16th Annual Meeting of the American Ecological Engineering Society

Hosted by the University of Tennessee | Knoxville, Tennessee | Hilton Knoxville

"Rooftop to Rivers: Integrating Natural and Built Ecosystems"

Monday, June 6

4-8pm Registration, Hilton Knoxville, 501 West Church Ave, Knoxville, TN 37902
4-6pm Informal Gathering at Hilton, Sponsor table set up
6pm Market Square Crawl/Outdoor Knoxville Festivities

Link to Map

Visit our Website:
aees2016.utk.edu

Tuesday, June 7

7-9am Continental Breakfast, Registration and Poster set up
8am **The UTIA College of Ag, Science & Natural Resources Student Design Competition Team Meeting**
8:30-10:30am **The UTIA AgResearch Welcome and Plenary Session** **Rooftop To Rivers: Integrating Built and Natural Ecosystems**
Invited Speakers: Bill Hunt, PhD, P.E. North Carolina State University Laura Wildman, P.E. PrincetonHydro.com
10:30-11:50am Concurrent Technical Sessions

Watershed Planning *Moderator: Cully Hession*		**Stream Restoration I** *Moderator: John Schwartz*		**Wastewater Treatment In Ag & Coal** *Moderator: David Blersch*	
Martin	A multi-watershed model approach to guiding agricultural nutrient load reductions for Lake Erie	Mumaw	Urban Stream Restoration for Permit Compliance: Opportunities and Constraints	Yarberry	Development of an anaerobic digestion starter-kit for disaster relief and military deployment
Austin	Return to Neverland: An Ecological Engineering Critique of Total Maximum Daily Loading Nutrient Criteria for Water Quality Reclamation of Impaired Lake and Reservoirs	Babbit	PRACTICAL APPLICATIONS: IMPROVING DEGRADED STREAMS IN A CONSTRAINED ENVIRONMENT	Witarsa	Poultry Litter Treatment Using Anaerobic Digestion Combined with Chemical/Biochemical Nutrient Removal Techniques
Ayers	River Ecology Mapping using Geospatial Sensors and Video	Lammers	Can stream restoration remedy the nutrient pollution problem?	Lansing	Small-Scale Anaerobic Digestion Use to Increase Sustainability in the Animal Production Sector
Horne	Ecological Engineering Water Mega-projects: is it time?	McMahon	Stream Restoration as Green Infrastructure: Integration with Watershed Stewardship	Graves	Biogeochemical Conversion of Calcium Sulfite into Gypsum in Flue Gas Desulfurization Waste

Noon Opening Luncheon (Lunch Provided)
1:30-2:30pm Concurrent Technical Sessions

Climate Change *Moderator: Ani Jayakaran*		**Ecosystem Services** *Moderator: Tess Wynn-Thompson*		**Sustainable Food Systems** *Moderator: TBD*	
July	Effect of Climate on Wetland Plan Phenology - Case Study of Andean Mountain Wetlands.	McDonough (Presented by Moore)	Understanding the Relationship between Urban Best Management Practices and Ecosystem Services	Wilson	Assessing the sustainability of current management practices in an intensively managed landscape
Toms	Horizontal Levees: An Innovative Approach to Climate Change Adaptation in San Francisco Bay	Keys	A cost-effective image processing approach for monitoring and assessment of fluvial ecohydrology	Hayes	Long-Term Impacts of Biodegradable Plastic Mulches for Sustainable Production of Fruits and Vegetables
Celik	Hydrologic conditions, salinity fluctuations, and forested cover changes along a tidal gradient along the St. Mark River and East River: Distributary rivers of the Apalachicola River in Northwest Florida	Rey Sanchez	The carbon balance in a heterogeneous estuarine wetland in Northern Ohio.	Diemont	Ecological engineering for food: Succession and wild edibles

Tuesday, June 7 (continued)

