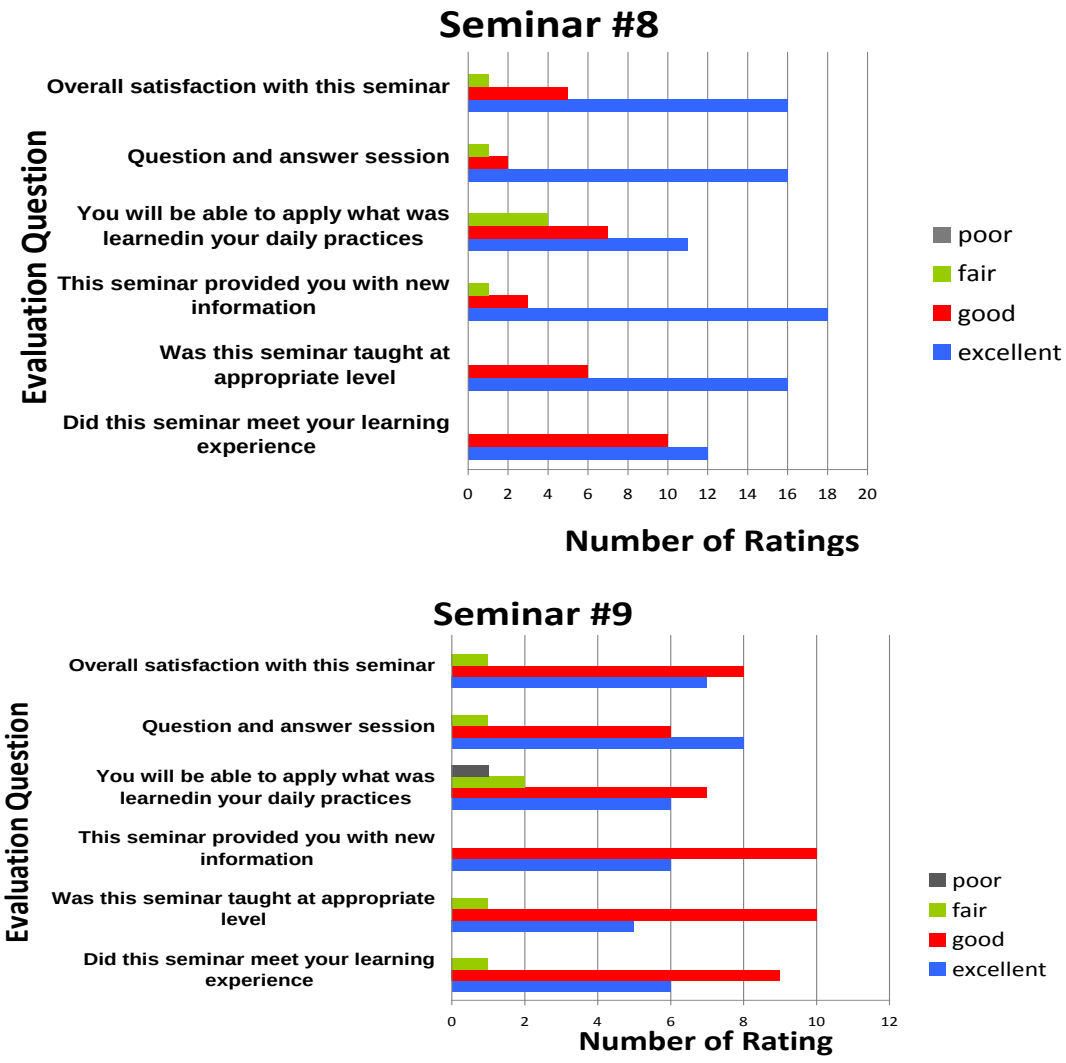


Figure 3. Results of post seminar evaluation for seminar 8 (Water, Energy and Power) and 9 (Water Workforce Development and Green Jobs)

3.3. Additional Outcomes

A formal post-seminar survey was not conducted due to time constraints. However, program participants were asked to notify the PI and Co-PI of any outcomes related to the program. Outcomes identified included:

- Identification of funding opportunities for research identified during DCAWIP programs, including funding for the National Capital Region Flood Risk Assessment Program.
- Submittal of DCWRRI grant proposals based upon information received during DCAWIP programs, including the Metropolitan Washington Public Officials Water Leadership Program.
- Enrollment of new students in the UDC graduate degree programs based upon information received during DCAWIP programs.
- Development of a joint Watershed Steward Certification program between UDC and the Anacostia Watershed Society.

3.4. Publications

An extended abstract of the DCAWIP is accepted for both oral and poster presentations at the 2011 Universities Council on Water Resources Annual Conference. The extended abstract will be published in the conference proceedings. Another article is also accepted to be published in a streamline publication of the American Water Works Association.

4. CONCLUSIONS AND RECOMMENDATIONS

The DC Area Water Issues Program (DCAWIP) demonstrated a strong interest by students, faculty, staff, and area stakeholders to come together on a regular basis to learn more about area issues and programs, and to develop opportunities for greater student and other university involvement in the larger community of water professionals. The program consistently had at least 30 attendees, with 2 programs with attendance of more than 50.

There was consistent support for reception sponsorships, which was not part of the original proposal budget. The inclusion of food was found to be important both in attracting attendance and in providing opportunities for participants to continue discussion and generate new opportunities for collaboration and understanding. The program created opportunities for collaboration between students, faculty, and staff with area water providers and other water stakeholders, such as the Anacostia Watershed Society, Metropolitan Washington Council of Governments, DC Department of the Environment, DC Water, and Washington Aqueduct.

There were some concerns regarding the timeframe, although the time was selected to accommodate the evening classes of most of the UDC students, and to be late enough in the day for area professionals to leave work early to attend the seminars. Including the boat tour during the university Veteran's Day holiday was also considered a good opportunity for students and others to gain a firsthand experience with the Anacostia River, which was featured in many of the seminar discussions.

Conference abstracts have been submitted for posters at the American Water Works Association and Universities Council on Water Resources conferences in 2011, although notice has not yet been provided regarding their acceptance.

There has been interest in the potential offering of a similar program on a for-credit basis, although additional administrative considerations would need to be addressed. There was also interest in less frequent gatherings when UDC can involve members of the DC area water community to the campus along with high level speakers. Any continuation of the program or program components would require additional funding to be secured.

DC Water Issues Program
Summer/Fall Paid Internship Available
Applications Due July 19, 2010

Watercat Consulting is now accepting applications for a student intern to support development of the DC Water Resources Research Institute's *DC Water Issues Program*.

Through development of the DC Water Issues Program, the student intern will build communication networks among universities, departments, stakeholder organizations, and others in the DC professional community, supporting the development of a more cohesive water research community. The student selected for the internship will gain experience and connections within the DC water community, as well as skills in program development and meeting organization, which are essential for current, more collaborative approaches to water planning and policy development.

ABOUT THE PROGRAM

The DC Water Issues Program will be developed through the DC Water Resources Research Institute at the University of the District of Columbia (DC's Land Grant University), with funding from the US Geological Survey. This program is designed to create a more cohesive water research community in the District of Columbia. The program will include:

- a DC Water Issues Speaker Series, to provide an overview on DC Water Issues from representatives of area agencies and other water interests (stakeholders)
- a water faculty professional development brownbag lunch series
- tours of DC water features and facilities
- planning for a semiannual DC universities water research symposium

ABOUT THE INTERNSHIP

The intern will work with the DC Water Resources Research Institute at UDC Van Ness and at Watercat Consulting on Capitol Hill. Interns must commit to a minimum of 20 hours/week for the first 3 weeks of August and a minimum of 10 hours/week during the fall semester (August 25-December 17, 2010). Interns will be compensated $10/hour. Support tasks will include:

- Developing promotional materials such as flyers, pamphlets, articles, and press releases
- Developing and maintaining a contacts database of D.C.'s water leaders
- Attending DC Water Issues events, taking notes on presentations and preparing summaries
- Administrative support including phones and emails

The student intern will be working in an office environment requiring self-direction and the ability to adjust quickly to new developments. Preference given to applicants with prior office experience. Other qualifications include:

- Excellent research, writing, communication, and organizational skills.
- Comfort using Windows and the Microsoft Office.
- Ability to troubleshoot computer/network issues preferred.

ELIGIBILITY

Eligible applicants will be students at DC area universities, with first preference given to students from the University of the District of Columbia. Students from other universities within the DC Universities Consortium (American, Catholic, Georgetown, George Washington, Howard) are also encouraged to apply. Students can be in any major (science/engineering, social sciences, humanities) but should demonstrate a strong interest in water issues and policy.

