

**July 2013 - June 2014  
Annual Report**

**and**

**July 2015 - June 2016  
Appropriation Request**

**to the**

**Tennessee Higher  
Education Commission**

**September 2014**

 **Institute for a Secure &  
Sustainable Environment**

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Dr. Chris Cox, ISSE  
Director

The Institute for a Secure and Sustainable Environment (ISSE) continues to build on a model of faculty and student engagement in environmental sustainability research coupled to significant accomplishments in community building, outreach, research, and workforce training by ISSE staff members. A total of 45 faculty members engaged in ISSE research or participated in initiatives co-funded by ISSE during the 2013-2014 fiscal year. In addition, seven post-docs, 30 graduate students, and 23 undergraduates were engaged in these activities together with their faculty mentors. In another sign of positive engagement, 26 refereed journal publications were published during the reporting period, an increase of 18% over the previous year. Having now established a track record of engagement, partnership, and support among faculty, the focus in coming years will shift toward building a stronger base of faculty-led externally-funded research projects and continued growth in student support and scholarly research.

One strategy being employed to reach this objective is faculty-led seed projects. Two projects initiated last year are ongoing, while a third project was initiated this year. The first project is the development of an integrated database developed by an interdisciplinary faculty team that integrates water quality, hydrologic, meteorological, biodiversity, and land use data. So far, this database has been leveraged to secure a \$659,000 grant from the USDA NIWQ program with seven UT collaborators (PI: Forbes Walker, Biosystems Engineering and Soil Science). An additional \$5M USDA AFRI-CAP grant with investigators from UT, TN Tech, University of Memphis, and Middle Tennessee State University is pending. Other opportunities are being pursued while the capabilities of the database continue to be enhanced.

The second on-going seed project involves the development of feedstock and value-added chemicals from renewable biomass. Strategically, chemical products are critical to the financial success of biorefineries, and research in this area less developed than biofuels research. So far, that collaboration has yielded two awards totaling \$1.7M and an additional \$4M in proposals that were not funded.

A newly initiated seed project seeks to quantify temporal and spatial variations at the neighborhood scale (micro-climates) and relate these variations to land use and attitudes and behaviors of residents living in those neighborhoods. This exciting interdisciplinary initiative involved three tenure-track investigators from Geography, Civil and Environmental Engineering, and Social Work and has strong potential to appeal to federal funding agencies seeking to link environmental changes and their impacts on humans and their communities.

ISSE has also partnered with the UT Office of Research and Engagement (ORE) to begin two new initiatives related to environmental sustainability. The Green Economy Project seeks to bring together UT and ORNL researchers, government and community leaders, and businesses to share information and insights with the goal of expanding the green economy in the larger Knoxville

# INTRODUCTION

## Introduction (cont)

area. Another goal of the project is to establish an annual report on the status of the local green economy. The Initiative for Sustainable Mobility is supported by ORE, the UT Center for Transportation Research, and ISSE. It seeks to expand policy and operational research aimed at energy, environmental, and accessibility issues within the transportation sector.

Several notable externally funded projects are also reported here. A US Department of Defense project for optimization of ground water remediation projects has demonstrated the potential to reduce risk of project failure, while decreasing remediation costs by up to 50%. A project funded through EPA's Global Methane initiative seeks to quantify the potential for methane emission reductions in the wastewater industry in Chile. We also describe progress on eight projects funded by the USGS through the TN Water Resources Research Center (TNWRRC). The wide-ranging potential impacts of these projects include reduction of in-stream erosion through improved land use and storm-water management policies; better understanding of recharge processes of the Memphis aquifer; protection of Tennessee water quality through improved removal of pharmaceuticals and personal care products in small community waste treatment systems; assessment of land use effects on biodiversity in the Nolichucky River; and improved predictions of water quality resulting from various land usages.

Outreach, education, and training activities of the TNWRRC were also impactful. Erosion prevention training programs conducted on behalf of the Tennessee Department of Environment and Conservation were delivered to more than 2700 professionals. A new training program for low impact stormwater controls is under development. Adopt-a-Watershed service learning activities engaged more than 1600 K-12 students in Tennessee schools. The Tennessee Smart Yard Program trains residents to develop low impact landscapes in

their own yards. Finally the TNWRRC was active in several improvement projects in the Beaver Creek and Stock Creek watersheds.

The China-US Joint Research Center for Ecosystem and Environmental Change (JRCEEC) continued to foster relationships between educators and researchers of these two countries that share common economic goals and environmental challenges. Major progress was made in obtaining funding from the Chinese Scholarship Council to implement the 100 Scholars program designed to facilitate PhD studies for Chinese students at the University of Tennessee. This partnership is envisioned to deepen research collaborations between UT and our partner Chinese institutions.

The East Tennessee Clean Fuels Coalition continued its education and outreach mission to expand the use of alternative fuels in the region through market initiatives, idle reduction programs, clean fuels workshops, a National Plug-in Day promotion, and trade industry publications designed to promote clean fuel alternatives among fleet operators.

Through funding from NSF and USAID, GLORIAD had another successful year in building global cyberinfrastructure to connect scientific and educational communities around the world and expanded its services and expertise to include network measurement, monitoring and security. This expanded capability facilitated the submission of recent NSF proposals totaling over \$14M that are currently pending.

These are a few of the highlights achieved by ISSE-affiliated faculty researchers, their students, and ISSE staff members over the past year; many more of their accomplishments are described in this report. Overall it was a very successful year and I believe that ISSE is well positioned to build up these successes in the coming year.

# 2013-14 Programmatic Report

## 2013-2014 Programmatic Report

### Tennessee Water Resources Research Center (TNWRRC)

#### TVA Database Mining

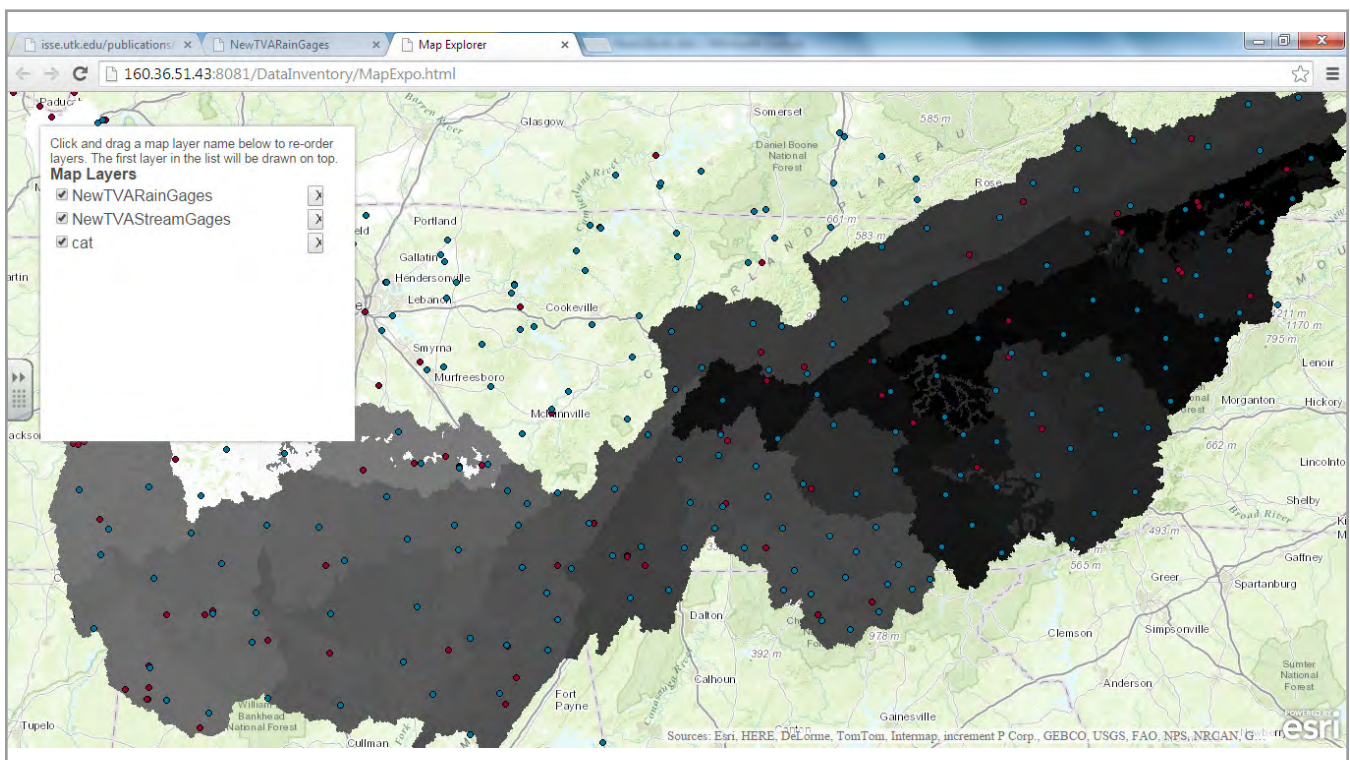
(PIs: Liem Tran, Geography, and John Schwartz, Civil and Environmental Engineering. Additional team members: Carol Harden and Kelsey Ellis, Geography; Richard Strange and Ben Keck, Forestry, Wildlife and Fisheries; Ungtae Kim and Jon Hathaway, Civil and Environmental Engineering)

This project, which just completed its second year, is jointly funded with UT's Office of Research and Engagement. The goal of the project is to create an integrated database that includes hydrologic, water quality, biodiversity, weather, climate, and land use data, to enable interdisciplinary systems-level investigations of water resource issues within the TVA system. This year, the focus was on data entry into a GIS-based database with a web interface. More than 80 datasets/layers and associated metadata have been processed and organized into an ESRI geodatabase. In addition more than two dozen GIS tools for data display, classification and attribute, and spatial queries have been implanted in the web interface.

Our current effort is to develop a data portal—the Tennessee Valley Authority (TVA) Data Portal—based on the already collected data and GIS layers as well as new data (e.g., hydrologic and hydraulic data, popula-

tion censuses, land cover data, elevation data, climate data, soil data, and more). The main goals of the TVA data portal are to (1) collect, preserve, integrate, and merge data sets to create custom outputs that measure hydrologic, environmental, and population changes in the TVA region, (2) develop tools and procedures to manage and disseminate the data collections as well as tools to communicate with other TVA databases, (3) perform outreach to engage the scientific community and the public regarding the data products, and (4) establish a database structure to ensure the long-term use of the data portal.

Two specific projects were completed by Civil Engineering MS students who graduated Spring semester 2013; they were Joe Rungee and James Jones. Joe Rungee completed a reservoir routing optimization problem examining the effects of climate change specifically on Norris Dam operations. The title of his thesis is: Climate Change Impacts on the Tennessee Valley Authority Regulated River Operations: Long-Term Assessment of the Norris Reservoir. One manuscript for publication is in preparation. James Jones, utilizing TVA's long-term climate data, explicitly examined trends over time and whether basin locations were co-related with any temporal climate changes. The title of his thesis is: Spatial and Temporal Variability in Precipitation and Streamflow in the Upper Tennessee Valley. Two manuscripts for publication were prepared—one manuscript was submitted to the *Journal of Hydrology – Regional*





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*Studies*, and has been accepted with minor revisions. Drs. Jon Hathaway and Kelsey Ellis were both involved with this work. The second manuscript will be submitted to *Hydrological Processes*.

A third project, involving Jennifer Starkey, is assisting TVA in the large-scale development of their river management system, specifically the development of a HEC-RAS unsteady flow model for the entire TVA system. Her research involves addressing and finding solutions to conditions that cause model instabilities. TVA's goal is to have a fully integrated climate-hydrology-hydraulics modeling system for prediction of water surface elevations based on climate forecasts and potential dam operations and flow regulation. Data to run this model will be archived in a new database by Deltares.

UT's development of a Data Portal will be linked with TVA's Deltares Archive system. UT's database development is more than the hydrological data that will be stored in the Deltares Archive, including biological, land use, water quality data. A broader array of database variables will enhance the capability of UT to pursue fundamental multidisciplinary research grants. UT will continue its working relationship with TVA's River Operations Division and long-term hydrological data management of the Tennessee Valley.

