



Tufts

WATER: SYSTEMS, SCIENCE & SOCIETY

**A research symposium hosted by the graduate
interdisciplinary water program at Tufts University**

Saturday, May 1, 2010

8:00 am to 5:00 pm

Fletcher School of Law and Diplomacy

Tufts University

160 Packard Avenue

Medford, Massachusetts

www.tufts.edu/water/symposium.html

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“A holistic, systemic approach, relying on integrated water resource management must replace the fragmentation in managing water.”

World Commission on Water 2000

Globally and locally, the water management problems of today are both profound and pervasive. The United Nations reports that 5 million people die annually from diseases caused by unsafe drinking water. Agriculture and urban areas overuse water supplies, so that rivers such as the Yellow River in China and the Colorado River in the United States are dry at their mouths. Disputes over the management of transboundary river systems can exacerbate inter-national tensions, perhaps leading to “water wars”. Runoff from agricultural and urban areas, as well as point sources such as combined sewer overflows, are causing 50% of watersheds in the United States to have either moderate or serious water quality problems. Long-term climate change and population growth will further stress water resources in many regions. According to the IPCC, acceptable adaptation will only be achieved through integrated water resource management.

The Water: Systems, Science, and Society (WSSS) program at Tufts University is designed to provide unique training to the next generation of water resource leaders. Established in 2004, the WSSS program builds on Tufts’ existing strengths in sciences, engineering, health, nutrition, diplomacy, and policy. By providing a forum for collaboration and information exchange between academic disciplines, WSSS students and faculty learn approaches and terminology from outside their own areas of expertise. Using this resource of community and language, practitioners are able to effectively develop a systems approach to problem solving. By attempting comprehensive incorporation of all relevant perspectives into decision support models, interdisciplinary teams can develop solutions that maximize net societal benefits.

The WSSS 2010 Symposium is an example of the WSSS program its best. Today’s event brings together students and both regional and national water experts. We are lucky to have presenters from public, private, and academic organizations. Beyond the presentations, however, we hope to draw on the knowledge and experience of a diverse gathering of researchers and practitioners. We encourage everyone present to contribute to the conversation during both formal and informal events. Thank you for coming to the first of what is to be an annual series of symposia. We hope that this event can provide each of you with greater connections with your colleagues, with the WSSS program serving as a hub for integrated water resources management.

Best regards,

Jack Melcher

MS/MA 2011

WSSS 2010 Symposium Master of Ceremonies

(with thanks the editorial by Kirshen, Rogers, & Vogel in the May/June 2004 issue of the Journal of Water Resources Planning and Management)

Schedule

8:00 - 9:00 am

Hall of Flags

Registration and Breakfast

9:00 - 9:30 am

ASEAN Auditorium

Keynote Speaker: Shared Vision Planning

Richard Palmer, Department Head and Professor,
Civil and Environmental Engineering,
University of Massachusetts, Amherst

9:30 - 10:30 am

ASEAN Auditorium

Student Presentations: Water, Agriculture, Health and Livelihood

- Karen Kosinski, *School of Engineering*
"Evaluation of a Novel Primary Prevention Technique for the Control of Urinary Schistosomiasis: A Pilot Intervention in Adasawase, Ghana"
- Peter Kelly-Joseph, Lauren Caputo, Ellen Tyler, *various schools*
"2010 WSSS Practicum, Elbow Cay, The Bahamas"
- Georgia Kayser, *Fletcher School of Law & Diplomacy*
"Assessing the Impact of Post-Construction Support on System Performance & Sustainability in Community Managed Water Supply: Evidence from El Salvador"
- Shonda Gaylord, *Cummings School of Veterinary Medicine*
"Fiber Optic Microarray Detection of Cyanobacteria in Freshwater"
- Melissa Bailey, *Friedman School of Nutrition Science & Policy*
"Investing in Water Quality: How Have Environmental Quality Incentives Program Funds Been Distributed Across Livestock Systems?"

10:30 - 10:45 am

ASEAN Mezzanine

Break

10:45 - 12:00 pm

ASEAN Auditorium

Panel Discussion: Climate Change Adaptation

- Peter Rogers, *Gordon McKay Professor of Environmental Engineering and Professor of City and Regional Planning, Harvard University*
- Jerome Delli Priscoli, *Seniors Advisor, US Army Corps of Engineers Institute for Water Resources*
- Herman Karl, *Co-Director, MIT-USGS Science Impact Collaborative (MUSIC)*
- Tim Griffin, *Director, Agriculture, Food and Environment Program, Friedman School of Nutrition Science and Policy*

12:00 - 1:15 pm
Hall of Flags

Lunch and Poster Session

1:15 - 2:15 pm
ASEAN Auditorium

Student Presentations: Water Resources Management, Planning and Conflict

- Yushiou Tsai, *School of Engineering*
"Sensitivity of Streamflow to Land Use, Water Use, and Climate in Eastern US"
- Brian Thomas, *School of Engineering*
"Impact of Stormwater BMPs on Boston Groundwater Levels"
- Melissa Ng, *School of Engineering*
"The Hydromorphology of Two Urbanizing Watersheds"
- Rhiannon Ervin, *School of Engineering*
"Exploring the Use of Partitioning Tracers for the Assessment of DNAPL Source Zone Architecture"
- Vicki Zoltay, *Senior Analyst, Abt Associates*
"Generalized Watershed Management Modeling: Case Study Ipswich River"