APPLICATION

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

Applications must be received by email (cat@watercatconsulting.com)
no later than MONDAY, JULY 19, 2010

1209 E Street SE, Washington, DC 20003 (202) 344-7894
www.watercatconsulting.com cat@watercatconsulting.com

APPENDIX B: PROGRAM FLYERS AND ANNOUNCEMENTS

UNIVERSITY OF THE DISTRICT OF COLUMBIA 1851
College of Agriculture, Urban Sustainability, and Environmental Sciences

DC Area
Water Issues Program

DC Area Water Issues Program (DCAWIP) Fall 2010 Weekly Seminar
Thursdays, 4:00-5:30 PM (Sponsored Refreshments 5:30-6:30)
UDC's Van Ness Campus, 4200 Connecticut Ave., NW, Building 41

DC Area Water Issues Program (DCAWIP) -- a feature of UDC's College of Agriculture, Urban Sustainability and Environmental Sciences -- is a comprehensive set of university events open to all students, faculty, and area stakeholders who are interested in water. Funded by the US Geological Survey (USGS) through a DC Water Resources Research Institute (DCWRRI), this Program is being developed with the goal of creating a more cohesive water research community in the DC area. DCAWIP is a multi-disciplinary program, exploring science and engineering, policy, and socioeconomic aspects of DC area water and watersheds. Every Thursday, at the DCAWIP Fall 2010 Weekly Seminar, speakers from water "stakeholder" organizations provide insightful, practical information about their efforts to address local water issues. Students, scholars, professionals, community leaders and others interested in water issues in the District are encouraged to attend the seminar and stay for refreshments and announcements of community building activities.

Upcoming DCAWIP Seminars for August/September	**SEMINAR ONE: DC Regional Severe Flood Risks and Protections** Thursday, August 26, 2010, 4:00-5:30 + Community Building Reception 5:30-6:30 ***Gerry Galloway and National Capital Region Flood Risk Assessment Program Team*** ***Reception sponsored by UDC***
PROGRAMS CONTINUE THROUGH DECEMBER 16	**SEMINAR TWO: Getting to Know DC's Water, Watersheds, and Stakeholders** Thursday , September 2, 2010, 4:00-5:30 + Community Building Reception 5:30-6:30 ***Joe Hoffman, Executive Director, Interstate Commission on the Potomac River Basin*** ***Reception sponsored by Interstate Commission on the Potomac River Basin***
	SEMINAR THREE: DC Drinking Water Supply Systems and Treatment Thursday, September 9, 2010, 4:00-5:30 + Community Building Reception 5:30-6:30 ***Patty Gamby, Deputy General Manager, Washington Aqueduct*** ***Rich Giani, Water Quality Manager, DC Water*** ***(formerly known as DC Water and Sanitation Authority or "DCWASA")*** ***Reception sponsors: JMT and EBA Engineering***
	SEMINAR FOUR: Regional Cooperation: the Anacostia Watershed Restoration Plan Thursday, September 16, 2010, 4:00-5:30 + Community Building Reception 5:30-6:30 ***Ted Graham, Director Env. Programs, Metropolitan Wash. Council of Governments*** ***Reception sponsor to be determined***
	SEMINAR FIVE: DC Department of Environment's Water Pollution Control Approach Thursday, September 23, 2010, 4:00-5:30 + Community Building Reception 5:30-6:30 ***Hamid Karimi, Deputy Director, DC Department of Environment*** ***Reception sponsor to be determined***
	SEMINAR SIX: DC's Waters in History and Culture Thursday, September 30, 2010, 4:00-5:30 + Community Building Reception 5:30-6:30 ***Dr. Jack Wennersten, Author of "Anacostia: Death and Life of an American River" and "Chesapeake: An Environmental Biography"*** ***Reception sponsor to be determined – WITH BOOK SIGNING***

For more information, please contact Dr. Tolessa Deksissa at tdeksissa@udc.edu / 202-274-5273
or Dr. Cat Shrier at cat@watercatconsulting.com / 202-344-7894

Rev. 903/10

UNIVERSITY OF THE DISTRICT OF COLUMBIA 1851
College of Agriculture, Urban Sustainability, and Environmental Sciences

DC Area Water Issues Program

DC Area Water Issues Program (DCAWIP)
Fall 2010 Weekly Seminar Programs
Thursdays, 4:00-5:30 PM Plus Sponsored Reception 5:30-6:30
UDC's Van Ness Campus, 4200 Connecticut Ave., NW, Building 41, Room A-03

DC Area Water Issues Program (DCAWIP), offered by UDC's College of Agriculture, Urban Sustainability and Environmental Sciences (CAUSES, is a comprehensive set of university events open to all DC Area students, faculty, water managers, and members of the general public who are interested in water. Funded by the US Geological Survey (USGS) through DC Water Resources Research Institute (DCWRRI), this Program was developed with ***the goal of creating a more cohesive water research community in the DC area.*** *Every Thursday, speakers from water "stakeholder" organizations provide insightful, practical information about local water issues and their role in the water community, followed by a reception. For more information, contact Dr. Tolessa Deksissa, CAUSES/UDC, at 202-274-5273 or tdeksissa@udc.edu or Dr. Cat Shrier at 202-344-7894 or cat@watercatconsulting.com*

August 26	**DC Regional Severe Flood Risks and Protections** Gerry Galloway and National Capital Region Flood Risk Assessment Program Team
Sept. 2	**Getting to Know DC's Water, Watersheds, and Stakeholders** Joe Hoffman, Interstate Commission on the Potomac River Basin
Sept. 9	**DC Drinking Water Supply Systems and Treatment** Tom Jacobus, Washington Aqueduct and Rich Giani, DC Water
Sept 16	**Regional Cooperation: The Anacostia Watershed Restoration Plan** Ted Graham, Metropolitan Washington Council of Governments (MWCOG)
Sept 23	**DC Department of Environment's Water Pollution Control Approach** Hamid Karimi, Deputy Director DC Department of Environment
Sept. 30	**Water in DC's History and Culture** Jack Wennersten, Author, Anacostia: Death and Life of an American River Commodore Steve Ricks, Chair, Historic Anacostia Boating Association
Oct. 7	**DC's Federal Water "Footprint" and Greening the Federal House** John Simpson, GSA Office of Federal High Performance Green Buildings
Oct 14	**Water Energy and Power in DC** Ernest Jolly, DC Water, Beverly Perry, PEPCO, and Sheila Hollis, Public Service Commission
Oct.21	**Water Workforce Development and Green Jobs in DC (PLUS GREEN JOBS TRAINING FAIR** Annette Gantt, Earth Conservation Corps, John Wasiutynski, DC Department of Environment and Ron Lord, International Association of Plumbers and Mechanical Officials (IAPMO)
Oct.28	**DC Area Water Advocacy Roundtable and Film Screening on Global Water Advocacy** With Dottie Yunger, Anacostia Riverkeeper, Brent Bolin, Anacostia Watershed Society Irv Sheffey, Sierra Club, Paul Schwartz, Clean Water Action **BONUS PROGRAM: RUNNING DRY: BEYOND THE BRINK FILM SCREENING** **AND CONVERSATION WITH PRODUCER/WRITER/DIRECTOR JIM THEBAUT**
Nov 4	**Funding Opportunities for Water Research and Education (PLUS FUNDING FAIR)** Bill Hare, DCWRRI/USGS, Jim Dobrowolski, USDA National Institute of Food and Agriculture Greg Lank, USEPA "People, Prosperity, and the Planet (P3)" Student Competition; Lindsay Birt, Doctoral Candidate/NAS Science & Policy Fellow

***** HOLIDAY NOVEMBER 11 (VETERAN'S DAY) *** ANACOSTIA WATERSHED SOCIETY BOAT TOUR *****

Nov 18	**Water, Trees, and Gardens in the DC Area (PLUS GARDEN PROGRAMS FAIR AND FOOD DRIVE)** *Sandy Farber Bandier, Master Gardener Program Coordinator, DC Cooperative Extension* *Mark Busciano, Executive Director, Casey Trees* *Marcelo Lopez, Wiley Mensch*