Two major grants have been submitted this year using the TVA database as a means to calibrate hydrological models for applied research related to water availability and climate change. The two grants are:

**Proposal Title:** Increasing the Resilience of Agricultural Production in the Tennessee and Cumberland River Basins through More Efficient Water Resource Use

**Investigators:** Forbes Walker (PI), Chris Clark, Chris Boyer, Dayton Lambert, Thanos Papanicolaou, John Schwartz; Jon Hathaway, Daniel De La Torre Ugarte, Lambert McGregor, Lixia He, Andrew Griffith, Michael Buschermohle, Brian Leib, Don Tyler, Larry Steckel, Justin Rhinehart, Gregory Nail; Alfred Kalyanapu (TnTech), Brian Waldron (U-Memphis); William Gill (MSTU)

**Funding Agency:** USDA AFRI-CAP Water Resources

**Date:** April 2015 - September 2020

**Funding Amount:** \$5,000,000; **Status:** pending

**Proposal Title:** Using hydro-economic modeling to optimally allocate water in the humid southeastern U.S.

**Investigators:** Clark, Christopher D., Christopher Boyer, Shawn Hawkins, Dayton M. Lambert, Lixia He Lambert, Thanos Papanicolaou, and Forbes Walker.  
**Collaborators:** John Schwartz, Chris Wilson, and Jon Hathaway

**Funding Agency:** USDA NIWQ Program

**Date:** Sept. 2014 – Sept. 2017

**Funding Amount:** \$659,926; **Status:** funded

### USGS Projects

The TNWRRC is one of 54 state-level Water Resource Research Institutes of the US Geological Survey (USGS) and administers several state-level grants through the program. Active projects during this reporting period include:

#### *Determining Channel Protection Flows in Urban Watersheds Through Effective Strategies for Stormwater Management and Stream Restoration*

(PI: John Schwartz, Civil and Environmental Engineering)

Many municipalities and states throughout the country are struggling with how best to comply with regulations stemming from the Clean Water Act and prevent further degradation of local water resources. A large body of relatively recent research has demonstrated the detrimental impacts of urbanization. Urbanization causes widespread changes to stream hydrology and biological impairment due to excessive instream suspended sediment, among other impacts. Increased volume and rate of runoff has led to stream channel degradation in many communities. In-stream erosion contributes more sediment to streams than upland erosion in many cases. However, the linkages between urbanization, stormwater management policy, stream channel geometry, and channel degradation are still poorly understood over the range of watershed settings. This research project is proposed to help clarify the relationships between urbanization, geomorphology, and stormwater management and policy. The complex interactions of these factors will be examined at several pilot streams near Knoxville, Tennessee. The pilot streams will be monitored to calibrate hydrologic models, and to support the use of EPA's SUSTAIN model. The understanding gained through this field and modeling effort will be used to create simple numeric guidance that can be used to set channel protection policy, design site-level stormwater controls for channel protection, and create sound watershed TMDL plans to protect streams from impairment. The data created through this project can be adapted for direct use in channel protection efforts throughout the nation.

#### *Re-filling the Bucket: Recharge Processes for the Memphis Aquifer in the Exposure Belt in Western Tennessee*

(Team: Dan Larsen, Scott Schoefnacker, and Brian Waldron, University of Memphis)

Little is currently known regarding direct recharge to the Memphis aquifer across the unconfined region

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in western Tennessee; however, initial investigations indicate that little recharge may penetrate through the upland surfaces, taking possibly 100 years to move from the ground surface down to the water table. Gaining an understanding of recharge processes in the unconfined region of the aquifer is critical to understanding input rates both spatially and temporally so as to ascertain the impact of land use and climate change and ultimately effect the long-term sustainability of this valuable and heavily relied upon natural resource.

The proposed project will investigate recharge processes in the unconfined region of the Memphis aquifer at the Pinecrest site, near LaGrange, Tennessee. Initial investigations have included using vadose-zone and saturated zone chloride mass balance methods (CMB) to estimate recharge in the upland region (i.e. thick vadose zone), installation of and continuous water level monitoring in an observation well on an upland surface screened within the Memphis aquifer, and recurrent analyses of vadose zone soil moisture profiles within one of the wells using a neutron probe. Furthermore, geologic mapping and reconnaissance soil studies have clarified geologic and soil control on recharge processes.

### ***Long-term Evaluation of Norris Dam Operations under Changing Environments***

(PI: Ungtae Kim, ISSE and Department of Civil and Environmental Engineering)

This project aims to provide practical decision-making information for long-term water resources management in the TVA region based on demonstrated data sources and robust hydrologic methods. The uncertainty of the results generated in this project inherently relies on the credibility of current and future watershed information. This project therefore will emphasize the role of the operating guide currently used in the Norris reservoir to maintain the Clinch River keeping its designated performance. This study found that while the current operating guide will allow the Norris reservoir to meet various flood protection, navigation, and electrical power generation goals in the future, it may be possible to gain additional operating flexibility through modification of the operating guide to meet future conditions.

### ***Engineered Strategy to Remediate Trace Organic Contaminants using Recirculating Packed-Bed Media Biofilters at Decentralized Wastewater Treatment Systems*** (Team: John R. Buchanan and Jennifer DeBruyn, Biosystems Engineering and Soil Science)

This project will create new information as to the ability of recirculating packed-bed media biofilters to remove seven trace organic contaminants from domestic

wastewater. Each day hundreds of chemicals, including hormones, antibiotics, surfactants, and other pharmaceuticals and personal care products (PPCPs) are used and subsequently released to the environment through domestic/municipal wastewater discharge.

These organic wastewater contaminants (OWCs) have been widely detected in surface and groundwater resources, and in soils under the land application of municipal biosolids and septage. The ecological and environmental risks resulting from the release of OWCs are not fully understood. Recirculating packed-bed media biofilters (RPBMB) are a low-cost and low-maintenance wastewater treatment process that is well suited for individual onsite and very small community applications. Approximately 25% of the domestic wastewater generated in the US is processed by individual onsite or very small wastewater treatment systems. Unlike municipal sewage treatment plants, these small systems generally depend on the soil for treatment and effluent dispersal.

The specific objective of this project is to determine whether the combination of endogenous respiration and nitrate-reducing conditions found in a RPBMB can maximize the biodegradation of OWCs found in domestic wastewater. Using a series of laboratory-scale RPBMB, the removal of seven commonly found OWCs will be monitored. The OWCs will include triclosan, bisphenol-A, ibuprofen, diclofenac, naproxen, sulfamethoxazole, and 17 $\alpha$ -ethinyl estradiol.

### ***Assessment of Watershed Land Use Stressors on the Biological Integrity of the Nolichucky River in Tennessee*** (PI: J. Brian Alford, Forestry, Wildlife and Fisheries)

In the Nolichucky River watershed of east Tennessee, there are five fish and seven mussel species listed as endangered or threatened by the State or the U.S. Fish and Wildlife Service, making it one of the most critically important "hot spots" for North American biodiversity. There is concern that pesticide runoff from tomato farming may have caused acute and chronic effects that cause fish mortality and may degrade biotic integrity and ecosystem function. The purpose of this project is to assess the influence of land use stressors in the Nolichucky River watershed on (1) bioindicators of population health in representative fish and benthic invertebrate species and (2) the biological integrity of fish and invertebrate communities. The results of this proposed study will help non-governmental conservation groups and state and federal agencies to better monitor the potential impacts of non-point runoff contaminants to aquatic biota in the Nolichucky watershed. In addition, predictive models developed by this research will enable these groups to more efficiently allocate

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resources and restoration priorities to improving water quality in one of the Nation's most historic and ecologically diverse ecosystems.

### ***High Resolution Monitoring of Urban Stormwater Quality*** (Team: Jon Hathaway and Kim Carter, Civil and Environmental Engineering)

The objective of this project is to obtain a high-resolution water quality data set from an urbanized watershed in Knoxville, Tennessee. The data collected during this study will be of great interest to the scientific community due to the relative lack of quality data sets that can be found in literature. The data collected will be used to characterize emerging pollutants in stormwater runoff, evaluate the intra- and inter-event variability of pollutants, and will be used in future modeling efforts by the principal investigators. The results of this analysis will provide a greater understanding of what influences pollutant fate and transport in urban watersheds, and provide a strong basis for future research.

### ***Underground Reactive Barrier to Attenuate Contaminants from Agricultural Drainage***

(Team: Jaehoon Lee, John Buchanan, Jennifer DeBruyn, Shawn Hawkins, Andrea Ludwig, and Forbes Walker, Biosystems Engineering and Soil Science)

There is a great need for cost-effective and proven best management practices to mediate contaminants (e.g. excess nutrients, pathogens, veterinary pharmaceuticals, etc.) in agricultural drainage. One technology for remediating agricultural chemicals, such as nitrogen (N), is by promoting denitrification using denitrification beds, also called underground reactive barriers. A denitrification bed is constructed by mixing an organic carbon (C) source (typically sawdust or woodchips) into soil below the water table in order to intercept groundwater flow. The increased and continued supply of C to denitrifiers enhances denitrification of the water, thus reducing NO<sub>3</sub><sup>-</sup> in the discharge. The purpose of this proposal is to carry out field studies evaluating an advanced underground reactive barrier using a combination of woodchips and charcoal/biochar. Our preliminary study showed that the addition of biochar/charcoal was very effective in removing phosphorus (P) as well as veterinary antibiotics, which are emerging contaminants. We propose to install underground reactive barriers in the new UT Little River Animal and Environmental Unit located in Walland, Tennessee. The research and education center is bounded by streams on three sides and lies in the floodplain of a state-declared exceptional waterway. This is a unique opportunity, because the data from this study will enable us to advance the underground reactive barrier technology to treat various contaminants in agricultural drainage

while utilizing byproducts from bio-energy production. We will determine if these barriers will help to reduce N, P, and veterinary antibiotics as well as pathogen/fecal bacteria.

### ***Recalibrating the SAGT SPARROW to Accommodate Changes in Agricultural Inputs***

(Team: Dayton Lambert, Christopher Boyer, and Christopher Clark, Agricultural and Resource Economics; John Schwartz, Civil and Environmental Engineering).

The United States Geological Survey's SPATIally Referenced Regression on Watershed Attributes (SPARROW) is a convenient model for forecasting the impacts land use has on water quality through changes in source and non-source point nutrient loading. SPARROW uses nonlinear regression to explain nutrient mass balance in watershed networks as a function of land use, pollution point sources, nutrient runoff from agriculture and urban activities, geophysical features, and climatic factors. Nutrient loading predictions are generated using the stream network configuration of basins. The SPARROW model has been used extensively to forecast changes in nutrient loading in the Mississippi and Tennessee River basins. Our research modifies the South Atlantic-Gulf-Tennessee (SAGT) basin system SPARROW model (developed by Hoos et al. and calibrated and applied by Hoos and McMahon) to examine the impacts land use change resulting from a mature cellulosic biofuel industry (including fiber, wood, and forest residue feedstock) will have on water quality in this region. The challenge we face is updating the agricultural input use and forest land coverage data generously provided by the USGS to inform our counterfactual scenarios. The funding request will provide an opportunity to enhance the modeling capability of SPARROW for the SAGT basin.

### **Training Activities**

TNWRRC coordinates two statewide training and certification programs for the Tennessee Department of Environment and Conservation (TDEC). The Erosion Prevention and Sediment Control Training and Certification program (TNEPSC) is comprised of three basic courses:

- The Level I Fundamentals of Erosion Prevention and Sediment Control for Construction Sites is a one-day foundation-building course for individuals involved in all aspects of land disturbing activities. It was offered 16 times in nine communities with 1306 people attending.
- The Level II Design Principles for Erosion Prevention and Sediment Control for Construction Sites is an intensive two-day course for engineers and



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other design professionals focused on engineering technology needed to plan and design practices and controls for preventing erosion and managing sediment and other stormwater pollutants on construction sites. It was offered seven times in four communities with 184 professionals attending.

- The Level I Recertification is a half-day course for those who have successfully completed the Level I course and need to renew their Level I certification. Recertification is required every three years. It was offered 16 times in 11 communities with 1247 people attending.

The Tennessee Hydrologic Determination Training Program (TN-HDT) is the second training program coordinated by TNWRRC for TDEC. The TN-HDT program consists of a three-day course designed to provide participants with a basic understanding of the underlying scientific principles, the legal ramifications, and the practical investigative techniques surrounding the determination of wet weather conveyances versus streams and other surface water features. The course was offered twice with a total of 45 people attending. The state regulations that established the TN-HDT certification program require those who successfully complete the TN-HDT course attend a one-day refresher course every three years to maintain their certification. The first refresher courses were offered in 2014. Four courses were offered across the State with 48 persons attending.

### *Low Impact Development Stormwater Manual and Training Courses*

The TNWRRC, including faculty and graduate students from the Department of Civil and Environmental Engineering (CEE) and the Department of Biosystems Engineering and Soil Science (BESS), are working with staff from TDEC's Division of Water Resources to develop the first edition of the *Tennessee Permanent Stormwater Management and Design Guidance Manual*. TDEC has established stormwater runoff reduction as the primary treatment objective for new development and redevelopment projects across Tennessee. This new manual will provide detailed design guidelines for permanent stormwater control measures that meet this treatment objective. The primary purpose of this manual is to serve as a technical design reference for designated and non-designated (unregulated) MS4 (municipal separate storm sewer system) communities in Tennessee. It is intended to provide the information necessary to properly meet the minimum permanent stormwater management requirements as specified in MS4 permits. The UT team has also developed the Runoff Reduction Assessment Tool (RRAT) to be used

in conjunction with the Manual. The RRAT will assist professional engineers and other design professionals to ensure that the stormwater management plans they have prepared meet the permanent stormwater performance standards for new or redevelopment sites.

In addition, TDEC has contracted the TNWRRC to develop and deliver two new training courses that will inform local officials, administrators, design professionals and consultants, and private sector companies on the use of the manual to develop, implement, and maintain the permanent stormwater control measures and practices described in the manual. These courses will be offered beginning in 2015.