2:15 - 3:30 pm
ASEAN Auditorium

Panel Discussion: Water and Development

- Annette Huber-Lee, *Visiting Scholar, School of Engineering*
- Peter Weiskel, *MA/RI District Program Officer, USGS*
- Kirk Westphal, *P.E., CDM*
- Julie Wood, *Watershed Scientist, Charles River Watershed Association*
- Mark Smith, *Director, Eastern U.S. Freshwater Program, The Nature Conservancy*

3:30 - 4:15 pm
Hall of Flags

Professional Networking Reception

4:15 - 4:45 pm
ASEAN Auditorium

Honorary Speaker: Climate Change Adaptation

Paul Kirshen, Co-founder and former director of the WSSS program
Battelle Memorial Institute

4:45 - 5:00 pm
ASEAN Auditorium

Closing Remarks

Opening Keynote: Shared Vision Planning

Dr. Richard N. Palmer, PhD, PE

University of Massachusetts, Amherst



Richard Palmer is the Department Head and Professor of Civil and Environmental Engineering at the University of Massachusetts Amherst. From 1979 to 2008, he was a professor at the University of Washington in Seattle, Washington. His primary areas of interest are in the application of structured planning approaches to water resources. This includes the impacts of climate change on water resources, drought planning, real-time water resource management, and the application of decision support to civil engineering management problems. He helped develop the field of “shared vision modeling” in water resources planning and pioneered the use of “virtual drought exercises.”

Dr. Palmer received his PhD from Johns Hopkins University in 1979, his Master's of Science in Environmental Engineering from Stanford University in 1973. During his PhD research he was a member of a team at Johns Hopkins University and the Interstate Commission on the Potomac River Basin recognized as a finalist by ASCE for the Engineering Achievement of the Year in 1983. He received recognition for the Best Practice-Oriented Paper of the Year in the *Journal of Water Resources Planning and Management* by the ASCE in 1989. He was awarded the Huber Award for Research Excellence by the American Society of Civil Engineers (ASCE) in 1992. This honor was based upon his innovative application of simulation and optimization techniques to issues in water resource management. He was awarded the “Certificate of Recognition” for his editorial services to the *Journal of Water Resources Planning and Management* of ASCE in 1997, for which he was editor from 1993-1997. He received the “Service to the Profession” Award from the Water Resources Planning and Management Division of American Society of Civil Engineers (ASCE) in 1998. In 2006, he received from ASCE the Julian Hinds Award for his contributions to water resources planning and his research related to the impacts of climate change on water resources. He is married and the father of three almost-grown children. He and his wife are currently enjoying exploring their new environs in Western Massachusetts. He is a jazz enthusiast and plays saxophone often but poorly.



Tim Griffin

Dr. Timothy Griffin is the Director of the Food and Agriculture Program at the Friedman School of Nutrition Science and Policy at Tufts University. His research interests include the environmental impact of agriculture and the impacts of policy on the adoption of agricultural practices and systems. Before coming to Tufts he was a lead scientist at the USDA-ARS New England Plant Soil and Water Lab. He has extensive experience in both education and outreach regarding sustainable agriculture and nutrient management and has given over 500 presentations to growers, scientists and farm advisors. Dr. Griffin received his PhD from Michigan State University in Crop and Soil Science and his Masters from the University of Nebraska in Agronomy. He has published over 40 peer-reviewed articles, as well as numerous book chapters and trade and educational publications.



Herman Karl

Dr. Herman Karl is a USGS scientist and holds an appointment as a Visiting Lecturer in the Department of Urban Studies and Planning at the Massachusetts Institute of Technology. He has served as the co-director of the MIT-USGS Science Impact Collaborative (MUSIC) since 2004. Prior to his role as co-director of MUSIC, he was Chief Scientist of the Western Geographic Science Center at USGS. For the first 12 years of his career, Karl conducted research on sediment transport and depositional processes on continental margins to understand better complex natural systems. His current research includes experimenting with collaborative, consensus-based processes, such as Joint Fact Finding, whereby citizens partner with government to work together to achieve common goals and sustainable solutions to complex, science-intensive environmental disputes. He also studies mechanisms to facilitate synthesis, communication and translation of knowledge across discipline, cultural and institutional boundaries. Dr. Karl received a PhD from the University of Southern California in Geological Sciences, a MS from the University of Nebraska in Geology and a BS from Colgate University. He has received numerous awards for his leadership in USGS, for the quality of his publications and his contributions to government communications.

Panelists: Climate Change Adaptation



Jerome Delli Priscoli

Jerome Delli Priscoli is a Senior Advisor at the United States Army Corps of Engineers Institute for Water Resources. For 30 years he has designed and run social assessment, public participation and conflict resolution research and training programs. Dr Delli Priscoli has been advisor to the World Bank and UN water-related agencies on water policy issues, and he works closely with international government water ministers. He is author of many articles and books and is the Editor in Chief of the peer-reviewed journal *Water Policy*. He was an original member of the U.S. delegation to the multi-lateral Middle East peace talks on water, and he has played pivotal roles in each of the five world water forums and most of the critical water resources policy meetings over the last 15 years. He serves on the Bureau and Board of Governors of the World Water Council. The American Water Resources Association awarded him the Icko Iben award for achievement in cross-disciplinary communications in water in 2005. Dr. Priscoli is a Tufts alumnus.