2:40-3:40pm Concurrent Technical Sessions

Bioretention *Moderator: Jon Hathaway*		**Urban Watersheds** *Moderator: Daniel Yoder*		**Innovations in Ecological Engineering Education** *Moderator: Stew Diemont*	
Fears	Evaluation of Biofiltration Media for Optimum Stormwater Treatment Under Controlled Outflow Conditions	Woockman	Channel Protection: Surplus Stream Power, Channel Erosive Resistance Elements, and Sediment Source Potential	Cianfrani	Collaborative Learning: Exploring Systems Thinking Using a Living Building
Morse	How design affects microbial function and nitrogen treatment in bioretention	Bell	Urban stormwater control measures effect on watershed hydrology	Calabria	Study Abroad: Student Reflections from a Semester Design Studio in the Premontane Wet Forest of Costa Rica
Tamkin	Using carbon isotopes to measure the reduction of hydrocarbons by bioretention	Hitchcock	Evaluating Ecohydrological Function and Green Infrastructure to Support Low Impact Development in Coastal South Carolina	Calabria	Projective Design as a Research Strategy in Ecological Engineering

3:50-5:10pm Concurrent Technical Sessions

Urban Landscapes *Moderator: Andrea Ludwig*		**Stream Restoration II** *Moderator: Patrick McMahon*		**Treatment Wetlands** *Moderator: Alex Horne*	
Winston (presented by Hathaway)	Modeling bioretention performance under climate change scenarios in Ohio, USA	Jennings	Stream and Wetland Restoration at Rendezvous Mountain State Forest	Lewis	Supplementing Crews Lake Hydrology through Beneficial Water Reuse
Majidzadeh	Influence of home construction on soil carbon	Cooper	Does legacy sediment removal in stream restoration provide a reduction in floodplain nutrient release potential?	Vazquez-Burney	Ecological Design Approaches to Leaky Wetlands for Aquifer Recharge and Water Reuse: The 4G Wetlands
Jayakaran	Rain garden mesocosm and porous pavements performance in Western Washington	Dostal (present	Stream Revitalization and Stream Enhancements in the Czech Republic	Spangler	An Assessment of Floating Treatment Wetlands for Reducing Nutrient Loads and Enhancing Ecological Health in Coastal Virginia Nursery Retention Ponds
		Turner	Headwaters restoration of the West Virginia Coalfields: Adapting restoration techniques to high gradient Appalachian streams	Corwin	Recirculating Free Surface Wetland Treatment System to Reduce Nitrogen from Public School Wastewater to Meet California Standards

6pm - 9pm **The UT Institute for a Secure and Sustainable Environment Welcome Dinner Reception on the Tennessee Star Riverboat - Boarding from 6-6:55pm, depart 7pm.**

Wednesday, June 8

8-9am Student Design Competition Mentor Session with Industry Experts

9-10:20am Concurrent Technical Sessions

Green Infrastructure Applications *Moderator: Abigail Tamkin*		Stream Restoration III *Moderator: Desiree Tullos*		Novel Methods in Water Quality Monitoring *Moderator: Trisha Moore*	
Tirpak	The Health of Trees in Existing Bioretention Areas in Tennessee and North Carolina	Robinson	Measuring fundamental stream and wetland functions in a restored stream-wetland complex and un-restored comparison watershed in the Daniel Boone National Forest near Morehead, KY.	Cantor	Exploration of strategies to track the downstream impacts of human sewage in underserved rural communities
Wijesinghe	Applicability of Wetland Systems to Mitigate Stormwater Runoff in Coastal, South Carolina.	Chun	An application study of the vegetation assessment indicator and its grade standard for river environment condition in Korea	Hazen	Paradigm change? Predicting water geochemistry from microbial commumity structure
McCarthy (presented by Hathaway)	Stormwater biofilters for pathogen removal; selecting plants which naturally excrete antimicrobial compounds	Duke	South Harpeth River Bank Stabilization	Ellis	Hydrological assessment of tidal creeks to inform nutrient management recommendations
Baltaci	Effectiveness of Rain Barrels and Permeable Pavements as LID Practices for Flood Control in a Coastal Alabama Watershed	Jennings	Grassy Creek Restoration to Provide Hellbender Habitats	Messer	Photodegradation of Imidacloprid in Rivers: A Novel Water Quality Monitoring Approach