### **Watershed Initiatives**

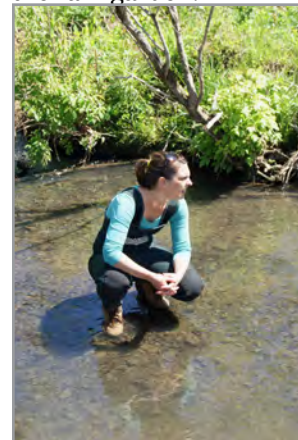
In FY14 TNWRRC served as project manager for two watershed initiatives, one in the Beaver Creek Watershed and one in the Stock Creek Watershed. TNWRRC uses the partnerships cultivated during these initiatives to provide opportunities for research and service learning activities for students and faculty.

#### *Beaver Creek*

TNWRRC continued to manage a grant from the Tennessee Healthy Watershed Initiative to build a Stormwater Best Management Practices demonstration park. WRRC Senior Research Associate Ruth Anne Hanahan designed and built a demonstration rain garden in the park as part of ISSE/Extension Tennessee Smart Yards initiative. Wesley Wright, Biosystems Engineering and Soil Science (BESS) Research Associate for Instrumentation, installed sensors to monitor infiltration rates in the rain garden.



*Wesley Wright, UT BESS, installs a sensor to capture flow rates in the Harrell Road rain garden.*



*Cathy Olsen, master's candidate in Geography, dons waders and assists in a Beaver Creek IBI.*

Several students conducted research projects with help from TNWRRC in the Beaver Creek Watershed. Cathy Olsen, Master's candidate in Geography, under Dr. Liem Tran and Dr. Carol Hardin, used Beaver Creek as a case study for her work in NPDES permit requirements for small municipalities. Rachel Craig, Doctoral candidate under Dr. Liem Tran in Geography, completed a then-and-now comparison of

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the *Beaver Creek Watershed Assessment*, published in 2003 as a guide to restoring the Beaver Creek Watershed. Craig took watershed restoration data compiled over the past 10 years to determine the effectiveness of restoration efforts as compared to the recommendations in the 2003 publication.

### Stock Creek

TNWRRC continued working with Knox County Stormwater and the Knox County Health Department during FY14 to identify failing septic systems in the Stock Creek watershed. Over 100 households were contacted resulting in 26 septic system repairs and an additional 25 septic tank pump outs. Dr. Alice Layton, UT Center for Environmental Technology, conducted *E.coli* analyses on samples taken from Stock Creek to assess the bacterial water quality of the watershed. Dr. Layton also used a fecal source indicator assay based on *Bacteriodes* ribosomal RNA, a technique she pioneered in Stock Creek in 2003. A comparison of water quality measurements between 2003 to 2014 showed no significant reduction in *E. coli* concentrations over time, indicating much work is left to be done. The fecal source indicator assays identified locations in the creek affected by bovine fecal impacts and those affected by human fecal contribution.

### Knox County Adopt-A-Watershed Program

The 2013/14 Knox County Adopt-A-Watershed (AAW) Program involved 1622 students across across 11 middle and high schools in hands-on learning activities to prepare them to conduct a service that would im-

prove the well-being of their schools' watershed. AAW is managed by the TNWRRC and is sponsored by Knox County Stormwater and the Water Quality Forum. Service learning projects are curriculum based and the selected services are coordinated with community partners to ensure they meet a need within the school's watershed. Of the students involved in AAW this past year, approximately 70% received six hours or more of class and field instruction on watershed concepts and processes to prepare them for their service event.

Service learning projects completed this year included the removal of exotic invasive plants along stream corridors in order to allow the re-establishment of native species; stabilization of eroding hillsides; establishment and maintenance of campus rain gardens and the diversion of parking lot debris from storm drains. Students across Conner Creek, Stock Creek, Beaver Creek and Ten Mile Creek Watersheds collectively removed about 2500 pounds of invasive, exotic plant material. Karns High and Grace Christian Academy students directed their efforts towards assisting Knox County in establishing its first Demonstration Stormwater Park, located in the Beaver Creek floodplain along Harrell Road. Students removed about 150 feet of old buried silt fence, stabilized a little over one acre of land with erosion control matting, and planted and mulched a rain garden. In the Stock Creek Watershed, South Doyle High students assisted in installing a campus rain garden. Students at Powell Middle in the Beaver Creek Watershed continued to maintain its two campus rain gardens. Classes in six schools installed inserts in



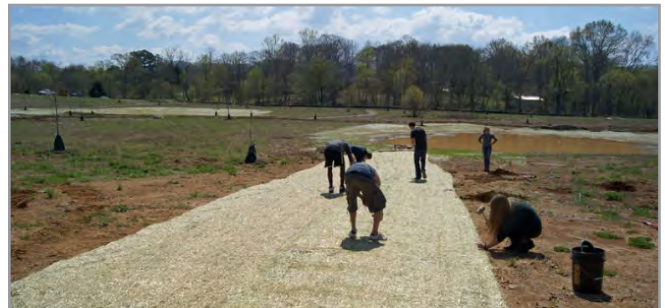
Hardin Valley Academy students remove privet along Conner Creek in Outdoor Classroom



Powell High students plant seedlings along Beaver Creek



Karns High students plant a rain garden located in Knox Co. Harrell Rd. Stormwater Park



Karns High students install erosion control matting at the Knox County Stormwater Park



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school parking lot storm drains and over the course of the year removed about one-half ton of parking lot debris that had accumulated in the inserts, material which would have otherwise entered our local waterways.

An AAW project conducted by West Valley Middle School's seventh-graders received special recognition from the Knox County School Board as an exemplary cross-curricular project-based initiative. Working with 12 teachers from social studies, math, language arts, and sciences, the project involved 420 students with a focus on campus erosion. Social studies students rated and ranked eroded sites on campus; math students calculated potential soil losses; science students stabilized eroded sites; and language arts students created outreach products to educate the community about the issue. A participating teacher and representative students presented this project to the Knox County School Board.



*Central High students remove storm drain to collect and measure collected debris in insert*



*West Valley Middle students with Superintendent Lindsey at Knox County School Board meeting where they presented their AAW cross-curricular erosion project*

AAW continued its support of six campus-based outdoor classrooms. Work in the Hardin Valley Academy Outdoor Classroom involved students removing invasive plants and installing native ones along Connor Creek. The Powell High Outdoor Classroom was reinvigorated by an industrious Watershed Club that renovated an amphitheater and a butterfly garden and organized a planting of 250 seedlings and shrubs along Beaver Creek. The South Doyle Middle Club likewise focused on riparian plantings along Baker Creek in their Outdoor Classroom, in addition to installing a butterfly garden. At the Halls Outdoor Classroom students, teachers, and local partners came together to conduct its annual HOC community spring celebration with approximately 225 in attendance.

### Tennessee Smart Yards

Tennessee Smart Yards has continued to rebrand itself and reach out to new communities across the state through a series of Train-the-Trainer Rain Garden Workshops supported by the Tennessee Department of Agriculture Nonpoint Source Program. The three workshops were respectively conducted in Madison, Cumberland and Green County at the following UT Centers:

- West Tennessee AgResearch and Education Center, Jackson
- Plateau AgResearch and Education Center near Crossville
- Clyde York 4-H Center, Greeneville

A total of sixty-one stormwater professionals, extension agents, and Master Gardeners participated in these workshops, with each session involving the participants in the installation of a rain garden. The intent of these gardens are twofold: to serve as rain garden demonstrations for the local communities and to be used as teaching tools for future rain garden workshops. After attending the Jackson workshop, the City of Mt. Juliet's Stormwater staff conducted a workshop for local residents, including the installation of a rain garden with the assistance of TNSY staff. TNSY has also continued its partnership with the Lower Clinch Watershed Council, conducting four rain garden workshops for the public over this past year and installing two demon-



*TNSY Smart Yards Rain Garden Educational Signage Located at the UT Gardens*

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station rain gardens. As a part of TNSY's rain garden educational effort, a template rain garden sign was created and initially installed at its demonstration garden located at the UT Gardens.

Tennessee Smart Yards has continued its outreach through its updated marketing materials (e.g., displays, brochures), its revamped web site (tnyards.utk.edu), Facebook page, and quarterly newsletters. TNSY also continued to have a presence across the state through participation in community events (e.g., UT Gardens Bloomsday) and through presentations and booths at conferences (e.g., TN Environmental Conference). Guidance documents have been produced, including

one specifically for the homeowner entitled *Water Your Liquid Assets, A Home Stormwater Assessment*. This extension publication can be incorporated into homeowner training as well as used by stormwater professionals and extension agents when assisting homeowners in considering the application of appropriate stormwater best management practices for their home landscapes. TNSY is in the final stages of completing a comprehensive native plant database containing trees, shrubs, and herbaceous plants that can assist homeowners in plant selections under varying landscape conditions. The contents of this database has been extensively researched and includes a blog managed by a Tennessee Master Gardener with extensive experience in installing native plant gardens.

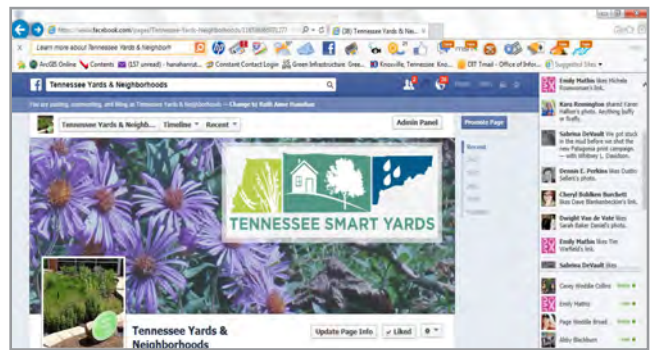
**The Nine Principles**  
Protect our resources... For generations to come...

- 1 Right Plant, Right Place**  
Plants selected to suit a specific site require less water, pesticides, and pruning.
- 2 Manage Soils & Mulch**  
Appropriate mulch management helps retain soil moisture, prevent erosion, and increase root growth.
- 3 Recycle**  
Compost grass clippings, leaves and yard trimmings, avoid using white goods, or plastics.
- 4 Water Efficiently**  
Efficient watering is key to a healthy landscape and the conservation of a precious resource.
- 5 Use Fertilizer Appropriately**  
Follow soil test recommendations for fertilizer application.
- 6 Manage Yard Pests**  
Overuse of pesticides can harm all good insects, people, pets, and the environment.
- 7 Reduce Stormwater & Pollutants**  
Water runoff off your yard can carry pollutants like soil, fertilizers, and pesticides that harm water quality.
- 8 Provide for Wildlife**  
Plants in your yard that provide food, water, and shelter can support Tennessee's diverse wildlife.
- 9 Protect Water's Edge**  
Careful management of waterfront property is critical to the health of Tennessee's waterways.

Tennessee Smart Yards is a University of Tennessee-led program that guides and assists Tennessee residents and neighborhood associations with practices they can easily use in their yards and common spaces to create healthier living spaces and communities.

Nine fundamental principles of sustainability serve as the cornerstone for the program and are being incorporated into an over-broadening selection of popular and practical workshops taught by UT Extension and water resource professionals.

Our hands-on courses aim to help homeowners achieve a landscape that reflects their values, desires, and needs, while ensuring the protection of Tennessee's invaluable waterways.



TN Smart Yards Native Plant Database Located on TNSY Website

**Healthy landscaping that protects our water resources**

**THINGS YOU CAN DO RIGHT NOW:**

- Let your grass grow taller
- Compost your yard waste
- Learn about your plants

**STORMWATER BEST MANAGEMENT PRACTICES:**

- Disconnect your downspouts
- Use a rain barrel
- Install a rain garden

For more information contact the statewide office  
Tennessee Water Resources Research Center  
867-674-9124

www.tnyards.utk.edu  
Find us on Facebook

TN Smart Yards Brochure

**Extension**  
**Rainwater: Your Liquid Asset A Home Stormwater Exercise**

**What is stormwater runoff?**  
Stormwater runoff is rainwater that does not soak into the surface on which it falls, but rather runs along the surface downhill. It is commonly associated with urban areas because of the increase in impervious surfaces (roads, driveways, roofs) which impede water from infiltrating (soaking into) the ground. Stormwater picks up and carries pollutants, like sediment, trash, tires, car parts and pollutants, to our streams and rivers. Excess stormwater also can result in flooding and damage to important infrastructure, such as roads, bridges, and sanitary sewers.

**Where does it come from?**  
The amount of stormwater produced during a rainfall depends on many factors, including the extent of impervious surfaces, topography, amount of vegetation and soil type. For example, soils that are primarily composed of clay and loam are composed of fine-textured particles and are therefore more susceptible to runoff.

The frequency of stormwater through communities are influenced primarily by the type of land and how local municipalities and property owners react. Stormwater flows downhill, following the path of least resistance and, from your home, may be treated and used, serve neighbor's properties, and through

Examples of stormwater flow on a property

Stormwater drainage pipes that empty into a creek. As it makes its journey, stormwater carries an impurity (grass) to the creek and ultimately connects each parcel of land -- and the activities happening on it -- to a local waterway.

**STORMWATER FACTS**

- For every inch of rain that falls, it takes an average of 10 minutes to infiltrate the ground. In urban areas, only 10% of the rain infiltrates the ground.
- For every inch of rain that falls, it takes an average of 10 minutes to infiltrate the ground. In urban areas, only 10% of the rain infiltrates the ground.
- The higher the rainfall, the more likely it is to cause flooding. The more impervious surfaces, the more likely it is to cause flooding.
- Stormwater runoff is a major cause of flooding in urban areas.
- Stormwater runoff is a major cause of flooding in urban areas.