Peter Rogers

Peter Rogers is the Gordon McKay Professor of Environmental Engineering and Professor of City Planning in the Division of Engineering and Applied Sciences at Harvard University. He is a member of the Technical Advisory Committee of the Global Water Partnership and the recipient of Guggenheim and Twentieth Century Fellowships. His research interests include the consequences of population on natural resources development, conflict resolution in international river basins, improved methods for managing natural resources and the environment, the impacts of global change on water resources, and the development of indices of environmental quality and sustainable development. He has carried out extensive field and model studies on population, water and energy resources, and environmental problems in Costa Rica, Pakistan, India, China, the Philippines, Bangladesh and 25 other countries. His most recent work has focused on the relationship between Chinese electric power developments and their impact on global warming. Professor Rogers is a member of the external advisory committee for the Tufts Water: Systems, Science, and Society Program.

Annette Huber-Lee

Dr. Huber-Lee has been conducting research on water planning and management nationally and internationally for nearly two decades. She specializes in incorporating social and economic values to reduce conflict and increase resilience in the design of water systems. Her educational background includes a PhD in Engineering Sciences from Harvard University, an MS in Civil Engineering from Massachusetts Institute of Technology and a BS in Agricultural Engineering from Cornell University.

Mark Smith

Mark P. Smith is the Director of the North America Freshwater Team for The Nature Conservancy (TNC). Prior to joining The Nature Conservancy, Mark spent six years as the Director of Water Policy at the Massachusetts Executive Office of Environmental Affairs (EOEA) and six years with the U.S. Environmental Protection Agency (EPA) in Boston as the project manager for the Casco Bay Estuary Project, part of EPA's National Estuary Program. He has an MA in Urban and Environmental Policy from Tufts University and a bachelor's degree from Washington University in St. Louis.



Peter Weiskel

Dr. Peter Weiskel has been a hydrologist with the U.S. Geological Survey since 1992. He presently serves as Associate Director of the USGS Massachusetts-Rhode Island Water Science Center, where he oversees the scientific program. Trained in geology and hydrology, Peter holds a BA from Yale and a PhD from Boston University. He also has a Master's degree in Education from Boston College. Since joining the USGS, his research has focused on coastal wetlands and their hydrology; the history, water-quality, and hydrology of urban watersheds, and—most recently—the development of indicators to characterize water availability, water use, and principles of sustainable water-resource management.

Panelists: Water & Development



Kirk Westphal

Mr. Westphal received a B.S. in Aerospace Engineering from Boston University in 1991, and an M.S. in Civil and Environmental Engineering from Tufts University in 2001. He worked for several aerospace firms before returning to graduate school to study water management. Since graduating from Tufts, he has worked at CDM in Cambridge, MA, and has participated in projects involving water supply planning and management, river basin management, and integrated resource planning for local, state, and federal clients across the United States. His primary roles involve the development of integrated system models for resource management and the facilitation of stakeholder participation in the formulation of regional water plans. He has twice received awards from EWRI for papers on water supply planning and management.

Julie Dyer Wood

Julie Dyer Wood is a Watershed Scientist with the Charles River Watershed Association (CRWA). At CRWA Julie works on a variety of projects including water quality monitoring and assessment, CRWA's Blue Cities™ Initiative, and public outreach and education to watershed residents and municipal officials. Prior to joining CRWA, Julie was an AmeriCorps volunteer with the Maryland Department of Natural Resources and a Program Educator at the New England Aquarium. Julie has a B.A. in mathematics from Boston College and a M.S. in Environmental Science from the University of Massachusetts.



Dr. Paul Kirshen recently joined Battelle Memorial Institute as a Research Leader in climate change adaptation. From 1996 to the June 2009, Dr. Kirshen was Research Professor in the Civil and Environmental Engineering Department of Tufts University and Director and Co-Founder of the Tufts University Water: Systems, Science, and Society (WSSS) graduate education program. Dr. Kirshen does research and consulting at the local, regional and global scales on climate change impacts and adaptation, and also integrated water resources management. He received his ScB in Engineering from Brown University and his MS and PhD in Civil and Environmental Engineering from MIT.

Some of his current projects include: Development of a Training Program in Climate Change Adaptation for local decision makers with the Consensus Building Institute for the Lincoln Land Institute; Integration of Adaptation Planning of the Built and Natural Environments, Battelle R&D; Scenario-Based Risk Assessment for

Adaptation of Coastal Municipalities to Climate Change in New England for the New England Environmental Finance Center, Portland ME and US EPA; Coastal Flooding and Environmental Justice: Developing Strategies for Adapting to Climate Change for US NOAA with the University of Massachusetts-Boston; and Guidance Tools for Planning and Management of Urban Drainage Systems under a Changing Climate for US NOAA with Tufts University.