***** HOLIDAY NOVEMBER 24 (THANKSGIVING) – NO CLASS – ENJOY THE HOLIDAY! *****

Dec 2	**Wastewater Treatment, Reuse, and Communications in DC Area (PLUS ASSOCIATION FAIR)** *Sudhir Murthy, DC Water* *Laurens van der Tak, CH2M HILL*
Dec 9	**Community-Based Water Resiliency PLUS DCAWIP PROGRAM SUMMARY REPORT** *Nushat Thomas, US Environmental Protection Agency* *DCAWIP Directors Tolessa Deksissa and Cat Shrier* ***ALL PAST SPEAKERS, SPONSORS, AND EXHIBITORS INVITED TO RETURN FOR RECOGNITION***

THANK YOU TO OUR SPONSORS
* The University of the District of Columbia
* Interstate Potomac River Basin Commission
* EBA Engineering
* JMT
* Metropolitan Washington Council of Governments
* Maryland Water Resources Research Center
* International Association of Plumbers and Mechanical Officials
* Watercat Consulting LLC
* CH2M HILL

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

DC Area
Water Issues Program

SEMINAR NINE: Water Workforce Development and Green Jobs in DC

Annette Gantt, President, Earth Conservation Corps
John Wasiutynski, DC Department of Environment
Ron Lord, International Association of Plumbers & Mechanical Officials (IAPMO)

UDC-Van Ness, Building #41, Room A-03
4200 Connecticut Avenue NW, Washington DC
Thursday, October 21, 2010, 4:00-5:30 pm
Refreshments with Green Jobs Training Fair to Follow

For more information please contact Dr. Tolessa Deksissa at tdeksissa@udc.edu or 202-274-5273 or Dr. Cat Shrier at cat@watercatconsulting.com or 202-344-7894.

University of the District of Columbia 1851

College of Agriculture, Urban Sustainability, and Environmental Sciences

DC Area Water Issues Program

DC Area Water Issues Program
Directions to Seminar Location
University of the District of Columbia
Building #41, Room A-03

Directions By Metro Rail:

Take the Red line to **Van Ness-UDC** station

- As you exit Metro walk South on Connecticut Ave towards Van Ness St.
- Enter **building 39** on your right
- Immediately go up the escalator to **level A**
- Exit through the automatic door and walk directly across campus to **building 41**
- Enter through the glass doors on your left hand side of the building, class room will be on your right

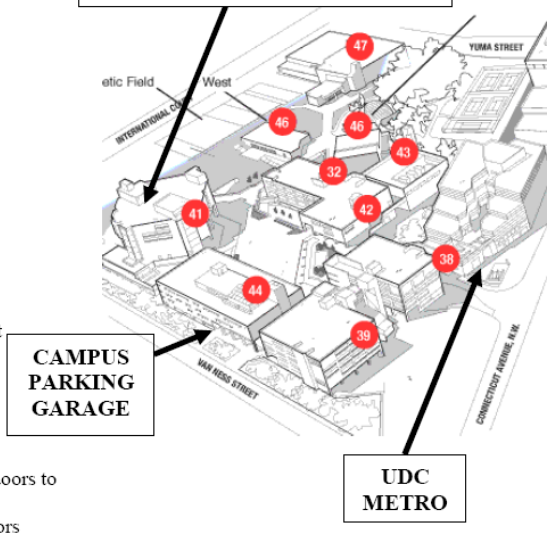
Directions By Car:

From Maryland (4.6 miles)
Take I-495 Exit 33 MD-185 Connecticut Ave
Towards Chevy Chase continue around roundabout & take 4th exit.
Continue on Connecticut Ave then turn right on Van Ness St.

From Virginia (3.9 miles)
Take I-295 North towards DC take 14th St bridge turn left on I St then turn right on Connecticut Ave continue on Connecticut Ave then turn on Van Ness St

Parking is available at the University's main garage located at the corner of Connecticut Ave. & Van Ness St.
*******NO meter parking available during rush hour (4-6:30)*****

- **From 2nd level garage**, follow signs that say university auditorium to exit garage
- Take the steps all the way to the top
- **Building 41** will be directly in front when looking forward
- **From 3rd level garage**, Exit through the red doors that say building 41
- Take the **elevator to level A**
- Veer left and pass through the red doors and also through the next set of doors to exit back outside
- Walk straight across approximately 25 steps till your reach the 4 glass doors



Directions By Metro Bus:

The following bus routes go to UDC:

H2- Crosstown Line
L1/L2/L4 – Connecticut Ave Lines

University of the District of Columbia Address:
4200 Connecticut Avenue NW
Washington, DC 20008

AFTER AUGUST 27, 2010 GARAGE PARKING ON VAN NESS ST WILL BE $8 PER DAY FOR VISITORS

PLEASE JOIN US FOR:
DCAWIP SEMINAR SIX: Water in DC's History and Culture

Jack Wennersten, Historian and Author

Location: UDC-Van Ness, Building #41, Room A-03, 4200 Connecticut Avenue NW, Washington DC (Van Ness Metro)

Date and Time: Thursday, September 30, 2010, 4:00-5:30 pm (5:30-6:30 refreshments, sponsor(s) needed

Program Description:
Located in Washington, D.C., the Anacostia River is a poster child for America's tragically neglected, abused urban waterways. There are compelling ethical grounds for remedying this river's environmental problems, for the Anacostia in our time demonstrates that environmental burdens like pollution and resource depletion are not shared equally. John R. Wennersten, author of Anacostia: Death and Life of an American River; The Chesapeake: An Environmental Biography; and the Oyster Wars of Chesapeake Bay, is an accomplished historian with a strong interest in environmental studies. Dr. Wennersten will be joined by Steve Ricks, Chair of the Historic Anacostia Boating Association & Commodore of the Washington Yacht Club. Followed by a book signing, this week's program explores the power of history and literature in DC Area Water Issues, recognizing that "if we can re-story our rivers, we can restore our rivers."

The Weekly Seminar is one of several DCAWIP activities during the Fall 2010 semester. Every Thursday, speakers from water "stakeholder" organizations
will provide insightful, practical information about local water issues and their role in the water community. Seminars take place Thursdays, 4:00 PM - 5:30 PM, at UDC's Van Ness campus (4200 Connecticut Ave., N.W., near the UDC/Van Ness Metro Station), with refreshments and community building to follow, sponsored by area businesses and water stakeholder organizations. Please notify your students, staff, and colleagues of the upcoming events, including this week's program, by forwarding this email and by posting the attached flyers. Additional program information will follow. For more information regarding the DC Area Water Issues Program, and for sponsorship opportunities, please contact Dr. Tolessa Deksissa at <mailto:tdeksissa@udc.edu> tdeksissa@udc.edu or 202-274-5273 or Dr. Cat Shrier at <mailto:cat@watercatconsulting.com> cat@watercatconsulting.com or 202-344-7894.

PLEASE JOIN US THIS THURSDAY AND EVERY THURSDAY FOR THE DCAWIP WEEKLY SEMINARS AND WATER COMMUNITY BUILDING RECEPTION AT UDC. PLEASE ARRIVE EARLY - WE START PROMPTLY AT 4 PM!

TOLESSA AND CAT

APPENDIX C: WEEKLY PROGRAM HANDOUTS

College of Agriculture, Urban Sustainability, and Environmental Sciences

DC Area Water Issues Program

DC Area Water Issues Program (DCAWIP)
Fall 2010 Weekly Seminar

DC Area Water Issues Program (DCAWIP) – offered by UDC's College of Agriculture, Urban Sustainability and Environmental Sciences (CAUSES) -- is a comprehensive set of university events open to all DC Area students, faculty, water managers, and members of the general public who are interested in water. DCAWIP is a multi-disciplinary program, exploring issues related t the science and engineering, policy, and socioeconomic aspects of water and watersheds in the DC area. Funded by the US Geological Survey (USGS) through a DC Water Resources Research Institute (DCWRRI seed grant), this Program is being developed with the goal of creating a more cohesive water research community in the DC area.

The Weekly Seminar is one of several activities being hosted by the DCAWIP during the Fall 2010 semester. Every Thursday, speakers from water "stakeholder" organizations will provide insightful, practical information about their efforts to address local water issues. Seminars will take place Thursdays, 4:00 PM – 5:30 PM, at UDC's Van Ness campus (4200 Connecticut Ave. N.W., near the UDC/Van Ness Metro Station), with refreshments to follow.

SEMINAR ONE: Dangerous Future: The Significant Flood Threat to Downtown Washington, DC and the Washington Metropolitan Area

Location: UDC-Van Ness, Building #41, Room A-03, 4200 Connecticut Avenue NW, Washington DC,
Date and Time: Thursday, August 26, 2010, 4:00-5:30 pm (refreshments to follow)

Recent weather has shown the impacts of heavy rains on our roads and power lines, while the 5-year anniversary of Hurricane Katrina have reminded us how a city can be devastated by severe weather. A panel of flood risk experts from UMD, GMU, and UDC will provide presentations on present and future flood challenges.