10:40am-Noon Concurrent Technical Sessions

Innovations in Green Infrastructure *Moderator: Jessica Thompson*		Stream Restoration IV *Moderator: Greg Jennings*		Wastewater Treatment & Resource Recovery *Moderator: Stephanie Lansing*	
Bean	Comparison of Bioretention and Wetland Retrofits within an Institutional Landscape for Mitigating Stormwater Nutrient Loads	Tsakiris	Science based restoration using boulders	Kemmerling	Bacteria, sunlight, and dirt: Making the most of human wastewater
Robinson	Towards a Methodology for Quantifying the Storm Event Hydraulic Performance of Modular Green Roofs	Tullos	Scale of flow field observation influences apparent velocity use and energy expenditure in juvenile coho salmon	Roy	Phosphorus recovery and recycling with ecological engineering: existing approaches and key challenges
Ahn	Collaboration between art and ecosystem restoration for stormwater management on an urban college campus - the case of the Rain Project	Wyssmann	Stream Restoration Influences of a Boulder Array: Bedload Transport Delay and Depositional Characteristics	Huynh	Fate and accumulation of triclosan in soil-plant systems receiving treated wastewater irrigation
Stovall	Design and Construction of a Regional Stormwater Detention Facility with Inclusive Stream and Wetland Elements	Ellis	Hydraulic Engineers Toolbox: process and design solutions	Brennan	Eco-Machine Aquaponics: Capturing Nutrients from Wastewater for Sustainable Food Production.

Noon Lunch Provided

Noon-5pm **UT Extension** Technical Field Trips

4:30pm Poster Reception, Hilton (See presentation list on page 5)

6:30pm **UTIA College of Ag, Science & Natural Resources** Student Design Competition Testing

Thursday, June 9

8:30-9:50am Concurrent Technical Sessions

Measuring Impacts of Green Infrastructure *Moderator: Robert Woockman*		Watershed Processes *Moderator: Daniel Hitchcock*		Ecosystem Modeling *Moderator: David Austin*	
Bynum	Ecological Benefits of Tennessee Multi-functional Stormwater Requirements The Obed River Case Study	Giannopoulos	Characteristic time scales of sediment at the catchment scale: Implications to stream ecology	Messer	Do First Order Nitrate Removal Models Accurately Predict NO3-N Removal in Wetlands?
McMillan	Influence of stormwater control measures on in-stream denitrification rates	Govenor	Commonalities in Benthic Stressors across the United States	Shepard Watkins	A food web model for estuaries in southeast Louisiana to evaluate coastal restoration projects (Part II)
Clinton	Seasonal patterns in stream macroinvertebrates in urban watersheds with stormwater control measures	Abban	Evaluating the Effects of Grassed waterways at the Watershed Scale Using a Coupled Hillslope and Instream Model	Shepard Watkins	Development of a food web model for estuaries in southeast Louisiana [Part 1]
Jaber	Impact of green infrastructure on stream bank shear stress at watershed scale	Bigham	Repeatability and Sensitivity Analysis of the Rosgen BANCS Model Developed to Predict Annual Streambank Erosion Rates	Kalin	WetQual: A Physically Based Wetland Nutrient Cycling Model