Recently completed projects include: Methodologies for Estimating Impacts of Climate Change on Operations of Water Treatment and Wastewater Treatment Plants, and Urban Drainage for the World Bank; Estimate of Global Costs of Water Supply by Region under Present and Future Climates for the UN Framework Convention on Climate Change; Infrastructure Systems, Services and Climate Change: Integrated Impacts and Response Strategies for the Boston Metropolitan Area for US Environmental Protection Agency ORD with University of Maryland, Boston University and others (known as CLIMB project); and better management under present climate variability as an adaptation to climate change in West Africa for US NOAA.

Student Presentation Abstracts

Karen Kosinski, *School of Engineering, Tufts University*

“Evaluation of a Novel Primary Prevention Technique for the Control of Urinary Schistosomiasis: A Pilot Intervention in Adasawase, Ghana”

Schistosomiasis is one of thirteen neglected tropical diseases and affects over 207 million people worldwide, primarily children and adolescents living in the rural tropics. Schistosomiasis is transmitted via skin contact with water that is contaminated with human waste. Long-term disease pathology can be severe, and although the disease is treatable, treatment does not confer immunity. Mass treatment of populations in endemic areas can strain health care systems and chemotherapy alone is rarely a sustainable control strategy. Instead, some researchers have argued for areas of safe water contact. In Japan, diminished river contact was shown to decrease reinfection rates and disease severity because parasite burden directly relates to contact with contaminated water. To date, no studies have been found that evaluate the use of a water recreation area in the primary prevention of schistosomiasis. Data collected in 2008 indicate that in Adasawase, a rural town in Ghana, urinary schistosomiasis affected roughly 44% of girls and 61% of boys. Children were treated for the disease, but by June 2009, prevalence had rebounded to 26% of girls and 29% of boys. The children contract schistosomiasis in a local river where they swim and bathe. My doctoral thesis consists of testing the hypothesis that following treatment with praziquantel, a novel water recreation area will be an effective and sustainable method of preventing reinfection with *Schistosoma haematobium*, the causative agent of urinary schistosomiasis. It is expected that children who use this recreation area will have lower burdens of urinary schistosomiasis as compared with children who use river water. If schistosomiasis prevalence is shown to decrease in the presence of the water recreation area, the recreation area may represent a new tool for use by public health officials in terms of sustainable primary prevention of urinary schistosomiasis.

Georgia Kayser, *Fletcher School of Law & Diplomacy, Tufts University*

“Assessing the Impact of Post-Construction Support on System Performance & Sustainability in Community Managed Water Supply: Evidence from El Salvador”

This research describes the efficacy of "build-and-walk-away" drinking water systems relative to "build-and-support-with-on-going technical assistance" water systems in rural areas and small urban areas of El Salvador. Specifically, the research in El Salvador directly measures the impact of the Circuit Rider model on community run water supply system performance and sustainability in western El Salvador. The Circuit Rider model is designed to provide on-going technical assistance so that the Village Water Committees (VWC) and their operators have the capacity to prepare for and overcome technical, financial and operational obstacles. This study evaluates 60 small rural and peri-urban community-run water supply systems in El Salvador. The results find that the Circuit Rider model of post-construction support leads to lower rates of microbiologically contaminated water, higher rates of drinking water disinfection, improved operator knowledge about treatment, less negative community perception of chlorine (the most common source of drinking water disinfection in the global south), higher rates of community payment for water service, greater likelihood of household water meters, and greater financial transparency in El Salvador.

Shonda Gaylord, *Cummings School of Veterinary Medicine, Tufts University*

“Fiber Optic Microarray Detection of Cyanobacteria in Freshwater”

Water, Agriculture, Health, and Livelihood Cyanobacteria, often referred to as blue-green algae for their photosynthetic capabilities, can produce harmful toxins upon cell death. *Anabaena*, *Cylindrospermopsis* and *Microcystis* are three naturally occurring freshwater cyanobacteria that produce cyanotoxins. Some cyanotoxins function as neurotoxins, to produce post synaptic acetylcholine mimics causing paralysis of the respiratory muscles, and/or hepatotoxins, which causes liver failure via collapsing the actin filaments in hepatocytes. The LD50 for such toxin respectively is 20ug/kg and 50ug/kg compared to Cobra venom which has an LD50 of 185ug/kg in murine studies. This demonstrates the need to safely and effectively monitor influxes of large amounts of cyanobacteria in freshwater systems for public health measures and environmental integrity. With the use of nucleic acid based microarray hybridization it is possible to perform high throughput detection of such organisms with future multiplexing capabilities. The overall project goal is to adapt and validate a rapid and accurate optical fiber-based technology for the detection and enumeration of toxigenic cyanobacteria in the genera *Cylindrospermopsis*, *Microcystis*, and *Anabaena* in both laboratory and field settings. The technology can readily be adapted to target other cyanoHAB species as well as microbial pathogens and microorganisms of many types. Furthermore, it is highly amenable to automation, bringing us closer to the goal of an early warning system utilizing laboratory-based flow-through systems, or remote, moored instruments capable of detecting and providing early warning of organisms that threaten public and ecosystem health.