UNIVERSITY OF TENNESSEE  
INSTITUTE OF AGRICULTURE



## 2013-2014 Programmatic Report

### China-US Joint Research Center for Ecosystem and Environmental Change (JRCEEC)

#### BACKGROUND

The China-US Joint Research Center for Ecosystem and Environmental Change (JRCEEC) was established in 2006 to enhance collaboration among Chinese and US scientists in environmental research and education. The center's partners include University of Tennessee (UT), Oak Ridge National Laboratory (ORNL), Purdue University, Chinese Academy of Sciences (CAS), and University of Science and Technology of China (USTC). In 2011, the Center was accepted into the China-US EcoPartnership program, which was established by the U.S. Department of State and the China National Development and Reform Commission (NDRC). Financial support for the JRCEEC is provided by ISSE and the College of Agricultural Sciences and Natural Resources (CASNR).

#### ACTIVITIES AND PROGRESS IN 2014 FISCAL YEAR

##### *JRCEEC 2013 Annual Conference*

The seventh annual China-US workshop (also the 3rd annual symposium of the Ecopartnership) was held on November 17-19, 2013 in Gatlinburg, Tennessee, USA. The theme of the conference was "Environmental Health and Green Development." More than 150 scien-

tists, students, and industry and government leaders attended the conference. A total of 77 presentations (10 keynotes, 47 orals and 20 posters) were made in the six sessions: (1) biological processes of pollution and remediation, (2) agricultural sustainability and food security, (3) environmental conservation, (4) environmental health and waste treatment, (5) global climate change and resources utilization, and (6) technology-society interactions. UTIA Chancellor Dr. Larry Arrington made the opening speech. A welcome was given by other US leaders, including Dr. Taylor Eighmy (UTK Vice Chancellor), Dr. Anthony Palumbo (Director of ORNL Biosciences Division), Dr. Sherry Wang (Program Director of Tennessee Department of Environment and Conservation), Dr. Tim Filley (Ecopartnership Director at Purdue University), Dr. William Brown (UTIA Dean for Research), and Dr. Gary Saylor (JIBS Director). Almost 20 UT and ORNL faculty members and 20 UT graduate students presented their research and participated in the pre- and post-conference exchanges, such as group meetings.

##### *Collaborative Research Group*

The collaborative research group (CRG) on Biogeochemistry & Climate Change, led by Sean Schaeffer (UTIA faculty) and Xudong Zhang (CAS professor), held its third group meeting at UTIA on November 20, 2013. Primary outcomes included: 1) two joint manuscripts in peer-review or in preparation; 2) a Chinese PhD student has joined Schaeffer's group for a year-



Group picture of attendees at JRCEEC's 2013 Annual Workshop held in Gatlinburg, Tennessee, USA, on November 17-19, 2013



## 2013-2014 Programmatic Report

long isotopic research on terrestrial cycles of carbon and nitrogen; 3) a joint research proposal was prepared and submitted to the US NSF and NSF of China. The proposal was ranked number two out of seven proposals but not funded. The proposal will be resubmitted in 2015.

### Topical Workshops

In the second half of 2013, JRCEEC organized six workshops or special forums. The activities not only facilitated creation of new opportunities for research collaboration and data/sample exchange but also promoted UT's international reputation. The workshops were:

- China-US Joint Research Center Summer Workshop on Bioreporters and Their Applications, hosted by the CAS's Research Center for Eco-environmental Sciences, Beijing, China, May 20-June 10, 2013
- China-US Joint Workshop on "Biogeochemistry of Carbon and Nitrogen," hosted by Shenayng Agricultural University, Shenyang, China, June 27-28, 2013
- China-US Ecopartnership Workshop on "Land Use Change-An Opportunity for Agricultural Sustainability," hosted by Shenyang Agricultural University, Shenyang, China, December 14-15, 2013
- Special Forum—"China-US Ecopartnership: Biomass and Bioenergy," hosted by China Agricultural University, Beijing, China, December 16, 2013

- Special Forum—"China-US Ecopartnership: Below-ground Ecology and Biomass Assessment," hosted by the CAS's Institute of Geographic Sciences, Chinese Academy of Sciences, Beijing, China, December 16, 2013
- China-US Ecopartnership Workshop on "Resources and Environmental Policy Research," hosted by Research Development Center, The State Council of China, Beijing, China, December 17, 2013

### The 100 PhD Program

The 100-PhD program has been funded by the China Scholarship Council (CSC) to provide 100 scholarships during the years from 2015 to 2020. A total of approximately \$8 million will be provided by the CSC to cover the living stipends of UT Ph.D students recruited from China. The proposal for this program is one of 15 proposals selected from 190 proposals for financial support. A web page for the program is under construction and a university-wide committee has been established to manage the program. Student recruitment and faculty partnering are ongoing.

### Joint Research Proposal

A joint research proposal, "Dimensions US-China: Linking viral and bacterial biodiversity to ecosystem function in agricultural and successional landscapes" (\$1,615,696; PIs: Mark Radosevich and Hui Xu), was submitted to the US NSF. The proposal was not funded but received high rankings.



## 2013-2014 Programmatic Report

### East Tennessee Clean Fuels Coalition (ETCleanFuels)

#### Alternative Fuels Market Initiative

This partnership, managed by the Center for Transportation and the Environment in Atlanta, is working to identify barriers to gaseous fuel deployment in a four-state region (South Carolina, Georgia, Tennessee, and Alabama). Project partners in this DOE-awarded grant are addressing barriers in several ways: by hosting workshops of fleet managers, industry representatives, and government officials to determine what they perceive as barriers; hosting first responder safety training for alternative fuel vehicles; creating comprehensive workbooks covering natural gas, propane, and policies and incentives related to these two fuels; working with public relations firms to create a targeted campaign to improve perception of gaseous fuels; and conducting case studies with fleets that have implemented natural gas or propane.

#### Idle Reduction Initiatives

Through a subcontract with Oak Ridge National Laboratory, project facilitator Kristy Keel-Blackmon is co-authoring a comprehensive Idle Reduction Guide. The high-level report will be used to encourage idle reduction among fleet management within the Department of Energy and the federal complex. Best practices, technical information supporting idling reduction, environmental benefits, and case studies will be included to formulate a complete case for reducing unnecessary idling. The final product will include the finished report, a PowerPoint presentation, and a one-page overview of the report with the end goal being that any fleet manager could create their own idle reduction program based on these materials. The project should be completed by late 2014.

Additionally, ETCleanFuels began an EPA-funded project to bring truck stop electrification to five southeastern states in EPA Region 4. Partnering with IdleAir, this project will install EPA SmartWay-verified, anti-idling equipment at six interstate highway locations where no such equipment currently exists. As a result, multiple pollutants of concern created by heavy-duty, long-haul trucks will be reduced, thereby protecting human health and the environment. An outreach program will also be implemented to ensure the continued use of the project equipment. Clean Cities coalitions in each state will work together on the outreach component of the project.

### Chattanooga Natural Gas Vehicle Forum

In November 2013, ETCleanFuels partnered with Chattanooga Gas, the Chattanooga Area Chamber, and the Tennessee Trucking Association to host a natural gas vehicle forum at the Chattanooga Business Incubator. Many area fleets and businesses were invited to learn about the benefits of using natural gas as a transportation fuel. Expert speakers, including ETCleanFuels executive director Jonathan Overly, discussed compressed natural gas basics, current regional activities, natural gas vehicle options, and the environmental and cost-saving benefits that can be seen with this fuel. A natural gas vehicle showcase after the forum helped to reinforce the speakers' messages and showed fleet managers many options that could apply to their fleets. Qualified vehicle modifiers and conversion companies were present to exhibit their technologies and answer questions. Interactions at the event encouraged ongoing conversations about ideal locations in Chattanooga for siting a compressed natural gas fueling station.





## 2013-2014 Programmatic Report

### National Plug In Day 2013

ETCleanFuels acted as facilitator for Tennessee’s 2013 National Plug In Day events in Memphis, Nashville, Chattanooga, Townsend, and Kingsport, and directly organized events in Knoxville (Market Square and Neyland Stadium), Maryville College, and East Tennessee State University in Johnson City. Tennessee succeeded in organizing the most per capita Plug In Day events in the nation with a total of nine separate events spread across the state. Each site had an electric vehicle showcase, educational opportunities, and giveaways. Some sites held ride-and-drive opportunities, guest speakers, and electric vehicle parades. In total, Tennessee’s nine events provided outreach and education about electric vehicles to over 10,500 people. TDEC’s Office of Energy Programs partnered on the events, providing t-shirts and brochures for participants. Plug In Day is celebrated both nationally and internationally every year in late September.



### Alternative Fuels Implementation Team

The Alternative Fuels Implementation Team is a five-state project that works to reduce barriers to alternative fuel use. Clean Cities coalitions in Tennessee, North Carolina, South Carolina, Virginia, and Kentucky, along with other regional partners, are collaborating on this project under the management of the North Carolina Clean Energy Technology Center at NCSU. The project’s main activities include evaluating and suggesting changes to state contract road signage policies, assessing biofuel retailer marketing needs, creating an alternative fuel user database, reviewing incentives for alternative fuels and vehicles, and creating and hosting the Southeast Alternative Fuels Conference and Expo, which is to be held in Raleigh, NC in late 2014.

### Publications

ETCleanFuels produces two publications: a statewide alternative fuels newsletter, The Tennessee Clean Fuels Advisor, and the Clean Cities-powered ezine, Fuels Fix. The Clean Fuels Advisor, produced through partnership with the Tennessee Department of Transportation, is printed twice yearly and is mailed to nearly 3,000 recipients in 46 states. Fuels Fix is a nationwide publication that reflects progress made by Clean Cities coalitions and their stakeholders. It includes alternative fuel success stories, notifications of industry events, and technological advances from national partners.



## 2013-2014 Programmatic Report

### Center for International Networking Initiatives/GLORIAD

The US National Science Foundation (NSF) and US Agency for International Development (USAID) have provided a total of \$22M in funding for the Global Ring Network for Advanced Application Development (GLORIAD) to build and manage cyberinfrastructure (especially advanced network services) connecting science and education communities across the globe. GLORIAD's international partners have invested over \$220M cumulatively. GLORIAD enables global open science cooperation via carefully organized collaboration and co-funding with public and private sectors in North America, Europe, Asia, and Africa. The science communities served by the GLORIAD program, funded by the US NSF since 1997, now circle the northern hemisphere. Partners include Russia, China, Korea, the Netherlands, Canada, the five Nordic countries, Egypt, India, Malaysia, and Singapore. The GLORIAD network serves every knowledge discipline—from high-energy physics to atmospheric and climate change science to renewable energy research to nuclear nonproliferation to genomics and medicine to economics and history. The current GLORIAD map is shown below.



In addition to its day-to-day work managing network links between the US, Russia, China, Korea, Egypt, Singapore, India, and GLORIAD's other European and North American partners, the GLORIAD team worked on re-engineering network services across North America supporting ever-increasing work with the Chinese Academy of Sciences. They also worked with Korean partners on doubling capacity for US-Korea science (to a total of 25 Gbps), continued work with Russian and Nordic partners on a 10-Gbps upgrade of the current US-Russia network, contributed equipment to new partners in Malaysia, and began working with new partners in the Gulf region on connections to Qatar and Kuwait.

The GLORIAD team launched the new InSight measurement, monitoring and security system with three separating versions of the system providing service to different communities—an open, public version of the

system at <https://insight.gloriad.org/>, a closed, secure version for network operations teams at <https://insightnoc.gloriad.org/>, and an open, public version of its historical system with data spanning 1999 to current day at <https://insight.gloriad.org/history/>. This work has involved expanding the partnership with Cisco Systems and Qosient—leveraging more than \$1M in equipment contributions from Cisco and deploying advanced argus technology throughout the GLORIAD-US infrastructure, enabling rich insight into utilization and performance of the GLORIAD network. The work on GLORIAD's new monitoring and security system has been extensive and will likely pave the way for new work and new funding opportunities in the near future.



*GLORIAD InSight System. A sample analytic dashboard illustrating near-real-time updates of live traffic flows and including country-level summarization, average packet loss, protocol, application and various performance flags, source/destination by US state and country and individual flow records.*

GLORIAD organized its annual board meeting—this year in Singapore—with participants representing over 15 countries. The team submitted over \$14 million in new proposals to the NSF, under the new IRNC solicitation, intended to support global networking from 2016–2020; we are awaiting word from the NSF review as this report is written.

### Current Year Plans

GLORIAD new program year is focused on completing the 10-Gbps network upgrade between US-Russia, deploying the new 10-Gbps link to/from India and Malaysia, adding new North/East-African community connections to the GLORIAD exchange in Cairo, beginning a new program emphasis on science connectivity in the Gulf (Middle East) region, and extending its infrastructure, relationships and work in West Africa.

Additionally, the GLORIAD team will continue its close work with Cisco and Qosient to advance the state-of-the-art in network measurement, monitoring and security and extend this work with its partners in China, Korea, Egypt and India. The team will continue work this next year on a new global collaborative system for managing R&E infrastructure in a distributed, decentralized fashion—the distributed virtual network operations center (dvNOC).