4:00 PM–4:20 PM	**Introduction to the DC Area Water Issues Program and UDC Welcome** • Cat Shrier and Tolessa Deksissa, DC Area Water Issues Program • Dean Gloria Wyche-Moore, UDC College of Agriculture, Urban Sustainability, and Environmental Sciences (CAUSES) and Dean Beverly Hartline, UDC Research
4:20 PM–5:10 PM	**Regional Flood Challenges and Response** • **Introduction to the NCR FRAP Team** William Hare, University of the District of Columbia/DCWRRI • **The Flood Threat to the Federal Triangle and Downtown Washington 12 feet of water on Constitution Avenue?** Gerald Galloway, University of Maryland • **The Challenges to Northern Virginia, Reagan National Airport and Potomac Crossings** Mark Houck, George Mason University • **Flood Challenges in the Anacostia Basin, Prince George's and Montgomery Counties** Richard McCuen, University of Maryland • **Regional Flood Risk Program Methodology and Conduct** Gregory Baecher, University of Maryland
5:10 PM–5:30 PM	**Questions and Discussion**
5:30 PM-6:30 PM	**Refreshments and Discussion with Speakers, Students and Attendees**

For more information regarding the DC Area Water Issues Program, please contact Dr. Tolessa Deksissa at tdeksissa@udc.edu or 202-274-5273 or Cat Shrier at cat@watercatconsulting.com or 202-344-7894.

University of the District of Columbia 1851

College of Agriculture, Urban Sustainability, and Environmental Sciences

DC Area Water Issues Program

DC Area Water Issues Program (DCAWIP)
Fall 2010 Weekly Seminar

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SEMINAR TWO: Getting to Know DC Area Water Resources

Location: UDC-Van Ness, Building #41, Room A-03, 4200 Connecticut Avenue NW, Washington DC
Date and Time: Thursday, September 2, 2010, 4:00-5:30 pm (refreshments to follow)

*Called "the Nation's River," the Potomac River Basin includes portions of Maryland, Pennsylvania, Virginia, West Virginia, and the District of Columbia, and provides water supply and recreation for more than six million basin residents. The Interstate Commission on the Potomac River Basin ("ICPRB") provides regional cooperation and partnerships among the basin states and federal government to enhance, protect, and conserve the water and associated land resources. Joe Hoffman, ICPRB's Executive Director since 1998, will talk with us about where we were, where we are, and where we're going with our water supply and water quality, recognizing that "****basin water issues are DC Area water issues****."*

4:00 PM–4:20 PM	**Introduction to the DC Area Water Issues Program and UDC Welcome** • Tolessa Deksissa and Cat Shrier, DC Area Water Issues Program Directors • Recognition of Distinguished Visitors • "The Water Peace" – greet your neighbors in the water community
4:20 PM–5:00 PM	**Getting to Know DC Area Water Resources** • Introduction of our Speaker Tolessa Deksissa, DC Area Water Issues Program Director • Joe Hoffman, Executive Director Interstate Commission on the Potomac River Basin
5:00 PM–5:20 PM	• **Questions and Dialogue with the Water Community** Cat Shrier, DC Area Water Issues Program Director, Facilitator
5:20 PM-6:30 PM	**Refreshments and Community Building (reception sponsored by ICPRB)**

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UNIVERSITY OF THE DISTRICT OF COLUMBIA 1851

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SEMINAR THREE: DC's Drinking Water Supply Systems and Treatment
Patty Gamby, Deputy General Manager, Washington Aqueduct
Rich Giani, Water Quality Manager, DC Water

Location: UDC-Van Ness, Building #41, Room A-03, 4200 Connecticut Avenue NW, Washington DC
Date and Time: Thursday, September 9, 2010, 4:00-5:30 pm (refreshments to follow)

DC's drinking water is supplied by the Washington Aqueduct and DC Water (formerly known as DCWASA, the DC Water and Sewer Authority). As the "wholesale" water provider, Washington Aqueduct collects water from the Potomac River, treats the water, and delivers it to "retailers" including DC Water. DC Water then distributes the water to homes and businesses, monitoring the water as it moves through the system to ensure public health. Both Washington Aqueduct and DC Water work to protect the people who live and work in DC from drinking water contaminants, such as lead, copper, coliforms, and chemicals that form after disinfection (called "disinfection byproducts). Patty Gamby, Deputy General Manager of Washington Aqueduct, and Rich Giani, Water Quality Manager for DC Water, will provide an overview of where our drinking water comes from, how it gets to our homes and businesses, and how it is treated to protect our health and environment.

4:00 PM–4:20 PM	**Introduction to the DC Area Water Issues Program, Recognition of Distinguished Visitors, and "The Water Peace" (greet your neighbors)** • Tolessa Deksissa and Cat Shrier, DC Area Water Issues Program Directors
4:20 PM–5:00 PM	**DC's Drinking Water Supply Systems and Treatment** • Patty Gamby, Deputy General Manager Washington Aqueduct • Rich Giani, Water Quality Manager DC Water (formerly known as DCWASA)
5:00 PM–5:20 PM	**Questions and Dialogue with the Water Community** • Cat Shrier, DC Area Water Issues Program Co-Director and Facilitator
5:20 PM-6:30 PM	**Refreshments and Community Building (Sponsored by JMT and EBA Engineering)**

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College of Agriculture, Urban Sustainability, and Environmental Sciences

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SEMINAR FOUR: Regional Coordination and the Anacostia Watershed Restoration Plan
Ted Graham, Director, Department of Environmental Programs
Metropolitan Washington Council of Governments

Location: UDC-Van Ness, Building #41, Room A-03, 4200 Connecticut Avenue NW, Washington DC
Date and Time: Thursday, September 16, 2010, 4:00-5:30 pm

Over the course of more than 200 years, the Anacostia River has been abused and neglected, afflicted by extensive environmental problems throughout the entire watershed, which comprises 176 square miles in DC and Maryland's Montgomery and Prince George's Counties. "The Forgotten River" and its tributaries suffer from poorly controlled and polluted runoff, resulting in erosion, degraded habitat, toxic sediment and flooding. However, the Anacostia River and its tributaries also provide abundant natural beauty, essential wildlife habitat and many recreational amenities and excellent opportunities. The Anacostia Watershed Restoration Plan is an unprecedented regional, multijurisdictional initiative to indentify thousands of projects systematically to retrofit an entire urban watershed. Ted Graham, Director of Environmental Programs for the Metropolitan Washington Council of Governments, provides his insights on how local, state and federal governments and volunteer organizations came together and formed the Anacostia Watershed Restoration Partnership to coordinate the restoration of the watershed, focusing on managing stormwater and controlling combined sewer overflows, trash, and toxics, while working to restore aquatic and terrestrial habitats.

4:00 PM–4:20 PM	**Overview of the DC Area Water Issues Program, Recognition of Distinguished Visitors, and "The Water Peace" (greet your neighbors in the DC Water Community)** • Tolessa Deksissa and Cat Shrier, DC Area Water Issues Program Directors
4:20 PM–5:00 PM	**Metropolitan Washington Coordination on Stormwater** • Ted Graham, Ph.D., P.E., Director, Department of Environmental Programs Metropolitan Washington Council of Governments
5:00 PM–5:20 PM	**Questions and Dialogue with the Water Community**
5:20 PM-6:30 PM	**Refreshments and Community Building (reception sponsored by Metropolitan Washington Council of Governments**

Metropolitan Washington Council of Governments

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SEMINAR FIVE: Getting to Know the DC Department of the Environment

Location: UDC-Van Ness, Building #41, Room A-03, 4200 Connecticut Avenue NW, Washington DC

Date and Time: Thursday, September 23, 2010, 4:00-5:30 pm (refreshments to follow)

Because Washington, DC, is a totally urban area, the water pollution issues are unique from those of its surrounding jurisdictions. To address water pollution control, DC employs a multifaceted approach that uses regulations, incentives, and outreach and education to accomplish our protection goals. Created in 2006, the District Department of the Environment (DDOE) is responsible for DC's natural and indoor environments. As DDOE's Deputy Director, Dr. Hamid Karimi brings more than 25 years experience and leadership to this discussion of how DDOE facilitates cleaner air and water, greens our neighborhoods and building space, and assists with the management of hazardous and toxic wastes.