10:10-11:10am Concurrent Technical Sessions

Big Ideas: Knoxville-Area Projects *Moderator: Karina Bynum*		Green Energy *Moderator: Jay Martin*		BioSolutions *Moderator: Doug Hayes*	
Ludwig	Integrating Extension, Teaching and Compliance Using Green Infrastructure at the University of Tennessee	Horne	Renewable energy has a unique advantage for ecological engineering.	Krenz	Periphyton biofilms and benthic algae in constructed coalfield streams: structural and functional responses to altered top-down and bottom-up controls.
Fritz	Knoxville Urban Wilderness: Managing abandoned urban lands for recreation and conservation	Mangrum	Effect of Separation on Poultry Manure Digestion	Goodwin	Integrating Phytoremediation, Bioremediation, and Zerovalent Iron to Increase Groundwater Remediation Efforts for Chlorinated Solvents
Thompson	Regenerative Stormwater Conveyances: Restoring Natural Flows and Engaging the Community	Choudhury	Hydrogen Sulfide Removal from Biogas using Banana Peel Ash	Graves	Phytoremediation Complements Enhanced In Situ Bioremediation for Optimized Groundwater Remediation

11:30am **UTIA College of Ag, Science & Natural Resources** Student Design Competition Presentations
12:30-2pm Closing Luncheon and Annual Business Meeting (Lunch Provided)
2pm Executive Committee Meeting
3pm Organized Recreational Activities
Safe travels!