## 2013-2014 Programmatic Report

### Initiatives Co-Sponsored with the UT Office of Research and Engagement

#### The Green Economy Project

(PI: John Shefner, Sociology)

The Green Economy Project seeks to increase external funding to support research on Knoxville's Green Economy while nurturing that economic sector locally. This effort requires not only basic research, but outreach to other UT/ORNL researchers, government officials, community organizations, and big and small businesses in order to create multi-disciplinary and multi-sectoral teams and facilitate information sharing. The engagement component is aided this year by the Highlander Transitions Fellow, Tom Torres. Mr. Torres is forming working groups in order to begin a conversation that will culminate in a forum in Spring 2015. The working groups will be comprised of government sustainability representatives and utility officials, business owners, non-profit and economic development specialists, those with specialties and interest in technology transfer and representatives from educational institutions. The forum itself is intended to find the bridges and barriers to expanding the local green economy. The outcomes will include more shared knowledge of labor market needs, potentials for business growth, shared research interests, new regulations needed to grow the Green Economy, and ways to grow jobs. Academic outcomes will include research teams to pursue external research. Engagement outcomes will include a report on the state of the art of the local Green Economy, which will be marketed to the City of Knoxville, Knox County, the Tennessee Valley Authority, the Knoxville Utility Board, and the Chamber of Commerce. ISSE is providing funding for Mr. Torres, in addition to other assistance.

#### Initiative for Sustainable Mobility

(PIs: David Greene, Howard H. Baker Center for Public Policy; and Asad Khattak, Civil and Environmental Engineering)

The vision for the Initiative for Sustainable Mobility (ISM) is to improve the efficiency and effectiveness of transportation systems by focusing on innovative policies and operational strategies that address energy, environment, and equity considerations. Its goal is to address the grand challenge of sustainable mobility, with specific objectives as follows:

- enhance research collaborations among researchers at UT and ORNL;
- increase competitiveness in pursuing major research funding initiatives;

- increase UT's visibility in academia, policy making, and practice;
- enhance student participation in sustainable mobility research and education programs and train the next generation of workforce capable of addressing sustainability issues.

The Initiative is funded through support of UT's Office of Research and Engagement, with additional support from the Center for Transportation Research and ISSE.

### Other Projects and Initiatives

#### Groundwater Remediation Performance Assessment and Cost Optimization for Early Identification and Correction of Problems

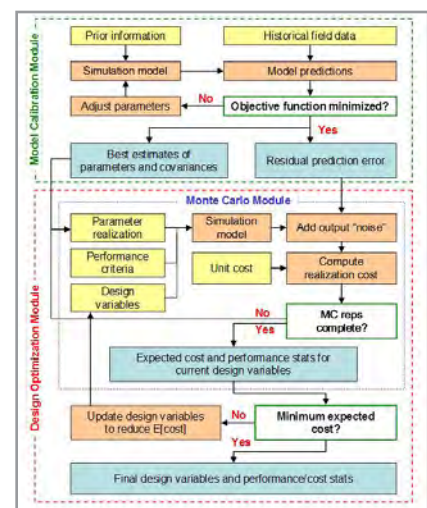
(Team: Jack Parker, UT, and Ungtae Kim, Cleveland State University)

##### Objective

This project, initiated in October 2013, is being conducted for the US Department of Defense to help clean up groundwater at US military installations contaminated by persistent chlorinated solvents. The objective is to develop a practical tool for optimizing the design and operation of groundwater remediation systems that explicitly considers uncertainty in site and remediation system characteristics, performance and cost model limitations, and measurement uncertainties that affect predictions of remediation performance and cost. The approach involves periodic reassessment of current remedial actions and determination of the cost-optimal forward strategy to meet remediation goals considering additional data collected since the previous assessment.

##### Technical Approach

The method is based on a semi-analytical mathematical model to simulate chlorinated solvent source depletion and dissolved phase transport in response to natural and engineered conditions. The performance model is coupled with cost functions for thermal source zone treatment and enhanced bioremediation by electron donor injection. Compliance criteria are defined by statistical

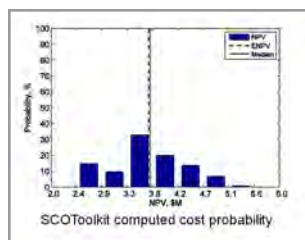


## 2013-2014 Programmatic Report

rules. The performance model is also coupled with an inverse solution to estimate model parameters, parameter covariances, and residual prediction error. A stochastic cost optimization (SCO) algorithm is used to determine values for design and operation variables, including monitoring, that minimize expected net present value cost over Monte Carlo realizations. The method is implemented in the SCOToolkit software, available in MATLAB or executable code. The method was applied to two well-characterized sites where different remedial technologies were used, to evaluate its ability to reduce costs and improve remedial designs.

### Example Application

SCOToolkit has been applied at various field sites. At the Fort Lewis East Gate Disposal Yard (EGDY) site, optimization of thermal source treatment indicated a need for a much larger treatment area than was actually employed, to avoid a high failure probability associ-



ated with source delineation uncertainty based on available source characterization data. The method was also used to optimize source and plume bioremediation at the site, using whey injection without additional source

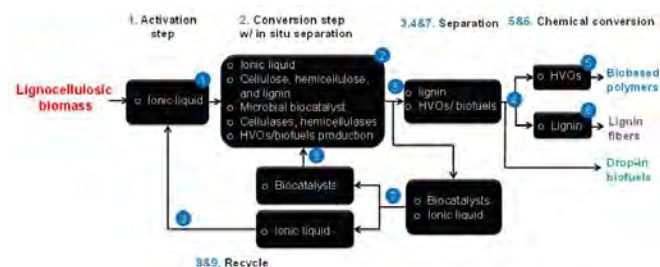
reduction. The results indicated that this strategy could achieve Maximum Concentration Limits by 2100, with a 94% probability of success using relatively low whey injection rates. The approach was applied to Dover AFB Area 5 to optimize dissolved plume bioremediation. Optimization to minimize long term operating costs indicated compliance criteria could be met using only five of the current ten emulsified vegetable oil injection galleries, with operating costs approximately half of current costs. Recalibration and optimization after an initial period of operation, using additional data from this period, was projected to further reduce operating costs.

The results indicate that SCOToolkit can reduce expected costs by 50% or more relative to conventional design methods, while substantially increasing the probability of meeting compliance targets. The method can also identify critical data gaps and uncertainties that will affect costs and performance projections.

### Renewable Production of Chemical Feedstocks and Value-Added Chemicals

Team: Joseph Bozell and Nicole Labbe, Forestry, Wildlife and Fisheries; Brian Long, Chemistry; and Cong-Trinh, Chemical and Biomolecular Engineering. This project was jointly funded with the Sustainable Energy Education & Research Center [SEERC]

Biobased products will provide the economic incentive required to support a robust biorefining industry. Integrating production of these high-value chemicals with high-volume, low-value biofuels from lignocellulosic biomass will result in an overall profitable operation. This helps reduce the nation's dependence on foreign supplies of strategic raw materials, diminish the environmental footprint of chemical manufacture and dramatically increase the contribution of the domestic rural economy to the nation's industrial sector. By realizing this high potential impact, our multi-disciplinary and multi-institutional team of chemists and biochemical engineers from the Center for Renewable Carbon (CRC: Professors Nicole Labbe and Joseph Bozell), UT Depts of Chemistry (Professor Brian Long) and Chemical and Biomolecular Engineering (Professor Cong T. Trinh) are gathered to develop an integrated chemical and biocatalytic processes for rapid, cost-effective transformation of biomass (cellulose, hemicellulose, and lignin) into high-value products while also generating fundamental knowledge regarding interaction of



*Integrated chemical and biocatalytic processes for rapid, cost-effective transformation of lignocellulosic biomass into valuable products including biobased-polymers, lignin fibers, and drop-in biofuels*

the catalytic and biocatalytic systems with carbohydrates and lignin.

Our goals are:

- To establish chemical catalysis and biocatalysis as the standard for rapid, cost-effective transformation of biorefinery carbohydrates and lignin into high value products
- To generate fundamental knowledge regarding interaction of catalytic systems with carbohydrates and lignin
- To tailor organisms for the biochemical production of critical biorefinery platforms from carbohydrates and lignin

The impacts of the research are:

- The integration of chemical and biological catalysis will significantly improve the ability of the biore-

## 2013-2014 Programmatic Report

finery to convert the building blocks of nature into high value chemical products

- Bioproducts development will be critical to the growth of a viable biorefining industry
- Incorporation of biobased products expertise as a core capability within the CRC and the UT community will offer significant broader impacts.

### Program outcomes

Proposals resulting from collaboration:

- Trinh/Labbé: “Biocatalyst design for simultaneous saccharification and fermentation to produce biochemical and biofuels from ionic liquid-activated lignocellulosic biomass,” to NSF, \$449,590 (not awarded)
- Bozell/Long/Trinh: “Catalytic Activation of Renewable Materials (CARMA) - Fundamental Science to Enable the Integrated Biorefinery,” \$2,999,125 (not awarded)
- Bozell/Labbé/Long/Trinh: “Purchase of a new Gas Chromatograph/Mass Spectrometer (GC/MS) for the ISSE program in catalytic transformations of renewable carbon,” ISSE program, \$97,341 (awarded)
- Bozell/Long: “Site selective catalysis for the structural modification of biorefinery carbohydrates and lignin” to NSF catalysis section \$474,947 (not awarded)
- Bozell: “Center for Direct Catalytic Conversion of Biomass to Biofuels (C3Bio),” to DOE/BES, \$1,500,000 (awarded June 2014)
- Bozell: “Nucleophilic iron catalysts for functionalization of carbohydrates” to ACS/PRF \$110,000 (not awarded)
- Trinh: “Enabling Direct Microbial Biotransformation of Methane and Derived Methanol to Valuable Biochemicals and Biofuels by *Yarrowia Lipolytica*” to NSF/EAGER \$197,046 (awarded)

All: upcoming opportunities will be pursued within USDA/AFRI, DOE/BES, DOE/BETO and NSF (e. g. GOALI program)

### Assessment of Methane Resources from Municipal Wastewater in Chile

(Team: Qiang He, Chris Cox, and Gregory Reed, Civil and Environmental Engineering; and Christian Seal, University of Santiago de Chile)

With the support of ISSE, Dr. He’s research group focused on the assessment of methane resources in the wastewater industry and the development of innovative strategies to enhance the production of methane from wastewater.

Building upon past methane research supported by ISSE, a research team led by Dr. He secured funding from the highly competitive U.S. EPA Global Methane Initiative (GMI) program for the “Assessment of Methane Resources from Municipal Wastewater in Chile”. Methane is a greenhouse gas (GHG) that is 21 times more potent than carbon dioxide in global warming potential. Municipal wastewater represents one of the important sources of methane emission. However, methane is also a clean and renewable source of energy. Therefore, the recovery of methane from wastewater, specifically by anaerobic digestion, has been practiced in the U.S. and other developed countries to reduce GHG emission and produce renewable energy. The recovery of methane as a resource from wastewater, however, has been hindered by technical and economical obstacles in less developed countries, such as Chile. Joined by our collaborators in Chile, Universidad de Santiago de Chile, the project team will use Chile as a model to evaluate the technical and economical feasibility of anaerobic digestion and combined heat and power (CHP) technology for the recovery of methane from municipal WWTFs as a clean fuel (see schematic below). In March 2014, the research team attended the Global Methane Initiative Tri-Sector Sub-Committee Meeting for Agriculture, Municipal Solid Waste and Municipal Wastewater in Brazil and presented preliminary results. The research team also held project meetings at Santiago, Chile, in March 2014 with Chile Ministry of Environment and the Chile national wastewater regulator Superintendencia de Servicios Sanitarios to facilitate data sharing. As a result, important progress has been made in the collection of a comprehensive dataset of the wastewater industry in Chile. In-depth data analysis is currently on-going.

### Microbial Community Structure in Anaerobic Digestion

(PI: Qiang He, Civil and Environmental Engineering)

Anaerobic digestion is an important biological waste treatment process capable of simultaneous pollution mitigation and renewable energy recovery. The broader adoption of anaerobic digestion technology for waste treatment has been hindered by concerns of potential

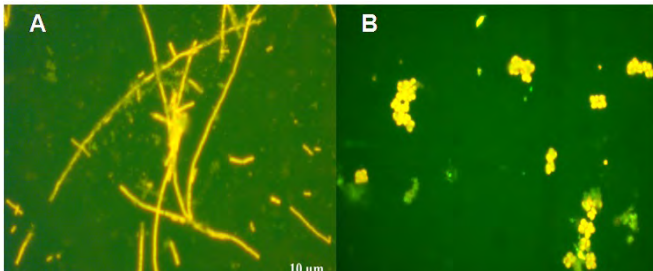


Figure 5 Schematic for a biogas-powered CHP process.



## 2013-2014 Programmatic Report

process instability resulting from the susceptibility of bacterial and methanogenic microbial populations to changes in process conditions, such as fluctuations in organic loading rates, which are frequently encountered in anaerobic digestion processes. Therefore, we have sought to gain insight into the linkages between process performance and the microbial community, which is valuable for developing efficient methanogenic processes. We have shown that anaerobic co-digestion of wastewater with other organic-rich feedstock, such as grease trap waste and food waste, can significantly enhance methane production efficiency. With the development of cutting-edge molecular tools, we have been able to identify microbial populations key to the stability of process performance when anaerobic digestion is impacted by substrate overloading. These important findings will be used to develop more efficient methane recovery technologies that could help to overcome the technical and economical barriers to the broader application of methane recovery from wastewater and beyond.