4:00 PM–4:20 PM	**Introduction to the DC Area Water Issues Program, Recognition of Distinguished Visitors, and "The Water Peace" (greet your neighbors)** • Tolessa Deksissa and Cat Shrier, DC Area Water Issues Program Directors
4:20 PM–5:00 PM	**Getting to Know the DC Department of the Environment** • **Hamid Karimi, Ph.D., Deputy Director** **District Department of the Environment**
5:00 PM–5:20 PM	**Questions and Dialogue with the Water Community**
5:20 PM-6:30 PM	**Refreshments and Community Building (Sponsored by UDC)**

UNIVERSITY OF THE DISTRICT OF COLUMBIA 1851

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University of the District of Columbia 1851

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DC Area Water Issues Program

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SEMINAR SIX: DC Area Waters in History and Culture

Dr. John Wennersten, Historian and Author

Steve Ricks, Chairman of the "Historic Anacostia Boating Association" & Commodore of the Washington Yacht Club

Location: UDC-Van Ness, Building #41, Room A-03, 4200 Connecticut Avenue NW, Washington DC

Date and Time: Thursday, September 30, 2010, 4:00-5:30 pm

5:30-6:30 Refreshments Sponsored by **Maryland Water Resources Research Center**

Located in Washington, D. C., the Anacostia River is a poster child for America's tragically neglected, abused urban waterways. There are compelling ethical grounds for remedying this river's environmental problems, for the Anacostia in our time demonstrates that environmental burdens like pollution and resource depletion are not shared equally. John R. Wennersten, author of Anacostia: Death and Life of an American River; The Chesapeake: An Environmental Biography; and the Oyster Wars of Chesapeake Bay, is an accomplished historian with a strong interest in environmental studies. ***Dr. Wennersten will be joined by Steve Ricks, Chair of the Historic Anacostia Boating Association & Commodore of the Washington Yacht Club.*** *Followed by a book signing, this week's program explores the power of history and literature in DC Area Water Issues, recognizing that* ***"if we can re-story our rivers, we can restore our rivers."***

4:00 PM–4:20 PM	**Introduction to the DC Area Water Issues Program, Recognition of Distinguished Visitors, and "The Water Peace" (greet your neighbors)** • Tolessa Deksissa and Cat Shrier, DC Area Water Issues Program Directors
4:20 PM–5:00 PM	**DC's Waters in History and Culture** • Dr. John Wennersten, Historian and Author "Anacostia: Death and Life of a River" & "Chesapeake: An Environmental Biography" • Steve Ricks, Chair of the Historic Anacostia Boating Association & Commodore of the Washington Yacht Club
5:00 PM–5:20 PM	**Questions and Dialogue with the Water Community**
5:20 PM-6:30 PM	**Refreshments and Community Building (reception sponsored by Maryland Water Resources Research Center)** BOOK SIGNING AND LIBRARY EXHIBIT ON AVAILABLE "WATER BOOKS"

MARYLAND Water Resources Research Center

For more information regarding the DC Area Water Issues Program, please contact Dr. Tolessa Deksissa at tdeksissa@udc.edu or 202-274-5273 or Dr. Cat Shrier at cat@watercatconsulting.com or 202-344-7894.

College of Agriculture, Urban Sustainability, and Environmental Sciences

DC Area Water Issues Program

DC Area Water Issues Program (DCAWIP)
Fall 2010 Weekly Seminar

SEMINAR SEVEN: DC's Federal Family and the Greening of the Federal House
John Simpson, GSA Office of Federal High Performance Green Buildings
UDC-Van Ness, Building #41, Room A-03, 4200 Connecticut Avenue NW, Washington DC
Thursday, October 7, 2010, 4:00-5:30 pm
5:30-6:30 Refreshments (Sponsor: **International Association of Plumbing & Mechanical Officials (IAPMO)**)

The "Federal Footprint" and "Federal Family" are significant in DC both as a major employer and user of water and related resources (more than 30% of the land area and 27% of jobs in Washington, DC), and in terms of individual federal employees who are DC Area residents and a major part of the DC Area Water Community. Obama's 2009 Executive Order 13514 on Federal Leadership in Environmental, Energy and Economic Performance tasked agencies to develop, implement and annually update a plan that prioritizes sustainability actions based on a positive return on investment for the American taxpayer. On September 9, 2010, 56 federal agencies filed their first Strategic Sustainability Performance Plans (SSPPs) (available at www.greengov.gov), and the first White House GreenGov Symposium will be held October 5-7 at GWU. The US General Services Administration's Office of Federal High Performance Green Buildings (GSA OFHPGB) provides technical support and demonstration projects for federal agencies. GSA OFHPGB's John Simpson, PE, LEED AP, will provide an overview on "Greening the Federal House" – particularly with respect to water -- and the federal water footprint in DC. Personnel from other federal agencies will be provided with an opportunity to share their perspectives.

4:00 PM–4:20 PM	**Introduction to the DC Area Water Issues Program, Recognition of Distinguished Visitors, and "The Water Peace" (greet your neighbors)** • Tolessa Deksissa and Cat Shrier, DC Area Water Issues Program Directors
4:20 PM–5:00 PM	**DC's Federal Family and the Greening of the Federal House** • John Simpson, PE, LEED AP, US General Services Administration Office of Federal High Performance Federal Buildings
5:00 PM–5:20 PM	**Questions and Dialogue with the Water Community**
5:20 PM-6:30 PM	**Refreshments and Community Building (Anacostia Artwork Provided by Bruce McNeil)** **Sponsor: International Association of Plumbing and Mechanical Officials (IAPMO)**

IAPMO

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DC Area
Water Issues Program

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SEMINAR EIGHT: Water, Power, and Energy in a Green DC

Ernest Jolly, Energy Manager, DC Water
Beverly Perry, Senior Vice President, PEPCO Holdings Inc.
Sheila Slocum Hollis, Board Member, US Energy Association, and Partner, Duane Morris LLP

UDC-Van Ness, Building #41, Room A-03, 4200 Connecticut Avenue NW, Washington DC
Thursday, October 14, 2010, 4:00-5:30 pm
5:30-6:30 Refreshments (Sponsor: **Watercat Consulting LLC**))

As stated by the National Science & Technology Council in 2004, "A very close linkage exists between the Nation's energy future and water future – water is crucial to the production of energy….conversely, many of the technologies for withdrawing, storing, or treating water consume large amounts of energy." This connection is readily apparent in DC, where our water and power providers are working towards closer communication, coordination, and collaboration on resource planning and management, and to reduce associated carbon emissions, while area energy developers recognize their need for both water and power, and their role in maintaining water quality. Addressing the 'Water-Energy Nexus" issues locally are Ernest Jolly (DC Water), speaking on electric power and energy demands for water supply; Beverly Perry (PEPCO), speaking on water demands for electric power and how PEPCO provides electricity for water/wastewater utilities and home water use; and Sheila Hollis (Duane Morris LLP/US Energy Association and former director of the Office of Enforcement of the Federal Energy Regulatory Commission), speaking on ensuring power supplies for water facilities.

4:00 PM–4:20 PM	**Introduction to the DC Area Water Issues Program, Recognition of Distinguished Visitors, and "The Water Peace" (greet your neighbors)** • Tolessa Deksissa and Cat Shrier, DC Area Water Issues Program Directors
4:20 PM–5:00 PM	**Water, Power, and Energy in a Green DC** • **Ernest Jolly, Energy Manager, DC Water** • **Beverly Perry, Senior Vice President, PEPCO Holdings Inc.** • **Sheila Slocum Hollis, Duane Morris LLP/US Energy Association**
5:00 PM–5:20 PM	**Questions and Dialogue with the Water Community**
5:20 PM-6:30 PM	**Refreshments and Community Building (Sponsor: Watercat Consulting LLC)** **Artwork is provided by Bruce McNeil**

Watercat Consulting LLC www.watercatconsulting.com
WCEE Women's Council on Energy and the Environment
WIPP Women Impacting Public Policy
ENTREPRENEURS ENERGY & ENVIRONMENT

Sponsored by Watercat Consulting LLC in recognition of WCEE Water Issues Group and WIPP E3 Committee

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College of Agriculture, Urban Sustainability, and Environmental Sciences

DC Area Water Issues Program

DC Area Water Issues Program (DCAWIP) Fall 2010 Weekly Seminar Presents:
SEMINAR NINE: Water Workforce Development and Green Jobs in DC
Annette Gantt, President, Earth Conservation Corps
John Wasiutynski, DC Department of Environment
Ron Lord, International Association of Plumbers and Mechanical Officials (IAPMO)
Location: UDC-Van Ness, Building #41, Room A-03, 4200 Connecticut Avenue NW, Washington DC
Date and Time: Thursday, October 21, 2010, 4:00-5:30 pm
5:30-6:30 Refreshments Sponsor: **International Association of Plumbers and Mechanical Officials**