Melissa Bailey, *Friedman School of Nutrition Science and Policy, Tufts University*

“Investing in Water Quality: How Have Environmental Quality Incentives Program Funds Been Distributed Across Livestock Systems?”

The Environmental Quality Incentives Program (EQIP), a program of the U.S. Department of Agriculture (USDA) that provides incentive and cost share payments to farmers who adopt conservation practices, is at the core of federal policies available to minimize the degradation of water resources associated with both extensive and intensive livestock production. While both extensive and intensive livestock systems pose risks to water quality, there is uncertainty over what kinds of livestock-related practices and production have received support through EQIP, and the merits of these investments. To fill this research gap, we analyzed EQIP contract data from FY1997-2008 to characterize and compare payments for practices that target water quality across confined and unconfined production within the beef, dairy, poultry and swine industries.

We found that practices associated with intensive, confined animal production, in particular waste storage facilities, dominated EQIP's support for the dairy, swine and poultry sectors. In contrast, investments to the beef sector were distinct in that beef received the largest share of EQIP payments for water quality and unconfined, extensive practices such as fencing were among the top funded activities for beef production. Industry characteristics for each livestock sector are presented to help explain the funding pattern described and the environmental tradeoffs of dominant practices are discussed. While we recognize that certain interest groups may oppose the high level of investment documented for confined practices, we suggest that the environmental outcomes of

Student Presentation Abstracts

EQIP spending are more likely tied to day to day management, rather than inherent characteristics, of the practices receiving funds. For this reason, technical assistance and post-installation monitoring are recommended as tools necessary for ensuring that EQIP investments result in water quality improvements.

Yu-shiou Tsai, *School of Engineering, Tufts University*

“Sensitivity of Streamflow to Land Use, Water Use, and Climate in Eastern US”

The objective of this research is to assess the sensitivities of freshwater availability in the eastern U.S. to the three main influences: changes in climate, land use, and water withdrawals. These sensitivities are quantified in terms of the dimensionless measures known as elasticities, such as climate, land-use, and water-withdrawal elasticities of streamflow. The climate elasticities are represented by precipitation and temperature elasticities; the land-use elasticities are represented by agriculture-land, grass-land, forested-land, and urban-land elasticities; and water-withdrawal elasticity is represented by freshwater-withdrawal elasticity. We document that multivariate approaches to estimation of such elasticities is necessary, with very different results obtained when one does not consider multivariate interactions among climate, land-use and water-use. For example, our results indicate that across the entire eastern U.S. (water resource regions 01, 02, and 03) and in each region alone, both annual mean and annual minimum flows appear to be quite sensitive to changes in both climate and land-use and those elasticities are markedly different when each are estimated independently, as if climate and land-use were truly independent variables.

Brian Thomas, *School of Engineering, Tufts University*

“Impact of Stormwater BMPs on Boston Groundwater Levels”

Water Resources Management, Planning, and Conflict Over the past century, the City of Boston has periodically experienced a decline in water table elevations and the associated deterioration of untreated timber piles which support building foundations. To combat declining water tables, Boston has instituted a groundwater conservation overlay district enforced by City zoning boards to require stormwater recharge practices for any new development or redevelopment project that increases impervious area. The primary goal of this research was to determine if such stormwater recharge best management practices (BMPs) have had an impact on groundwater levels in Boston. Recharge to the water table in Boston results from the infiltration of rainfall and snowmelt, leakage from water mains, and recharge from man-made systems (Aldrich and Lambrechts, 1986). As water providers in Massachusetts strive to meet requirements of Massachusetts General Law Chapter 21G, which requires unaccounted-for water (e.g. leaking water pipes) to less than 10 percent (<10%), investigations have been conducted to isolate and remediate leaking water pipes throughout the city. Given the high percentage of impervious cover area of Boston, the remaining sources of recharge are primarily man-made systems, including pump and infiltrate systems and stormwater recharge BMPs.

The goal of this study was to determine the extent to which installed stormwater recharge BMPs have led to increased groundwater levels. Regional multivariate regression models were developed to determine the potential effects of recharge BMPs on observed groundwater elevations. Our final

models reveal that the installation of recharge BMPs has a slight but significant positive impact on groundwater levels in the Back Bay with the effect being proportional to their capacity and inversely proportional to their distance from the location of interest. The resulting models can be used to predict the impact on average well elevations at a particular location, of installing a recharge BMP (or a set of such BMPs) of a particular capacity at a particular distance from that location.

Melissa Ng, *School of Engineering, Tufts University*

“The Hydromorphology of Two Urbanizing Watersheds”

It is now common knowledge that human activities including water diversions and land development, in addition to climate, have a significant impact on streamflow and other hydrologic processes. The effects of changes in land use, water withdrawals and climate are experienced simultaneously and may interact with each other. Increasingly, it is necessary for hydrologists to develop methods for predicting streamflow which account for human activities. Most previous research has investigated the effects of changes in climate or land use on streamflow, and rarely both simultaneously. There are even fewer studies that address the effects of water withdrawal on streamflow and even fewer on the impacts of all three. The primary objective of this study is to develop stochastic streamflow models for predicting monthly streamflows for two urbanizing watersheds in the vicinity of Boston. Streamflows in urban environments are impacted by climatic, land use and water use effects. In this initial study, multivariate non-stationary monthly stochastic streamflow models are developed using multivariate linear regression.