Identification of specific microbial populations in anaerobic digestion

### Biofuels Research

(PI: Chris Cox, Civil and Environmental Engineering)

*Clostridium thermocellum* is a bacterium capable of breaking down lignocellulosic biomass and fermenting it into ethanol and other useful end products. Jinlyung Choi, a PhD candidate in Chemical and Biomolecular Engineering, is investigating mechanisms by which the cell regulates enzymes critical to this conversion and well as additional critical cellular processes. He has identified a key regulatory protein that controls the production of many of these proteins and enzymes within the cell. His work will lend a better understanding of how genes are regulated in *Clostridium thermocellum* and may provide guidance for the design of genetically engineered organisms for more efficient biofuels production. He is on track to graduate later in 2014 and has two manuscripts in preparation.

### TDEC Energy Data Collection and Performance Calculation

(Team: Catherine A. Wilt, ISSE and Jean Peretz, Howard H. Baker Center for Public Policy)

This project, titled “Tennessee Energy Data Collection and Performance Calculation,” was funded by the Tennessee Department of Environment and Conservation (TDEC) through the Howard H. Baker Center for Public Policy.

This project assisted in the development of a baseline of energy usage and costs across the State of Tennessee’s building portfolio—a substantial undertaking. From January 1-May 31, 2014, UT researchers and TDEC staff collected energy use and associated cost data for 65.7 million square feet of state-owned and operated properties for calendar year 2012, approximately 68% of the entire portfolio. Numerous state agencies participated in the process, such as the departments of Corrections, Mental Health and Substance Abuse Services, Environment and Conservation (including state parks), Transportation, Education, Board of Regents colleges and universities, and the University of Tennessee system. All data gathered was compiled and organized into the Environmental Protection Agency’s Energy Star Portfolio Manager as a central database. The resulting energy use and cost data was also used to identify and evaluate potential energy efficiency measures that could assist the State in reducing its energy consumption and costs in State buildings.

Findings from this project demonstrated that Tennessee’s state building portfolio used at least 7,041,598,156 kBtus of energy, at a cost of \$109,606,275 (these are both conservative figures, as they represent 68% of all state buildings). This finding, and the level of support from state agencies in providing the supporting data, is an excellent first step in energy efficiency planning for the state building portfolio. Results from the project are available in the full report, Energy Collection and Performance Calculation Project, available on the Baker Center’s web site.

### DOE Rooftop Solar Challenge

(Team: Catherine A. Wilt, ISSE and Jean Peretz, Howard H. Baker Center for Public Policy)

This project, titled “Inducing Photovoltaic Market Transformation in Tennessee,” was to encourage wider use of solar energy by streamlining permitting processes, cutting red tape, and lowering the costs for rooftop solar systems in communities across Tennessee. It was funded by the U.S. Department of Energy for the period March 2012-September 2013.

ISSE staff worked alongside other UTK researchers at the Howard H. Baker Jr. Center for Public Policy and the Tennessee Solar Institute to increase market penetration of solar photovoltaic (PV) installations in the State of Tennessee. UTK partnered with local govern-



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ment departments and electrical distributors in four communities: Knoxville and Knox County, Memphis and Shelby County, Nashville, and the City of Franklin. Over the course of the 18-month effort, the project partners accomplished the following goals:

- developed best practices and processes to streamline permitting and interconnection applications,
- standardized interconnection processes and requirements for PV installations,
- identified alternative financing models for funding solar projects and worked with the real estate community to better value solar installations associated with properties, and
- developed unified planning and zoning criteria.

As a direct result of this research effort, all four partner cities now meet or exceed the streamlined permitting and interconnection processes developed; these four cities now serve as models for other communities across the country. In addition, the project produced a rooftop solar application for both Android and iOS Smartphones to allow Tennesseans to more easily navigate the process of installing rooftop solar panels. According to DOE metrics for the Rooftop Solar Challenge, the four partner cities increased the efficiency of their rooftop solar permitting, interconnection, financing and zoning procedures by approximately 75 percent.

### Microenvironments, Vulnerability, and Resilience in the City of Knoxville: A Comparative Study of Four Urban Neighborhoods

(Team: Kelsey Ellis, Geography; Jon Hathaway, Civil and Environmental Engineering; and Lisa Reyes Mason, Social Work)

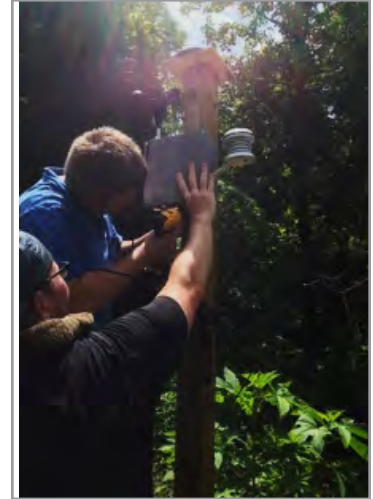
#### Project Summary

As we shift toward a largely urban society, understanding the impact of expanding cities and suburbs is of extreme importance. Cities are known to influence the local climatology and hydrology, among other environmental factors. At a smaller scale, research suggests that microclimates exist across and within neighborhoods, which may relate to social vulnerability and resilience to environmental change in ways that matter for program and policy development. This study uses an interdisciplinary approach to extend beyond the concept of microclimates to that of microenvironments. The main objective is to use sensor-based monitoring and qualitative data collection to understand environmental variability between four Knoxville neighborhoods, and its relationship to land use decisions and

resident perceptions of environmental problems and priorities.

#### Progress

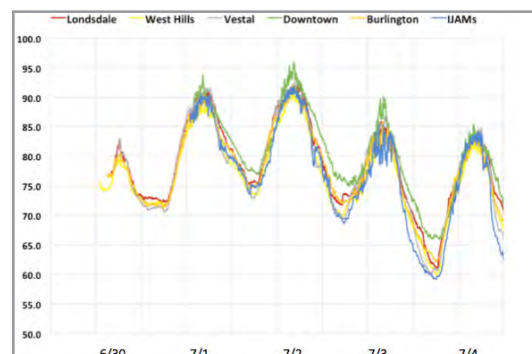
A group of students installed ten monitoring stations in the month of June (see picture): two each in four neighborhoods (West Hills, Vestal, Burlington, and Lonsdale), and control locations in Downtown Knoxville and in Ijams Nature Center. Sensors are currently recording temperature, humidity, and wind data in five minute increments.



In-depth surveys are ongoing with residents of each neighborhood, focusing on their perceptions of their local environment.

#### Initial Results

Temperature data indicate significant differences between neighborhoods across Knoxville (see graph for first few days of temperature data), especially at night. However, any two stations located in the same neighborhood did not exhibit significant differences in temperature. This suggests that neighborhood-scale characteristics and overall location relative to downtown account for more differences in climate than smaller-scale attributes such as a tree cluster. This hypothesis will continue to be tested as data are collected. Qualitative interviews have guided our decisions on which variables will be monitored moving into Phase 2 of the project (see below) and are shedding light on how environmental priorities may vary among neighborhoods. Focus groups and phone surveys are scheduled to gain information on how residents would like to access and utilize local environmental data.



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### Goals for FY 2014–2015

The project will enter Phase 2 in the spring semester, when (1) improved sensor platforms (monitoring more variables, including air quality, light and noise) designed by Electrical Engineering and Computer Science undergraduate students are built and installed, and (2) a phone survey is conducted with a random sample of neighborhood residents. A proposal was submitted to NSF in February 2014 to request additional funds to increase the number of sensors to 100, and create platforms for sharing data with citizens, city planners, and schools.

### International Center for Air Pollution and Energy Studies (iCAPES)

(PI: Joshua Fu, Civil and Environmental Engineering)

The International Center for Air Pollution and Energy Studies (iCAPES) conducted a couple of international collaborative research and outreach projects including the development of the Community Edition of Air Benefit and Cost Analysis and Attainment Assessment System (ABaCAS) and air quality assessment of potential VOC emission controls in Beijing, China. The tasks and progress achieved for the Air Benefit and Cost Analysis and Attainment Assessment System in community edition (ABaCAS-CE) from July 1, 2013 to June 30, 2014 include: (1) The RSM-VAT-CE, BenMAP-CE, CoST-CE and SMAT-CE were integrated into the prototype of ABaCAS; (2) The link between CoST-CE and RSM-VAT-CE was developed so that control cost from pollutant reduction scenarios and its corresponding air quality benefit could be visualized and analyzed together; (3) The ABaCAS-CE was applied to the case study of Yangtze River Delta and Beijing-Tianjin-Heibei region in China. The creation, visualization and analysis capability of RSM-VAT was improved, as well as the computational speed and flexibility of ABaCAS-CE for application of BenMAP-CE. A user-friendly interface for the ABaCAS-CE, linking the BenMAP-CE, RSM-VAT-CE, CoST-CE and SMAT-CE together, was developed to provide information about total control cost, air quality change, and health benefits to support the decision making of regional air quality management; (4) An ABaCAS training workshop was held on May 28, 2014 at Tsinghua University in Beijing, China, to introduce the tool to researchers and officials from universities, environmental agencies, and local governments in China. An international conference organized by UT, Tsinghua University, Zhejiang University and South China University of Technology was held from May 29 to May 30, 2014; (5) The ABaCAS was developed as a community edition so that it can be promoted to the general public for their own application and research.

The other project, air quality assessment of potential VOC emission controls in Beijing, China, has the results from the development of a diurnal parking vapor emissions model. GPS data is being collected in Beijing and the progress is on-going. The iCAPES has engaged in various international activities, and hopes to develop exploratory collaborations in Chile and other countries.

### Other Activities

The Center for Sustainable Business and Development (CSBD), led by Dr. Rachel Chen, completed two studies: “The Economic Impacts of Trails, Greenways, and Bikeways: From Green to Gold” funded by the US Department of Transportation and “Economic Impacts of the Tennessee Aquarium in Hamilton County, Tennessee.” A new CSBD project, the Impacts of Transportation Contributions of TDOT Projects on Businesses’ Successes and Community Development in Tennessee, was funded by the Tennessee Department of Transportation and is underway. The CSBD hosted the 2013 Leadership Summit: Sustainable Quality of Life on Thursday, October 3. Panel members included Dr. Shari Meghreblian, Deputy Commissioner, Tennessee Department of Environment and Conservation (TDEC); John Schroer, Commissioner of Transportation for the State of Tennessee; and Jai Templeton, Deputy Commissioner of Agriculture for the State of Tennessee. This campus-wide summit provides an opportunity for students and faculty to interact with state leaders.

ISSE co-sponsored the 3rd Annual Watershed Symposium, held February 18, 2014. Its theme was “Climate Change and Water Resources.” The keynote address was given by Thomas Wilbanks, Ph.D., Global Change and Developing Country Programs, Oak Ridge National Laboratory. His topic was: *Is Climate Change a Problem for Water Resource Management in Tennessee and the Southern US?* The Symposium was attended by UT faculty, staff, and students, and by other area professionals.

On March 10-11, 2013 Keith Bowers, president and founder of Biohabitat’s Inc., was on campus for two lectures and a workshop. Biohabitats is a leading design firm that seeks to integrate habitat preservation and restoration within their design work. The lectures and workshop were attended by students and faculty from various departments on campus as well as professionals affiliated with Oak Ridge National Laboratory, representatives from local and state government agencies,



Keith Bowers lecture and workshop, March 10-11, 2013

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and consulting firms. His visit was co-sponsored by the departments of Landscape Architecture and Plant Sciences, the TNWRRC, and ISSE.

The Sustainability Working Group (SWG) is a grass-roots effort to create a campus-wide community of faculty, staff, and students who are engaged in interdisciplinary education, research, and service in support of a more socially, economically and environmentally sustainable world. The goals of the group are to create a sustainability minor; to strengthen the existing sustainability major (an interdisciplinary studies program in the College of Arts and Sciences); to improve communication of teaching, research, outreach, and institutional projects related to sustainability throughout the UT community and with our partners; and to plan a UT Sustainability Symposium to be held in late 2015 or early 2016. ISSE Director Chris Cox has served on the steering committee of this organization and is co-chair of the communication committee.

Dr. Sheila Webster, ISSE Research Director, and Rex Short, ISSE Senior Research Associate, teamed with a nationwide network of colleges and delivered training to workers at Department of Energy (DOE) environmental restoration and waste sites across the United States. The network, Community College Consortium for Health and Safety Training (CCCHST), which is administered by the Partnership for Environmental Technology Education (PETE), partnered with Hazardous Materials Training and Research Institute (HMTRI) and sub-awardees at the University of Tennessee and Amarillo College, Texas. The National Institute of Environmental Health Sciences (NIEHS) directed funds to PETE for the purpose of delivering convenient and

cost-effective NIEHS-approved worker training to DOE contractors and subcontractors serving DOE facilities.