There is a critical need to produce employees in water-related fields -- trained to work in a "greener" water industry. In 2005, almost 40% of water utility workers were eligible to retire within 10 years (Water Research Foundation). Green jobs training – including programs focused on water -- provide an opportunity for economic development. This week's program highlights water-related "green jobs" training programs and the industries and agencies that provide opportunities for trainees to receive hands-on experience, including: the Earth Conservation Corps (ECC), which engages unemployed community youth in Anacostia in workforce training, environmental education, and media arts to help them learn the skills they need to become candidates for the emerging workforce and environmental stewards through advocacy, action, and community service; the DC Department of Environment, which supports ECC programs, providing opportunities for training program participants and staff to gain hands-on experience while supporting DC's efforts to clean its water environments; and the International Association of Plumbers and Mechanical Officials, which provides training for these industries, which are essential for green buildings. ***RECEPTION WITH GREEN JOBS TRAINING "FAIR".***

4:00 PM–4:15 PM	**Introduction to the DC Area Water Issues Program, Recognition of Distinguished Visitors, and "The Water Peace" (greet your neighbors)** • Tolessa Deksissa and Cat Shrier, DC Area Water Issues Program Directors
4:15 PM–5:00 PM	**Water Workforce Development and Green Jobs in DC** • Annette Gantt, President, Earth Conservation Corps (with video) • John Wasiutynski, DC Department of Environment • Ron Lord, International Association of Plumbers and Mechanical Officials (IAPMO)
5:00 PM–5:20 PM	**Questions and Dialogue with the DC Area Water Community**
5:20 PM-6:30 PM	**Refreshments and Community Building (SPONSOR: IAPMO)**

International Association of Plumbers and Mechanical Officials

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College of Agriculture, Urban Sustainability, and Environmental Sciences

DC Area Water Issues Program

DC Area Water Issues Program (DCAWIP)
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SEMINAR TEN: Water Advocacy in DC
Water Advocacy Roundtable
Dottie Yunger, Anacostia Riverkeeper; Brent Bolin, Anacostia Watershed Society
Irv Sheffey, Sierra Club; Paul Schwartz, Clean Water Action
UDC-Van Ness, Building #41, Room A-03, 4200 Connecticut Avenue NW, Washington DC
Thursday, October 28, 2010, 4:00-5:30 pm
5:30-6:30 Reception
6:30-8:00 Documentary Filmmaker Jim Thebaut + Screening of "Running Dry: Beyond the Brink"

This week will feature a special panel of representatives from water advocacy organizations, each of which plays different roles in water issues within DC. Each speaker will provide information on their organization and its DC-based water activities; how they personally entered into careers in water advocacy; and opportunities for members of the DC Area Water Community to get involved. Anacostia Riverkeeper Dottie Yunger and Anacostia Watershed Society's Brent Bolin will talk about locally-based water advocacy. Irv Sheffey and Paul Schwartz present views from national organizations working locally. After the reception, we will have a special presentation by The Chronicles Group's Jim Thebaut, who will discuss the use of film to raise awareness of global water issues, and present a 25-minute "preview" of his latest film, "Running Dry: Beyond the Brink."

4:00 PM–4:15 PM	**Introduction to the DC Area Water Issues Program, Recognition of Distinguished Visitors, and "The Water Peace" (greet your neighbors)** • Tolessa Deksissa and Cat Shrier, DC Area Water Issues Program Directors
4:15 PM–5:00 PM	**Water Advocacy Roundtable:** ***Dottie Yunger, Anacostia Riverkeeper;*** ***Brent Bolin, Anacostia Watershed Society;*** ***Irv Sheffey, Sierra Club;*** ***Paul Schwartz, Clean Water Action***
5:00 PM–5:20 PM	**Questions and Dialogue with the Water Community**
5:20 PM-6:30 PM	**Refreshments and Community Building Sponsored by: SPONSORSHIP AVAILABLE**
6:30-8:00 PM	**Jim Thebaut, The Chronicles Group Films, speaking on global water advocacy through film with a screening of a 25-minute preview of "RUNNING DRY: BEYOND THE BRINK"**

DC Area Water Issues Program (DCAWIP) – offered by UDC's College of Agriculture, Urban Sustainability and Environmental Sciences (CAUSES) -- is a comprehensive set of university events open to all DC Area students, faculty, water managers, and members of the general public who are interested in water. DCAWIP is a multi-disciplinary program, exploring issues related to the science and engineering, policy, and socioeconomic aspects of water and watersheds in the DC area. Funded by the US Geological Survey (USGS) through DC Water Resources Research Institute (DCWRRI), this Program was developed with ***the goal of creating a more cohesive water research community in the DC area****. Every Thursday at 4 pm, at UDC's Van Ness Campus, speakers from water "stakeholder" organizations provide insightful, practical information about DC water issues and their role in the water community, with sponsored refreshments and community-building reception to follow.*

For more information please contact Dr. Tolessa Deksissa at tdeksissa@udc.edu or 202-274-5273 or Dr. Cat Shrier at cat@watercatconsulting.com or 202-344-7894.

University of the District of Columbia 1851
College of Agriculture, Urban Sustainability, and Environmental Sciences

DC Area Water Issues Program

DC Area Water Issues Program (DCAWIP)
Fall 2010 Weekly Seminar
SEMINAR ELEVEN: Funding for Water Research and Education
Jim Dobrowolski, USDA National Institute of Food and Agriculture
Greg Lank, EPA People, Prosperity, and the Planet (P3) Grant Competition
Bill Hare, DC Water Resources Research Institute/USGS Grants
Lindsay Birt, NAS Christine Mirzayan Science & Technology Policy Graduate Fellow
UDC-Van Ness, Building #41, Room A-03, 4200 Connecticut Avenue NW, Washington DC
Thursday, November 4, 2010, 4:00-5:30 pm
5:30-6:30 Refreshments -- GRANTS AND FELLOWSHIPS FAIR DURING RECEPTION

Who pays for water research and education? This panel features representatives from agencies that provide funding for water research, as well as fellowships and other funding for students in water-related fields. Jim Dobrowolski (USDA National Institute of Food and Agriculture) and Greg Lank (EPA P3 Research Grant Competition) will discuss current funding priorities and how water-related faculty and students can access funds from their agencies. DC Water Resources Research Institute Director Bill Hare will provide an overview of the USGS-funded grants. We will also hear from Purdue doctoral candidate Lindsay Birt, a current Chrstine Mirzayan Science & Technology Policy Graduate Fellow at the National Academy of Sciences, on her experiences applying for and receiving (or not) several grants and fellowships to support her education. ***During the Reception, we invite organizations that provide water-related grants, fellowships, and scholarships to distribute information on their funding programs and representatives to talk with water faculty, researchers, and students.***

4:00 PM–4:15 PM	**Introduction to the DC Area Water Issues Program, Recognition of Distinguished Visitors, and "The Water Peace" (greet your neighbors)** • Tolessa Deksissa and Cat Shrier, DC Area Water Issues Program Directors
4:15 PM–5:00 PM	**Funding for Water Research and Education** • ***Jim Dobrowolski, USDA National Institute of Food and Agriculture*** • ***Greg Lank, EPA People, Prosperity, and the Planet (P3) Grant Competition*** • ***Bill Hare, DC Water Resources Research Institute/USGS Grants*** • ***Lindsay Birt, NAS Chrstine Mirzayan Science & Technology Policy Graduate Fellow***
5:00 PM–5:20 PM	**Questions and Dialogue with the Water Community**
5:20 PM-6:30 PM	**Refreshments and Community Building (Fair)**

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UNIVERSITY OF THE DISTRICT OF COLUMBIA 1851

College of Agriculture, Urban Sustainability, and Environmental Sciences

DC Area Water Issues Program

DC Area Water Issues Program (DCAWIP)
Fall 2010 Weekly Seminar
SEMINAR TWELVE: Water, Trees and Gardens in the DC Area

Sandy Farber Bandier, Master Gardener Program Coordinator, UDC Cooperative Extension
Marcelo Lopez, Wiles Mensch Corporation
Mark Buscaino, Executive Director, Casey Trees

UDC-Van Ness, Building #41, Room A-03, 4200 Connecticut Avenue NW, Washington DC
Thursday, November 18, 2010, 4:00-5:30 pm
5:30-6:30 Refreshments –GARDENING AND AGRICULTURE PROGRAMS FAIR DURING RECEPTION