Rhiannon Ervin, *School of Engineering, Tufts University*

“Exploring the Use of Partitioning Tracers for the Assessment of DNAPL Source Zone Architecture”

Approximately 60% of EPA National Priority List sites are known to have groundwater that is contaminated by dense nonaqueous phase liquids (DNAPL). The physical properties of these compounds allow them to remain in the subsurface for decades. Additionally, these chemicals appear to be harmful to humans at parts per billion levels. Consequently, if DNAPL contaminated sites are not remediated, the contamination can remain in the subsurface, contaminating groundwater for hundreds of years. Recent research highlights the importance of quantifying the relationship between DNAPL spatial distribution, source strength and source longevity. Since the precise spatial distribution of DNAPL saturations (also known as the DNAPL architecture) may be impractical (technically or economically) to assess, attention is now placed on understanding the key features of the DNAPL architecture that control the down gradient dissolved concentrations. Partitioning tracers are one tool that may permit interrogation of DNAPL architecture. Traditional use of partitioning interwell tracer tests, however, provide an estimate of DNAPL saturation that is integrated over the flow path of the tracer. While helpful in estimating overall saturations or total mass of DNAPL, few interwell tracer tests are designed to provide sufficient resolution to assess DNAPL architecture. Here we explore using partitioning tracers under the conditions of nonlinear and nonequilibrium transport, with the intent of refining estimates of DNAPL architecture in localized portions of the source zone. Initial efforts were directed toward

Student Presentation Abstracts

elucidating equilibrium interactions of several common partitioning alcohols in a system comprising water and TCE-NAPL. Results illustrate the importance of assessing the partitioning of these tracers over a wide concentration range. Column experiments comprising sandy media containing uniformly entrapped TCE-NAPL were conducted to explore kinetic mass transport of each tracer. Results suggest the possibility of exploiting the diffusional resistance within the DNAPL to assess localized source architecture. Current efforts are focused on evaluating the potential of nonequilibrium transport to yield estimates of DNAPL architecture in systems comprising nonuniform distributions of DNAPL.

Vicki Zoltay, *Senior Analyst, Abt Associates*

“Generalized Watershed Management Modeling: Case Study Ipswich River”

Complex interactions among components of a watershed system necessitate the evaluation of management options within a watershed framework in order to realize the full impact of management decisions. A generic optimization model was developed to evaluate a broad range of technical, economic and policy management options within a watershed context. With continued development and urbanization, human impact on the hydrology of a watershed can be significant such that it not only impacts but dominates the system. Therefore, the model integrates natural and human elements of a watershed system. Since water demands consist of concurrent requirements for both water quantity and quality, the model was developed considering both the flow and the concentration of constituents to evaluate the full impact of management decisions. The initial application of the model to the upper Ipswich River Basin in Massachusetts is a linear programming formulation where quantity is considered in management decisions. A future version will include a nonlinear solution to the combined consideration of the quantity and quality impacts of various decisions. Initial results demonstrate the relative efficacy of undervalued management options. The results also document the merits of integrated water resources management by demonstrating the value of management strategies that serve several integrated functions. For example, increased infiltration benefits both stormwater and water supply management. The model also successfully reveals that the apparent economic inefficiency of demand management occurs when consumptive demand is reduced and the pricing of wastewater services is based on water demand rather than actual wastewater flows.

Jalal F. Elhayek, *Friedman School of Nutrition Science and Policy, Tufts University*

“Balancing In-stream and Consumptive Water Uses: Mitigating the Impact of Hydroelectric Energy Generation on Endangered Salmon in California”

California's spring-run Chinook salmon (SRCS), a key species of the Butte Creek Watershed, have been listed as threatened under the Endangered Species Act since 1999. The loss of SRCS would have implications for the integrity of the marine and riverine ecosystems in which they live, as well as for the fishermen that depend on salmon catch for their livelihoods. The operation of hydroelectric projects in the watershed contributes significantly to SRCS population decline. Currently, permits for hydroelectric projects in Butte Creek are being reviewed, with particular focus on their impacts on SRCS populations. The Stockholm Environment Institute is utilizing their WEAP model to identify the potential outcomes of various scenarios and management strategies relevant to the protection SRCS in Butte Creek. This research presents the regulatory framework through which management strategies are developed. It also presents the scientific bases for such strategies. After describing the process by which various public and private stakeholders engage in the permit process, tradeoffs between continued operation of hydroelectric projects and the enhancement of SRCS populations are considered.

Dr. Andrew Jay, *Massachusetts Oyster Project for Clean Water*

“Exploration of the cost-effectiveness of using oysters for nitrogen removal from wastewater relative to treatment plants”

The average person excretes about 12 pounds of nitrogen in sewage waste per year. In many urban or coastal communities it is treated in plants that also remove other solids and seek to lower the Biochemical Oxygen Demand (BOD). As a result it is difficult to obtain numbers for the cost solely for removing nitrogen. Our literature search and research has obtained values as high as \$28-31.50 per pound. In a 2004 study examining retrofitting existing treatment plants to remove more nitrogen prepared for the Maryland Department of the Environment by Gannett Fleming, the incremental cost per pound of nitrogen removal ranged from a low of \$0.55 per pound to \$30.29 per pound.