ISSE received a sub-award from PETE and trained workers at the following DOE locations: Oak Ridge Operations, Tennessee; Savannah River Site, South Carolina; Paducah Gaseous Diffusion, Kentucky, and Portsmouth Site, Ohio. In 2013-2014, ISSE facilitated training for approximately 1,500 workers. Sixty workers received training using the online course, which was modified and updated during the year.

The short-term goal was to prevent work-related illnesses and injury through training and education of workers in the DOE Nuclear Weapons Complex. Workers gain the knowledge and skills to protect themselves and their communities from exposure to hazardous materials (including radiological hazards) encountered during hazardous waste operations, facility decommissioning and decontamination, hazardous materials transportation, environmental restoration of contaminated facilities or chemical emergency response. Students are professionals, technicians, workers, and supervisors who are required to receive 29CFR1910.120 certification and recertification as waste site workers/supervisors, chemical emergency responders, and handlers of hazardous and radiological materials, confined space entrants or rescue personnel at waste sites. They perform cleanup, waste management, waste transportation, engineering services, and analysis and testing.

The long-term goal is to assure that workers become and remain active participants in determining and improving the health and safety conditions under which they work and that avenues for collaborative employer-employee relationships in creating safe workplaces are established.





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### Equipment Purchases

ISSE provided cost sharing on several equipment purchases in 2013-2014 to enhance capabilities in sustainability research as follows:

- Gas Chromatograph/Mass Spectrometry (GC/MS) (PI: Joe Bozell and Nicole Labbé, Center for Renewable Carbon; Brian Long, Chemistry; Cong Trinh, Chemical and Biomolecular Engineering)—This instrument is used to measure organic products and intermediates associated with the renewable chemicals project described earlier this report. UT Ag Research and ISSE jointly purchased the instrument.
- Particle Image Velocimeter (PIV) (PI: Thanos Papanicolau, Kim Carter, and John Hathaway, Civil and Environmental Engineering)—A PIV is a laser-based non-intrusive instrument that provides the spatial and temporal distribution of complex flow fields in natural and engineered environments. A few of the potential applications of this instrument include fundamental studies of sediment transport and geo-morphology; evaluation of flow patterns in green infrastructure, stormwater control and erosion prevention systems; and characterization of flow patterns in enhanced oil recovery operations. The instrument was purchased through funding from the UTK Office of Research and Engagement with cost sharing provided by the research accounts of the PI team and ISSE.
- Ion Chromatograph (PI: John Schwartz, Kim Carter, John Hathaway, and Qiang He, Civil and Environmental Engineering)—This instrument is used for the routine quantification of the concentrations of various cations and anions in water samples. It will be used in a wide variety of projects related to water quality. It was purchased through funding jointly provided by ISSE and the research funds of the PI team.
- Real-time Quantitative Polymerase Chain Reaction Fluorometer (PI: Steve Ripp, Center for Environmental Biotechnology)—This instrument is used to quantify gene expression within biological cells. It will be used in various projects related to environmental biosensors, biofuels manufacturing, environmental process performance evaluation, and source tracking of microbial pollution, among others. The instrument was purchased through funding from the UTK Office of Research and Engagement with cost sharing provided by other researchers in the Center for Environmental Biotechnology and ISSE.

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## Research Accounts

Account #	Project Name	PI	Title	Start	End	Award Amt	FY14 Expenditures
R011334309	Shanghai Doctor Asphalt Tech Co	Huang, Baoshan	Laboratory Investigation of Performance of Rubber Modified Asphalt Binder and Mixture	12/1/2012	1/31/2014	\$ 20,001.00	\$ 10,159.72
R012531077	Racheff Environment Fund	Cox, Chris	Unrestricted Research Support	5/31/1985	12/31/2047	\$ -	\$ 241.00
R013601030	ISSE Support Fund	Cox, Chris	Unrestricted Research Support	4/15/2007	12/31/2047	\$ -	\$ (2,425.45)
R013601098	ED-09-26773-00	Hanahan, Ruth Anne	Tennessee Yard and Neighborhood Program	10/16/2008	10/15/2013	\$ 91,514.46	\$ 7,757.36
R013601121	DOE-DE-EE0001709	Overly, Jonathan	I-75 Green Corridor Project	10/1/2009	9/30/2014	\$ 818,091.00	\$ 186,561.27
R013601126	UT-B 4000088499	Sheffield, John	The Role of Developing Countries in Fusion Energy	12/14/2009	9/30/2013	\$ 49,964.89	\$ 1,646.83
R013601136	NSF OCI-0963058	Cole, Gregory	IRNC:ProNet: GLORIAD	8/1/2010	7/31/2015	\$ 1,907,541.00	\$ 193,531.80
R013601137	NSF OCI-0963058	Cole, Gregory	IRNC:ProNet: GLORIAD	8/1/2010	7/31/2015	\$ 40,000.00	\$ 82.47
R013601139	Ruby Falls CSBT Fund	Chen, Jui-Chi	Unrestricted Research Support for Center for Sustainable Business and Tourism	9/17/2010	12/31/2047	\$ 25,000.00	\$ 2,225.18
R013601143	USDI-USGS-G11AP20107	Gangaware, Timothy R.	FY2011 WRRIP Application for TN Water Resources Center	3/1/2011	2/28/2015	\$ 61,344.00	\$ 984.87
R013601147	Knox County 10-370	Gangaware, Timothy R.	CAC AmeriCorps Water Quality Forum - Adopt-A-Watershed	12/1/2010	6/30/2014	\$ 194,000.00	\$ 51,659.93
R013601154	East TN Clean Fuels Coalition	Cox, Chris	Administrative Support for East Tennessee Clean Fuels Coalition - 2012	7/1/2011	9/30/2014	\$ 408,137.00	\$ 130,358.55
R013601155	USAID-AID-OAA-A-11-00018	Cole, Gregory	GLORIAD in Africa	8/26/2011	1/31/2014	\$ 3,249,117.00	\$ 903,046.41
R013601156	USAID-AID-OAA-A-11-00018	Cole, Gregory	GLORIAD in Africa	8/26/2011	1/31/2014	\$ 126,667.00	\$ -
R013601157	NSF OCI-0963058	Cole, Gregory	IRNC:ProNet: GLORIAD	8/1/2010	7/31/2015	\$ 3,568,710.00	\$ 1,074,787.03
R013601158	NSF OCI-0963058	Cole, Gregory	IRNC:ProNet: GLORIAD	8/1/2010	7/31/2015	\$ 60,000.00	\$ 23,020.26
R013601159	NSF OCI-0963058	Cole, Gregory	IRNC:ProNet: GLORIAD	8/1/2010	7/31/2015	\$ 15,000.00	\$ 32,214.69
R013601161	TN Dept. of Agriculture 25926	Hanahan, Ruth Anne	Tennessee Yards & Neighborhoods (TYN) Framework: Retooling for an Enduring Program	4/16/2011	4/15/2014	\$ 10,975.89	\$ 2,751.00

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### Research Accounts

Account #	Project Name	PI	Title	Start	End	Award Amt	FY14 Expenditures
R013601165	NSF CBET-1220731	Zhuang, Jie	Self-Protection of Organic Carbon in Soil Pores under Organic Agricultural Practices	6/1/2012	5/31/2015	\$ 90,844.00	\$ 27,844.26
R013601172	MeadWestvaco	Fu, Joshua Sing-Yih	Air quality assessment to MeadWestvaco on potential VOC emission controls in Beijing, China	8/1/2012	1/31/2015	\$ 119,729.00	\$ 11,168.72
R013601173	USDA NIFA 2012-51130-2046	Schwartz, John	Renewal of Integrated Watershed Management in Oostanuala Creek Watershed, Tennessee: stakeholder education, improving targeting and understanding of stakeholder behavior to improve implementation of best management practices for water quality	9/1/2012	8/31/2015	\$ 144,777.00	\$ 57,097.11
R013601174	Natl Partnership (PETE) 10491	Webster, Sheila	Worker Training at Department of Energy Facilities	9/1/2012	8/31/2013	\$ 107,494.22	\$ 19,464.65
R013601175	Energy Foundation-1208-16611	Fu, Joshua	Air Quality Management and Assessment Capacity Building and Training in China	9/1/2012	12/31/2013	\$ 100,000.00	\$ 40,523.10
R013601176	TDEC - 32701-01367	Gangaware, Timothy R.	Tennessee Permanent Stormwater Management Handbook	11/1/2012	11/30/2014	\$ 77,432.00	\$ 54,075.55
R013601177	LERDWG	Cox, Chris	Secretariat Lab Energy R&D Group 2012	10/1/2012	9/30/2014	\$ 25,000.00	\$ 14,761.76
R013601179	USDI-USGS-G11AP20107	Kim, Ung Tae	FY2013 WRRIP Application for TN Water Resources Center	3/1/2013	2/28/2015	\$ 11,428.00	\$ 11,428.00
R013601181	TN Dept of Agriculture 35925	Gangaware, Timothy R.	Beaver Creek Restoration Initiative	3/16/2013	7/1/2013	\$ 39,884.10	\$ 3,088.09
R013601182	Knox County	Gangaware, Timothy R.	Phase II Development of the Harrell Road Stormwater Demonstration Park	1/1/2013	6/30/2014	\$ 7,000.00	\$ 7,000.00
R013601183	Hardeman County 16930	Chen, Jui-Chi	Forecasting Economic Impacts of Hosting 4-H Camp in Hardeman County, Tennessee	5/6/2013	6/30/2013	\$ 8,000.00	\$ 6,258.91

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### Research Accounts

Account #	Project Name	PI	Title	Start	End	Award Amt	FY14 Expenditures
R013601184	EPA - XA-83539201	He, Qiang	Assessment of Methane Resources from Municipal Wastewater in Chile	1/1/2013	12/31/2015	\$ 99,748.00	\$ 11,130.64
R013601185	UT-B 4000125754	Sheffield, John	Fusion roadmapping and Pilot Plant studies	10/1/2013	9/30/2014	\$ 10,002.00	\$ 5,958.27
R013601186	USACE W912HQ-13-C-0069	Parker, John Charles	A Practical Approach for Remediation Performance Assessment and Optimization at DNAPL Sites for Early Identification and Correction of Problems Considering Uncertainty.	9/26/2013	9/25/2016	\$ 454,775.00	\$ 194,577.76
R013601187	Natl Partnership (PETE) 10514	Webster, Sheila	Worker Training at DOE facilities	9/1/2013	8/31/2014	\$ 107,500.00	\$ 79,020.22
R013601188	Toyota Motor Engine & Manufacture	Fu, Joshua Sing-Yih	Air Quality Simulation & Comparative Analysis	8/1/2013	2/28/2014	\$ 30,000.00	\$ 29,600.31
R013601189	Knox Co. Soil Conservation District	Gangaware, Timothy R	Stock Creek Watershed Restoration Project	3/1/2013	2/28/2015	\$ 17,250.00	\$ 11,644.75
R013601190	USDI-USGS-G11AP20107	Gangaware, Timothy R	FY2014 WRRIP Application for TN Water Resources Center	3/1/2014	2/28/2015	\$ 30,335.00	\$ 1,328.34
R013601194	USDI-NPS-GRSM-CESU P14AC00867	Schwartz, John Steven	Improving the GRSM's understanding of its natural resources and processes and thereby enhancing protection of the Park's resources	6/18/2014	6/17/2015	\$ 85,000.00	\$ 3,075.81

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### ISSE Related Publications

(UT affiliated authors are **shown in bold**)