How do gardeners think about water in the DC Area and what is the role of "Green Spaces" in managing water quality and quantity? These are the questions being considered for this week's program. The Master Gardener Program, an international flagship program of the COES Network of Land Grant Universities has the mission of educating the D.C. residents about safe, effective, and sustainable horticultural practices that build healthy gardens, landscapes, and communities. UDC's own Master Gardener Program Coordinator Sandy Farber Bandier will provide a brief overview of the Master Gardener Program, and share "a gardener's perspective" on water issues in the DC area, based on her personal experiences and questions she receives from area residents. Our main speakers for this week's seminar will be Marcelo Lopez of Wiles Mensch Corporation, low-impact design expert and designer for Casey Trees' new Brookland headquarters, and Mark Buscaino, Executive Director of Casey Trees, who will discuss Casey Trees' work with the DC Department of the Environment on tree planting to address the city's stormwater issues, as well as other water-related benefits from low impact design and green space. ***During the Reception, we encourage area gardening programs to provide representatives to discuss their programs and display materials, sign up volunteers, and otherwise promote their programs. Information will also be available on the many programs of the new UDC College of Agriculture, Urban Sustainability, and Environmental Sciences (CAUSES), including research, outreach, and extension.***

4:00 PM–4:15 PM	**Introduction to the DC Area Water Issues Program, Recognition of Distinguished Visitors, and "The Water Peace" (greet your neighbors)**
4:15 PM–5:00 PM	**Water, Trees, and Gardens in the DC Area** • ***Sandy Farber Bandier, DC Master Gardener Program Coordinator, UDC*** • ***Marcelo Lopez, Project Manager, Wiles Mensch Corporation*** • ***Mark Buscaino, Executive Director, Casey Trees***
5:00 PM–5:30 PM	**Questions and Dialogue with the Water Community**
5:30 PM-6:30 PM	**Community Building Reception with Gardening and Agriculture Programs Fair**

DC Area Water Issues Program (DCAWIP) – offered by UDC's College of Agriculture, Urban Sustainability and Environmental Sciences (CAUSES) -- is a comprehensive set of university events open to all DC Area students, faculty, water managers, and members of the general public who are interested in water. DCAWIP is a multi-disciplinary program, exploring issues related to the science and engineering, policy, and socioeconomic aspects of water and watersheds in the DC area. Funded by the US Geological Survey (USGS) through DC Water Resources Research Institute (DCWRRI), this Program was developed with ***the goal of creating a more cohesive water research community in the DC area****. Every Thursday at 4 pm, at UDC's Van Ness Campus, speakers from water "stakeholder" organizations provide insightful, practical information about DC water issues and their role in the water community, with sponsored refreshments and community-building reception to follow.*

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University of the District of Columbia 1851
College of Agriculture, Urban Sustainability, and Environmental Sciences

DC Area Water Issues Program

DC Area Water Issues Program (DCAWIP)
Fall 2010 Weekly Seminar
SEMINAR THIRTEEN: Wastewater Treatment, Reuse, and Communications
Sudhir Murthy, DC Water
Laurens van der Tak, CH2M HILL
UDC-Van Ness, Building #41, Room A-03, 4200 Connecticut Avenue NW, Washington DC
Thursday, December 2, 2010, 4:00-5:30 pm
5:30-6:30 Refreshments –PROFESSIONAL ASSOCIATIONS FAIR DURING RECEPTION

How do we treat wastewater? What are the options for reuse of wastewater for nonpotable and potable uses? How do we talk about wastewater and reuse? The Blue Plains Advanced Wastewater Treatment Plant is the largest advanced wastewater treatment plant in the world, with a capacity of 370 million gallons per day (MGD), a peak capacity of 1.076 billion gallons per day and covering 150 acres. Sudhir Murthy will provide an overview of the plant, as well as DC Water's related research in wastewater treatment and biosolids management, which has graduated roughly 40 MS and Ph.D. students in the last 8 years. Our second speaker, Laurens van der Tak, CH2M HILL, will then talk about approaches to water reuse in the DC area, including the indirect potable reuse project at UOSA and Fairfax Water, and nonpotable reuse options at Loudoun Water and will address some of the challenges of communicating about wastewater and water reuse. ***During the Reception, we encourage area professional associations involved with water, wastewater, and reuse to provide representatives to discuss their programs and display materials, sign up volunteers, and otherwise provide information on their associations.***

4:00 PM–4:15 PM	**Introduction to the DC Area Water Issues Program, Recognition of Distinguished Visitors, and "The Water Peace" (greet your neighbors)**
4:15 PM–5:00 PM	**Wastewater, Reuse and Communications** • ***Sudhir Murthy, DC Water*** • ***Laurens van der Tak, CH2M HILL***
5:00 PM–5:30 PM	**Questions and Dialogue with the Water Community**
5:30 PM-6:30 PM	**Refreshments and Community Building Sponsored by: CH2M HILLL**

CH2MHILL®

Sponsor: CH2M HILL

DC Area Water Issues Program (DCAWIP) – offered by UDC's College of Agriculture, Urban Sustainability and Environmental Sciences (CAUSES) -- is a comprehensive set of university events open to all DC Area students, faculty, water managers, and members of the general public who are interested in water. DCAWIP is a multi-disciplinary program, exploring issues related to the science and engineering, policy, and socioeconomic aspects of water and watersheds in the DC area. Funded by the US Geological Survey (USGS) through DC Water Resources Research Institute (DCWRRI), this Program was developed with ***the goal of creating a more cohesive water research community in the DC area****. Every Thursday at 4 pm, at UDC's Van Ness Campus, speakers from water "stakeholder" organizations provide insightful, practical information about DC water issues and their role in the water community, with sponsored refreshments and community-building reception to follow.*

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College of Agriculture, Urban Sustainability, and Environmental Sciences

DC Area Water Issues Program

DC Area Water Issues Program (DCAWIP)
Fall 2010 Weekly Seminar
SEMINAR FOURTEEN: Community-Based Water Resiliency
Nushat Thomas, EPA Office of Water
and a Summary Report of the DC Area Water Issues Program (DCAWIP)
Tolessa Deksissa and Cat Shrier, DCAWIP Directors
UDC-Van Ness, Building #41, Room A-03, 4200 Connecticut Avenue NW, Washington DC
Thursday, December 9, 2010, 4:00-5:30 pm
5:30-6:30 Refreshments with Past Speakers and Sponsors

Can you imagine a day without water? There are many threats to our water supply infrastructure, including natural disasters, criminal and terrorist act, failure of aging infrastructures, and failures in other sectors on which water supplies are dependent (such as power supplies). The impacts of water service interruptions can be addressed through creating greater community-level resiliency, including planning and preparation by individual citizens as well as hospital and businesses. EPA's Office of Water has developed a Community-Based Water Resiliency program to support better preparedness for water service interruptions at the community level, including a free interactive computerized tool. Nushat Thomas will provide an overview of this program and demonstrate the tools now available from the EPA. After Ms. Thomas' presentation, there will be a summary presentation of the DC Area Water Issues Program., and recognition of past speakers and sponsors.

4:00 PM–4:45 PM	**Introduction to the DC Area Water Issues Program, Recognition of Distinguished Visitors, and "The Water Peace" (greet your neighbors)** **Summary Presentation on the DC Area Water Issues Program Summary/Findings and Recognition of Past Speakers and Sponsors** • ***Tolessa Deksissa and Cat Shrier, DCAWIP Directors***
4:45 PM–5:30 PM	**Community-Based Water Resiliency and Summary Presentation on the DC Area Water Issues Program PLUS Questions and Dialogue with the Water Community** • ***Nushat Thomas, EPA***
5:30 PM-6:30 PM	**Refreshments and Community Building Reception: THANK YOU TO OUR SPONSORS**

DC Area Water Issues Program (DCAWIP) – offered by UDC's College of Agriculture, Urban Sustainability and Environmental Sciences (CAUSES) -- is a comprehensive set of university events open to all DC Area students, faculty, water managers, and members of the general public who are interested in water. DCAWIP is a multi-disciplinary program, exploring issues related to the science and engineering, policy, and socioeconomic aspects of water and watersheds in the DC area. Funded by the US Geological Survey (USGS) through DC Water Resources Research Institute (DCWRRI), this Program was developed with ***the goal of creating a more cohesive water research community in the DC area****. Every Thursday at 4 pm, at UDC's Van Ness Campus, speakers from water "stakeholder" organizations provide insightful, practical information about DC water issues and their role in the water community, with sponsored refreshments and community-building reception to follow.*