Oysters are about 1.4% nitrogen by weight and the nitrogen contained in the shells is effectively sequestered as the shells are quite durable lasting thousands of years. The presented model assumes tiny seed oysters can be obtained for \$0.01 each and that the oysters are assumed to live up to three years. The presented model is developed for discussion purposes, however, it indicates that if three year survival reaches 25%, that oysters could be cost-effective relative to treatment plant build-outs that cost \$16.55 per pound of nitrogen removal. Given the relative cost and the additional environmental benefits of oysters as a keystone species in the benthic community, the species should be considered as a method to augment physical plant build-outs. The proto-type model is presented for discussion purposes and ignores several factors including the energy costs associated with raising spat as well as the down-stream nitrogen removal of offspring should the oysters multiply.

Antarpreet Jutla, *School of Engineering, Tufts University*

“Satellites and Human Health: Potential for Tracking Cholera Outbreaks”

Cholera continues to be a significant health threat across the globe. The pattern and magnitude of the seven global pandemics suggest that cholera outbreaks primarily originate in coastal regions and spread inland through secondary means. Cholera bacteria show strong association with zooplankton and phytoplankton abundance in coastal ecosystems. Characterization of space-time variability of chlorophyll, a surrogate for phytoplankton abundance, in Northern Bay of Bengal (BoB) is an essential step to develop any methodology for tracking cholera in the Bengal Delta from space. Using ten years of satellite data, this study (a) quantifies the space-time distribution of chlorophyll in BoB region and (b) presents a hypothesis as to how coastal plankton may be related with cholera outbreaks. Preliminary results suggest that variability of chlorophyll at daily scale, irrespective of spatial averaging, resembles white noise. At a monthly scale, chlorophyll shows distinct annual seasonality and chlorophyll values are significantly higher close to the coast than those in the offshore regions. At pixel level (9 km) on monthly scale, on the other hand, chlorophyll does not exhibit much persistence in time. With increased spatial averaging, temporal persistence of monthly chlorophyll increases and lag one autocorrelation stabilizes around 0.60 for 1200 km² or larger areal averages. Spatial analyses of chlorophyll suggest that coastal region in BoB have a stable sill at 100 km range. Using satellite chlorophyll data, we observe that phytoplankton blooms occur every year in BoB, yet severe cholera outbreaks happen in certain years. This study provides a working hypothesis on how BoB coastal plankton blooms aided by regional hydroclimatic processes may lead to possible cholera outbreaks in Bengal Delta

David Roman, *School of Engineering, Tufts University*

“Regional Models of Suspended Sediment Transport for the Eastern U.S.”

Estimates of mean annual watershed sediment load, derived from suspended sediment concentration and streamflow data, are often not available at locations of interest. The purpose of this study was to develop multivariate regression models of mean annual suspended sediment loads useful for most river locations in the Eastern United States. The resulting models may be used at ungauged river locations to predict mean annual river sediment loads as a function of basin characteristics. The analysis is based on long-term mean sediment load estimates and explanatory variables obtained from a combined dataset of 1,201 USGS stations obtained from a SPatially Referenced Regression On Watershed attributes (SPARROW) study and the Geospatial Attributes of Gages for Evaluating Streamflow (GAGES) database. The resulting regional regression models, summarized for major U.S. water resources regions 1 through 8, and estimated in logarithmic space, exhibited prediction R-squared values ranging from 76.9% to 92.7%. The results indicate that mean annual sediment loads in the Eastern United States are generally influenced by a combination of basin area, land use patterns, seasonal precipitation, soil composition, hydrologic modification, and to a lesser extent, topography.

Seth Sheldon, *Department of Environmental, Earth and Ocean Sciences, UMass Boston*

“Thermoelectric Power and the Environment: The Water-Energy Nexus in Massachusetts”

Global water and energy demands are increasing, while the inextricable link between our energy and water systems (i.e. “The Water-Energy Nexus”) has been underappreciated, understudied, and underfunded. The presentation is an analysis of water use rates for thermoelectric power generation in the Commonwealth of Massachusetts, and it considers the geospatial relationship between power producing facilities and their natural environment for the years 2001-2006. The state’s energy industry falls within the larger context of the thermoelectric power industry in the United State, which here serves as a baseline for comparison. All of Massachusetts’ 38 large scale power facilities are considered (i.e. those with a nameplate production capacity of greater than 12.5 megawatts), and they are mapped in great detail (i.e. to the street level). A generalized model for water withdrawal and consumption rates is used to estimate total water use and to identify heavy users. The model uses nameplate capacity, cooling type, fuel type, and combustion type as input parameters. Areas of Critical Environmental Concern (ACEC), as identified by the Massachusetts Department of Conservation and Recreation are also identified and mapped, in addition to bodies of water (e.g., rivers, lakes), watersheds, and vernal pools. The intent of this research is two-fold: to identify power plants in Massachusetts that may be negatively affected by severe and prolonged drought, heat waves, or by sea level rise, and to identify areas in Massachusetts that are particularly susceptible to a reduction in water resources as a consequence of their proximity to high water demand power plants. The analysis has the added benefit of being able to identify individual plants for targeted improvements to state watershed conservation.