- Buonocore, J. J., **X. Dong**, J. D. Spengler, **J. S. Fu**, and J. I. Levy. 2014. Using the Community Multiscale Air Quality (CMAQ) Model to Estimate Public Health Impacts of PM<sub>2.5</sub> from Individual Power Plants. *Environment International* 68: 200-208.
- Chen, R.J.C.** 2014. Integrated Sustainable Business and Development System: Thoughts and Opinions. *Sustainability*: in-press.
- Chen, R.J.C.** 2014. From sustainability to customer loyalty: A case of full service hotels' guests. *Journal of Retailing and Consumer Services*. doi: 10.1016/j.jretconser.2014.08.007
- Chen, R.J.C.** 2014. Beyond Sustainability: From Sustainable Consumer Services to Sustainable Business. *Journal of Retailing and Consumer Services*. doi: 10.1016/j.jretconser.2014.08.002
- Chen, R.J.C.** 2013. How Can Stores Sustain Their Businesses? From Shopping Behaviors and Motivations to Environment Preferences. *Sustainability* 5(2): 617-628. doi:10.3390/su5020617
- Chen, R.J.C.** 2013. Beyond Management and Sustainability: Visitor Experiences of Physical Accessibility in the Great Smoky Mountains National Park, USA. *Journal of Management and Sustainability* 3(2): 145-154.
- Chen, S.**, Z. Zhu, J. Park, Z. Zhang, and **Q. He.** 2014. Development of Methanococcus-specific real-time quantitative PCR assay for assessing methanogen communities in anaerobic digestion. *Journal of Applied Microbiology* 116(6): 1474-1481.
- Dong, X.**, **J. Li**, **J. S. Fu**, **Y. Gao**, **K. Huang**, and G. Zhuang. 2014. Inorganic aerosols responses to emission changes in Yangtze River Delta, China. *Science of the Total Environment* 481: 522-532.
- Dong, X.**, **Y. Gao**, **J. S. Fu**, J. Li, **K. Huang**, G. Zhuang, and Y. Zhou. 2013. Probe into gaseous pollution and assessment of air quality benefit under sector dependent emission control strategies over megacities in Yangtze River Delta, China. *Atmospheric Environment* 79: 841-852.
- Guo, Tai-Long, Quan-Jiu Wang, Ding-Qiang Li, **Jie Zhuang**, and Lao-Sheng Wu. 2013. Flow hydraulic characteristic effect on sediment and solute transport on slope erosion. *Catena* 107: 145-153. doi:10.1016/j.catena.2013.03.001
- Huang, K.**, **J. S. Fu**, **Y. Gao**, **X. Dong**, G. Zhuang, and Y. Lin. 2014. Role of sectoral and multi-pollutant emission control strategies in improving atmospheric visibility in the Yangtze River Delta, China. *Environmental Pollution* 184: 426-434. doi: 10.1016/j.envpol.2013.09.029 (SCI, IF=3.73)
- Huang, K.**, **J. S. Fu**, N. C. Hsu, **Y. Gao**, **X. Dong**, S.-C. Tsay, and Y. F. Lam. 2013. Impact assessment of biomass burning on air quality in Southeast and East Asia during BASE-ASIA. *Atmospheric Environment* 78: 291-302.
- Jardine, P. M.**, C.M. Hansel, **J. C. Parker**, **U. Kim**, Y. Tang, M. A. Stewart, and L. Le. 2013. Assessing the Potential Consequences of Subsurface Bioremediation: Fe-Oxide Bioreductive Processes and the Propensity for Secondary Mineral Precipitation and Media Structural Breakdown. GSA annual meeting: 125th Anniversary of GSA, The Geological Society of America, October 27-30, Denver, CO.
- Keck, Benjamin P.**, **Zachary H. Marion**, **Derek J. Martin**, **Jason C. Kaufman**, **Carol P. Harden**, **John S. Schwartz**, and **Richard J. Strange.** 2014. Fish Functional Traits Correlated with Environmental Variables in a Temperate Biodiversity Hotspot. *PLOS ONE*: March 27, 2014. doi: 10.1371/journal.pone.0093237.
- Kim, U.**, **J. Parker**, P. Kitanidis, M. Cardiff, X. Liu, and J. Gillie. 2013. Stochastic Cost Optimization of DNAPL Remediation—Field Application. *Environmental Modeling & Software* 46: 12-20. doi:10.1016/j.envsoft.2012.05.003.
- Linville, J. L.**, M. Rodriguez, J. R. Mielenz, and **C. D. Cox.** 2013. Kinetic modeling of batch fermentation for Populus hydrolysate tolerant mutant and wild type strains of Clostridium thermocellum. *Biore-source Technology* 147: 605-613.
- Linville, J. L.**, M. Rodriguez, M. Land, M. H. Syed, N. L. Engle, T. J. Tschaplinski, J. R. Mielenz, and **C. D. Cox.** 2013. Industrial Robustness: Understanding the Mechanism of Tolerance for the Populus Hydrolysate-Tolerant Mutant Strain of Clostridium thermocellum. *PLOS ONE* 8(10), UNSP e78829.
- Parsa, H.G., M. Segarra-Ona, S. C. Jang, **R. J. C. Chen**, and A. J. Singh. 2014. Special Issue on Sustainable and Eco-Innovative Practices in Hospitality and Tourism. *The Cornell Hospitality Quarterly* 55(1): 5.
- Schwartz, J.S.**, M. Cai, M. A. Kulp, S. E. Moore, B. Nichols, and C. Parker. 2014. Biological Effects of Stream Water Quality on Aquatic Macroinvertebrates and Fish Communities within the Great Smoky Mountains National Park. *Natural Resource Report NPS/GRSM/NRR—2014*. National Park Service, Fort Collins, Colorado. 208 p.
- Shi, Wen-Juan, **Fu-Min Menn**, **Ting-Ting Xu**, Zibo T. Zhuang, **Clara Beasley**, **Steven A. Ripp**, **Jie**



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- Zhuang, Alice C. Layton, and Gary S. Saylor.** 2014. C60 reduces the bioavailability of mercury in aqueous solutions. *Chemosphere* 95: 324-328. doi:10.1016/j.chemosphere.2013.09.027.
- Sun, J., J. Schreifels, J. Wang, J. S. Fu, and S. Wang.** 2014. Cost estimate of multi-pollutant abatement from the power sector in the Yangtze River Delta region of China. *Energy Policy*. doi.org/10.1016/j.enpol.2014.02.007
- Tran, Liem T.,** and Robert V. O'Neill. 2013. Detecting the Effects of Land Use/Land Cover on Mean Annual Streamflow in the Upper Mississippi River Basin, USA. *Journal of Hydrology* 499:82-90.
- Tran, Liem T.,** Robert V. O'Neill, Elizabeth R. Smith, Randall J.F. Burns, and **Carol Harden.** 2013. Application of Hierarchy Theory to Cross-Scale Hydrologic Modeling of Nutrient Loads. *Water Resources Management* 1:1-17.
- Wan, X.-F., J. L. Barnett, F. Cunningham, **S. Chen, G. Yang, S. Nash, L.-P. Long, L. Ford, S. Blackmon, Y. Zhang, L. Hanson, and Q. He.** 2013. Detection of African swine fever virus-like sequences in ponds in the Mississippi Delta through metagenomic sequencing. *Virus Genes* 46(3): 441-446.
- Zhang, Y. and Q. He.** 2013. Characterization of bacterial diversity in drinking water by pyrosequencing. *Water Sci. Technol.-Water Supply* 13(2): 358-367.



# Summary of Faculty and Student Participation

## Faculty Actively Engaged in ISSE Research

Name	Affiliation
J. Brian Alford	Forestry, Wildlife and Fisheries
Christopher Boyer	Agricultural and Resource Economics
Joseph Bozell	Forestry, Wildlife and Fisheries
John Buchanan	Biosystems Engineering and Soil Science
Kim Carter	Civil and Environmental Engineering
Rachel Chen	Retail, Hospitality and Tourism Management
Christopher Clark	Agricultural and Resource Economics
Bradford Collett	Plant Sciences
Chris Cox	Civil and Environmental Engineering
Jennifer DeBruyn	Biosystems Engineering and Soil Science
John Drake	Civil and Environmental Engineering
Kelly Ellis	Geography
Annette Engel	Earth and Planetary Sciences
Joshua Fu	Civil and Environmental Engineering
David Greene	Economics
Carol Harden	Geography
Jon Hathaway	Civil and Environmental Engineering
Shawn Hawkins	Biosystems Engineering and Soil Science
Qiang He	Civil and Environmental Engineering
Baoshan Huang	Civil and Environmental Engineering
Phillip Jardine	Biosystems Engineering and Soil Science
Asad Khattak	Civil and Environmental Engineering
Ungtae Kim	ISSE, Civil and Environmental Engineering
Niki Labbe	Forestry, Wildlife and Fisheries
Dayton Lambert	Agricultural and Resource Economics
Alice Layton	Microbiology
Jaehoon Lee	Biosystems Engineering and Soil Science
Joanne Logan	Biosystems Engineering and Soil Science
Brian Long	Chemistry
Andrea Ludwig	Biosystems Engineering and Soil Science
Lisa Mason	Social Work
Larry McKay	Earth and Planetary Sciences
Micheal McKinney	Earth and Planetary Sciences
John Nolt	Philosophy
Thanos Papanicolaou	Civil and Environmental Engineering
Jack Parker	Civil and Environmental Engineering
Greg Reed	Civil and Environmental Engineering
Steven Ripp	Center for Environmental Biotechnology
Jennifer Rutherford	Civil and Environmental Engineering
Gary Saylor	Microbiology
John Schwartz	Civil and Environmental Engineering
John Shefner	Sociology
Richard Strange	Forestry, Wildlife and Fisheries
Liem Tran	Geography
Cong Trinh	Chemical Engineering
Forbes Walker	Biosystems Engineering and Soil Science
Jie Zhuang	Biosystems Engineering and Soil Science

## Post Docs and Graduate Students Involved in ISSE Research

Graduate Students	Department	Graduation Date
<b>Aplin, Matthew Williams</b>	MS/Civil & Environmental Engineering	Summer 2014
<b>Blanton Jr, Barry Nolan</b>	MS/Civil & Environmental Engineering	Summer 2014
<b>Bova, Tony</b>	Department of Chemistry	
<b>Budipradigdo, Maudy Indriani</b>	MS/Biosystems Engineering & Soil Science	
<b>Bulino, Christopher</b>	Department of Chemistry	
<b>Chen, Si</b>	PhD/Civil Engineering	Summer 2014
<b>Choi, Jinlyung</b>	PhD/Chemical & Biomolecular Engineering	Fall 2014
<b>Craig, Rachel</b>	PhD/Geography	
<b>Dong, Xinyi</b>	PhD/Civil & Environmental Engineering	Spring 2015
<b>Fink, Michael Joseph</b>	Biosystems Engineering & Soil Science	
<b>Gaddis, Abigail Laurel</b>	PhD/Civil & Environmental Engineering	Summer 2013
<b>Goeman, Aaron</b>	MS/Earth & Planetary Science	2014
<b>Gonzalez, Adrian Miguel</b>	PhD/Civil Engineering	2015
<b>Harrod, Wesley Morgan</b>	Civil & Environmental Engineering	
<b>Hromadka, Michael</b>	MBA	
<b>Izquierdo, Jose Manuel</b>	Geography	
<b>Jones, James Raymond</b>	MS/Civil & Environmental Engineering	Spring 2014
<b>Keck, Benjamin</b>	PhD/Forestry, Wildlife and Fisheries	Spring 2014
<b>LeDoux, St. Thomas</b>	MS/Earth & Planetary Science	
<b>Li, Yan</b>	Geography	
<b>Lynd, Jared</b>	Law	Spring 2015
<b>Martin, Derek Joseph</b>	PhD/Geography	Spring 2014
<b>Olsen, Cathy</b>	MS/Geography	
<b>Perez, Brittani</b>	MS/Biosystems Engineering & Soil Science	Spring 2015
<b>Rungee II, Joseph Patton</b>	MS/Environmental Engineering	Spring 2014
<b>Simmons, Paul Vanterpool</b>	MS/Civil & Environmental Engineering	Spring 2014
<b>Sun, Jian</b>	PhD/Civil & Environmental Engineering	2017
<b>Woockman, Robert Ryan</b>	PhD/Civil & Environmental Engineering	2015
<b>Wright, Wesley</b>	Biosystems Engineering & Soil Science	
<b>Yu, Ning</b>	PhD/Retail, Hospitality & Tourism Mgt	2015

Post-Docs/Other Professionals	Department
<b>Calcagno III, James Anthony</b>	Civil & Environmental Engineering
<b>Huang, Kan</b>	Civil & Environmental Engineering
<b>Linville, Jessica Leigh</b>	Civil & Environmental Engineering
<b>Njiojob Ngnoumeuchi, Costyl</b>	Department of Chemistry
<b>Pilon, Brent Steven</b>	Biosystems Engineering & Soil Science
<b>Ryu, Seunghyun</b>	Chemical Engineering
<b>Sherfy, Andrew Conrad</b>	Biosystems Engineering & Soil Science

## Undergraduate Students Involved in ISSE Research

<b>Undergraduate or Hourly</b>	<b>Department</b>	<b>Graduation Date</b>
<b>Benton, Rae</b>	Hotel, Restaurant & Tourism Mgt	
<b>Cecil, Alisha</b>	Management	
<b>Chatman, Alexandra Imani</b>	Biological Sciences	
<b>Christian, Jennifer Leigh</b>	MS/Social Work	Spring 2015
<b>Christian, Laurel</b>	Civil & Environmental Engineering	Spring 2015
<b>Cline, Christopher Allen</b>	Civil & Environmental Engineering	
<b>Davis, Janessa</b>	Earth & Planetary Science/Sustainability	Fall 2014
<b>D'Aprile, Franco</b>	Interdisciplinary/Sustainability	Spring 2016
<b>Graves, Jacob Stiner</b>	Civil & Environmental Engineering	
<b>Hamm, Charles</b>	Accounting	
<b>Henry, Joey Logan</b>	Civil & Environmental Engineering	
<b>Hipps, Julie</b>	Chemical & Biomolecular Engineering	
<b>Hoehn, Dylan Chase</b>	Undecided	
<b>Jared, Karessa Leigh</b>	Biosystems Engineering & Soil Science	
<b>Julian, Cory Alexander</b>	Civil & Environmental Engineering	
<b>Manka, Brandy</b>	Civil & Environmental Engineering	Spring 2016
<b>Nester, Logan Hutton</b>	Civil & Environmental Engineering	Spring 2015
<b>Prinston, Haniska</b>	Civil & Environmental Engineering	Spring 2014
<b>Rewcastle, Kenna Elizabeth</b>	College Scholars	
<b>Roth, Mary Katherine</b>	Civil & Environmental Engineering	
<b>Todd, Blake</b>	Accounting	
<b>Veeneman, Andrew Brian</b>	Civil & Environmental Engineering	
<b>Walton, Thomas Michael</b>	Civil & Environmental Engineering	