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APPENDIX D: SPECIAL PROGRAM ANNOUNCEMENTS
FILM SCREENING

University of the District of Columbia 1851
College of Agriculture, Urban Sustainability, and Environmental Sciences

DC Area Water Issues Program

DC Area Water Issues Program (DCAWIP) Presents:
An Evening with Documentary Filmmaker Jim Thebaut
and Preview Screening of "Running Dry: Beyond the Brink"

UDC-Van Ness, Building #41, Room A-03, 4200 Connecticut Avenue NW, Washington DC
Thursday, October 28, 2010, 5:30-6:30 Reception
6:30-8:30 Film Screening and Conversation with Jim Thebaut

Water scarcity, climate change and drought, poverty, disease, loss of agricultural land and food supply create a tremendous global security risk and will likely generate nuclear arms proliferation in regions seeking to secure access to scarce resources. India and Pakistan have been in the midst of a nuclear arms race while seeing increasing tensions over shared rivers. Pakistan's recent flood disaster shattered the lives of millions and led to increased recruitment of terrorists in the region -- another example of how extreme weather events caused by climate change further threaten international security. While the effects of climate change and water-related issues are being manifested all over the world, the "canary in the coal mine" may be Australia, a country where serious drought, lack of rainfall, significantly rising temperatures, and major water shortages are having a profound effect on the country's overall stability. Australia has sought to counter its water crisis and national security emergencies by implementing a comprehensive water policy and significant institutional "paradigm shift measures" within Australian society. As the latest film in The Chronicles Group's Running Dry Film Series, this 25 minute video preview of RUNNING DRY: BEYOND THE BRINK provides a synopsis of the critical challenges facing the planet, ramifications for global security, and potential solutions now being explored.

After the screening, Jim Thebaut, the Writer/Executive Producer of the Running Dry Film Series, will join the DC Area Water Community for a dialogue on the role of film in global water advocacy. As an Executive Producer/Producer and journalist, Jim Thebaut strives to educate, motivate and entertain diversified international audiences through his socially significant and acclaimed films, including his "Running Dry" film series produced by Jim's organization, the Chronicles Group, Inc, a non profit 501 (c) (3) Corporation which influences critical public policy about the threat of the evolving global humanitarian water crisis and its dire effect on international security. Jim's 2005 film RUNNING DRY led to enactment of the Senator Paul Simon Water for the Poor Act, which authorizes funding for water and sanitation in developing nations. He has organized the 2009 National Water Policy Event and 2010 Drought, Water Scarcity and International Security in the 21st Century Event on Capitol Hill.

This special program will follow DC Area Water Issues Program's 10th Weekly Water Seminar, a "Water Advocacy Roundtable" featuring Dottie Yunger, Anacostia Riverkeeper; Brent Bolin, Anacostia Watershed Society; Irv Sheffey, Sierra Club; and Paul Schwartz, Clean Water Action. Please join us for the weekly seminar and dialogue with the DC Area Water Community from 4:00-5:30, followed by a reception 5:30-6:30, before our discussion with Jim Thebaut and "Running Dry: Beyond the Brink" film screening.

DC Area Water Issues Program (DCAWIP) – offered by UDC's College of Agriculture, Urban Sustainability and Environmental Sciences (CAUSES) -- is a comprehensive set of university events open to all DC Area students, faculty, water managers, and members of the general public who are interested in water. DCAWIP is a multi-disciplinary program, exploring issues related to the science and engineering, policy, and socioeconomic aspects of water and watersheds in the DC area. Funded by the US Geological Survey (USGS) through DC Water Resources Research Institute (DCWRRI), this Program was developed with ***the goal of creating a more cohesive water research community in the DC area****. Every Thursday at 4 pm, at UDC's Van Ness Campus, speakers from water "stakeholder" organizations provide insightful, practical information about DC water issues and their role in the water community, with sponsored refreshments and community-building reception to follow.* For more information please contact Dr. Tolessa Deksissa at tdeksissa@udc.edu or 202-274-5273 or Dr. Cat Shrier at cat@watercatconsulting.com or 202-344-7894.

BOAT TOUR

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

DC Area Water Issues Program

ANACOSTIA WATERSHED SOCIETY

DC Area Water Issues Program (DCAWIP)
and the Anacostia Watershed Society Present:
2010 ANACOSTIA RIVER BOAT TOUR
November 11, 2010 (Veterans Day)

Don't miss this event! Anacostia Watershed Society President Jim Foster will join us at the Anacostia Watershed Society Office (4302 Baltimore Avenue, Bladensburg, MD) for a discussion of Anacostia watershed issues and lunch (provided) and will then lead us on a boat tour of the Anacostia River

Meet at UDC, Outside Building 41 at 10 am
Estimated time to return to UDC: 4 pm

Registration is limited to 15
with 5 spots reserved for UDC students/faculty/staff
and 5 spots reserved for students/faculty/staff from other DC Area Universities
to reserve your spot, come to the DC Area Water Issues Program Weekly Seminars and Reception 4-6:30 pm on Thursdays at UDC Building 41, 4200 Connecticut Ave

Suggested donation:
$10 for students/faculty/staff
$20 for others in the DC Area Water Community

Donations to be used to cover expenses for lunch and transportation, with net proceeds to be donated to the Anacostia Watershed Society Since 1989, the Anacostia Watershed Society mission has been to protect and restore the Anacostia River and its watershed community by cleaning the water, recovering the shores, and honoring the heritage with volunteers and support of the community. Registration is limited (15) and will be available every Thursday at DCAWIP seminars. For more information on the Anacostia Watershed Society visit www.anacostiaws.org DC Area Water Issues Program (DCAWIP) – offered by UDC's College of Agriculture, Urban Sustainability and Environmental Sciences (CAUSES) -- is a comprehensive set of university events open to all DC Area students, faculty, water managers, and members of the general public who are interested in water. DCAWIP is a multi-disciplinary program, exploring issues related to the science and engineering, policy, and socioeconomic aspects of water and watersheds in the DC area. Funded by the US Geological Survey (USGS) through DC Water Resources Research Institute (DCWRRI), this Program was developed with the goal of creating a more cohesive water research community in the DC area. Every Thursday at 4 pm, at UDC's Van Ness Campus, speakers from water "stakeholder" organizations provide insightful, practical information about DC water issues and their role in the water community, with sponsored refreshments and community-building reception to follow. For more information please contact Dr. Tolessa Deksissa at tdeksissa@udc.edu or 202-274-5273 or Dr. Cat Shrier at cat@watercatconsulting.com or 202-344-7894.

APPENDIX E: PROGRAM EVALUATION FORM

UNIVERSITY OF THE DISTRICT OF COLUMBIA 1851

DC Area
Water Issues Program

DC Area Water Issues Program (DCAWIP)
Learning Experience Evaluation Form

SEMINAR EIGHT: Water, Power, and Energy in DC

Ernest Jolly, Energy Manager, DC Water
Beverly Perry, Senior Vice President, PEPCO Holdings Inc.
Sheila Slocum Hollis, Board Member, US Energy Association, and Partner, Duane Morris LLP
Refreshment and community building reception sponsored by: Watercat Consulting LLC

Please rate this week's seminar for the following criteria: Your feed back is very important to us

- **Did this seminar meet your learning expectations:**
  ☐ Excellent ☐ Good ☐ Fair ☐ Poor
- **Was this seminar taught at the appropriate level:**
  ☐ Excellent ☐ Good ☐ Fair ☐ Poor
- **This seminar provided you with new information:**
  ☐ Excellent ☐ Good ☐ Fair ☐ Poor
- **You will be able to apply what was learned in your daily practices:**
  ☐ Excellent ☐ Good ☐ Fair ☐ Poor
- **Question and answer session:**
  ☐ Excellent ☐ Good ☐ Fair ☐ Poor
- **Overall satisfaction with this seminar:**
  ☐ Excellent ☐ Good ☐ Fair ☐ Poor
- **Do you think you will attend future seminars?** ☐ Yes ☐ No
- **Please Check All that Apply:**

☐ Student, Department _____ ☐ Faculty, Department _____

☐ University Staff ☐ Agency ☐ Consultant ☐ Nonprofit ☐ Organization ☐ Other

Overall comments regarding this seminar and speaker(s):_____
_____
_____
_____

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	15	0	0	0	15
Masters	1	0	0	0	1
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	16	0	0	0	16

Notable Awards and Achievements