Yu-shiou Tsai, *School of Engineering, Tufts University*

“Estimation of Climatic and Anthropogenic Influences on Freshwater Availability”

The objective of this research is to assess the sensitivities of freshwater availability to the three main influences: changes in climate, land use, and water withdrawals. These sensitivities are quantified in terms of the dimensionless measures such as climate, land-use, and water-withdrawal elasticities of streamflow. The climate elasticities are represented by precipitation and temperature elasticities; the land-use elasticities are represented by agriculture-land, grass-land, forested-land, and urban-land elasticities; and water-withdrawal elasticity is represented by freshwater-withdrawal elasticity. These elasticities are evaluated using an elasticity estimator, standardized departure about the mean-ordinary least squares estimator (SDM-OLS), that is based on the linear ordinary least squares regression procedure. The results show that (1) across water resource regions 01, 02, and 03 (eastern United States) and in region 03 alone, the estimates of the climate, land-use, and water-withdrawal elasticities are significant; (2) in region 01 the estimates of the precipitation, forested-land, urban-land elasticities are significant while the water-withdrawal elasticity is significant at $p\text{-value}=0.34$; (3) in region 02 the climate and land-use elasticities are significant while the water-withdrawal elasticity is significant at $p\text{-value}=0.10$.

Kaitlyn Weider & David Boutt, *Department of Geosciences, UMass Amherst*

“Regional Data-Driven Study of the Water Table Response in New England over the last 60 years”

The scientific evidence that humans are directly influencing the Earth’s natural climate is increasingly compelling. Numerous studies suggest that this climate change will lead to changes in the seasonality of surface water availability thereby increasing the need for groundwater development to offset those shortages. Groundwater storage and flow are constantly in flux as a response to anthropogenic and climatic stresses. This work focuses on improving and understanding how water level fluctuations in the New England region have responded to recent climatic changes and how these systems will respond to future predicted changes in Northeast climate.

Using 100 long term groundwater monitoring stations with 20 or more years of data coupled with 75 meteorological stations across the New England region, several statistical analyses are performed. Anomalies of groundwater and precipitation data are analyzed and compared regionally and within differing local aquifer systems to understand the sensitivity of the aquifer systems to change. Trend, regression and spectral analysis are performed on the groundwater data to identify statistical relationships with climatic variables, hydrogeologic properties, and the hydrologic setting.

Results suggest that regionally, New England aquifers respond strongly to yearly and decadal changes in climate. A strong coherence in the relationship between groundwater and climate variables exists with second order variability related to the hydrogeologic setting of the aquifer. The trend and regression analysis demonstrate that water level fluctuations are producing statistically significant results with increasing water levels over at least the past thirty years at most well sites. These results parallel the predicted changes in precipitation over time, with more winter precipitation falling as rain and less as snow. A unique aspect of this study is that it uses existing independent groundwater, surface water, and precipitation stations as a cost effective approach to investigate long-term changes in the water table response.

John Durant, *School of Engineering, Tufts University*

“The DiNEH Project: Geochemical controls on uranium transport in a waste-burdened mining district: Navajo Nation, NM”

Steve Cohen, Jyotsna Jagai, Karrie-Ann Toews, Bela Matyas, Alfred DeMaria, Jeffrey Griffiths, Elena Naumova, *School of Medicine, Tufts University*

“Socio-economic, Demographic and Environmental Indicators of Six Reported Enteric Infections in Massachusetts, 1993-2002”

Engineers Without Borders, *Tufts University*

“Interdisciplinary teams working on potable water projects in El Salvador”

Shonda Gaylord, *Cummings School of Veterinary Medicine, Tufts University*

“Water and Women”

Gogi Grewal, *Friedman School of Nutrition / School of Medicine, Tufts University*

“Safe Water Systems or Vaccination? Preventing Childhood Diarrheal Diseases in Developing Countries”

Katya Jarrell, *School of Medicine, Tufts University*

“Micro Hydropower for Rural Electrification in Nepal”

Nadine S. Lysiak, *Woods Hole Oceanographic Institute*

Interpreting a long-term stable isotope record derived from North Atlantic Right Whale baleen: Implications for ecosystem-level changes in the Gulf of Maine?

Sarah Mussoline, *Tufts University*

“Seasonal and spatial patterns of North Atlantic Right Whale upcalling behavior in the northwest Atlantic: Implications for management and conservation”

John Parker, *Fletcher School of Law and Diplomacy, Tufts University*

“Climate Change-Induced Freshwater Salination: Human Health Impacts and Adaptation Strategies”

Nathan Rawding, *Urban and Environmental Policy and Planning, Tufts University*

“Cyanobacteria (blue-green algae) and Cyanotoxins: The Scientific Basis for Regulatory Standards”

Kendall Webster, *Urban and Environmental Policy and Planning, Tufts University*

“Mapping landuse change in watersheds with increased peak flows”

Acknowledgements

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