Poster Reception - Wednesday, June 8th at 4:30pm-6:30pm

Poster Presenters		**Poster Title**
Bell	Natasha	Plant Selections for Vegetative Buffers: Can Phytopathogens be Remediated from Irrigation Water?
Billian	Hannah	Fate and Transport of Fecal Indicator Bacteria (FIB) and Microbial Source-Tracking (MST) Targets in Groundwater
Blanton	Jesse	In-Bench P-Filter Design and Monitoring for Two-Stage Ditches in the Western Lake Erie Basin
Blau	Ulysse	Review of promising Ecological Wastewater Treatment Technologies
Canaztuj	Maya	How tree xylem filters can make surface water drinkable
Christian	Laurel	Exploring the Influence of Urban Watershed Characteristics and Antecedent Climate on In-Stream Pollutant Dynamics
Chun	Seung-Hoon	An application study on river environment assessment system for designation guideline of river project zoning in Korea
Corkins	Chelsea	Do roots bind soils: Comparing the physical and biological role of roots in fluvial streambank erosion resistance
D'Ambrosio	Sofia	Importance of Pool Depth to Young-of-Year and Adult Coastal Cutthroat Trout
Ellis	Kathryn	HYDROLOGICAL ASSESSMENTS OF TIDAL CREEKS TO INFORM NUTRIENT MANAGEMENT RECOMMENDATIONS
Franti	Tom	Urban Stormwater Runoff Contaminant Mitigation by Bioretention Cells and Rain Gardens in Lincoln, Nebraska
Freudenberg	Violet	Relationship Between the Quality of Soil and the Quantities of Food and Water
Geberemariam	Thewodros	Post Construction Green Infrastructure Performance Monitoring Parameters and Their Functional Components
Hoehne	Suzanne	A Changing View of the Role of Surface Waters & Stormwater In Urban Planning and Design
Houston	Stephanie	MODELING PHOSPHORUS CONCENTRATION IN FIVE SHALLOW WET RETENTION PONDS IN MONTGOMERY COUNTY, VIRGINIA
Huber	David H.	Preliminary Analysis of the Bioremediation Potential of the Sediment Microbiome in the Highly Disturbed, Industrialized, Kanawha River (Charleston, WV)
Huber	David	Evaluating Co-Digestion in a Pilot-Scale Thermophilic Digester Stabilized on Poultry Litter Substrate: Performance, Resilience, and Microbial Community Adaptation
Kangas	Patrick	A Survey of a Novel Urban Estuarine Ecosystem
Kangas	Patrick	Moss Community Structure on House Roofs
Kangas	Patrick	Vermiculture Experiments Using Algal Biomass as a Substrate
Kangas	Patrick	Performance of an Experimental Algal Turf Scrubber near Baltimore Harbor, Maryland
Kaur	Manjinder	Effect of substratum roughness on filamentous algal species colonization recruitment and its biomass characteristics under different nutrient conditions
Ketchum	Qualla	Evaluation of Metrics for Assessing Stream Restoration Success and Failure in Mined Areas
Kurki-Fox	Jack	Assessing forested wetland trends and identifying key hydrologic and ecologic baseline characteristics that will improve wetland restoration in North Carolina
Lawrence	Rian	How tree xylem filters can make surface water drinkable
Liao	Hehuan	The interplay between conductivity and habitat on benthic community health in mixed-landuse streams in West Virginia, USA
Lisenbee	Whitney	Monitoring Water Quantity and Quality Before and After Harvest of Eastern Redcedar for Biofuel Production
Litton	Jarrod	Benthic algae cultivation for the recovery of nutrients from aquaponics wastewater
Majidzadeh	Hamed	Effect of urban impervious surfaces on soil carbon dynamic
Majidzadeh	Hamed	Effect of Urbanization on Spread of Urban Mosquitoes
Manka	Brandy	Driving Forces of Bioretention Effluent Nutrient Variability in Field Applications
Markle	Aldyn	Greywater Filtration in a Living Building: Assessing Water Quality and Microbial Community Composition in Wetland Mesocosms
Markle	Aldyn	Connecting the Living and Built Environment through the Living Building Challenge: Evaluating the Effectiveness of Integrating Alternative Building Practices
McAndrew	Brendan	Carbon and nitrogen capture performance of a floating treatment wetland as a measure for sustainable stormwater management in an urban environment
McKnight	Julie	Soil CO_2 flux and soil moisture variability in two constructed agricultural wetlands in East Tennessee: Implications for constructed wetland design and carbon budgets
Merritt	Danielle	Invertebrate Diversity on Urban Green Roofs in Charlotte, NC
Montoya Lozano	Ariana	Comparison of denitrification rates between restored and conventional agricultural floodplains.
Moore	Trisha	Urban-rural partnerships: a means to maximize watershed ecosystem services?
Ortiz de Zarate	Laura	Nutrients dynamics in riparian zones of agricultural watershed in North Carolina
Park	Dara	Defining Cover Management (C) and Length Slope (LS) Factors of RUSLE to Model Soil Erosion in Urban Landscapes
Pelle	Angela	Non-stationarity within the Obion Watershed
Rains	John	Pathogen die-off in algal turf scrubbers
Rogers	Brad	Assessing the utility commercial fluorimeter probe for rapid assessment of water quality trends using benthic chlorophyll
Roux	Anthony	Evaluation of 20 years of land use change on benthic macroinvertebrate diversity and function in Piedmont streams
Sachs	Andrew	Building a Floating Treatment Wetland as a Best Management Practice and Educational Tool on an Urban College Campus
Sivells	Teneil	Livestock Exclusion Influences on Water Quality for Two Small Streams in Southwest Virginia
Stephens	Timothy	Investigation of the effects of whitewater parks on aquatic resources: a spatially explicit hydraulic analysis
Tilley	David	Ecological Entrepreneurship: discovery the business outside of you
Tirpak	Andrew	Investigating the Treatment Performance Benefits of Trees in Stormwater Bioretention Mesocosms
West	Derek	Evaluating periphyton sampler size effects in direct comparisons with a commercial fluorimeter probe
Wind	Lauren	Environmental dissemination of antibiotic resistance genes from vegetable production
Withers	Urban	A review of alternative wetland systems for wastewater treatment in the rural Southeast
Wynn-Thompson	Theresa	Wetbud: A model for mitigation wetland design

Collection of Abstracts

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Rooftop to Rivers: Integrating Built and Natural Ecosystems

June7-9, 2016
Knoxville, TN
http://aees2016.utk.edu

The University of Tennessee

(Abstracts are arranged below by date, time, and session title.)

Presenter: Martin, Jay
Co-Authors: M. Kalcic, R.L. Muenich, D. Scavia, N. Aloysius, J. Arnold, J. Atwood, C. Boles, R. Confesor, J. DePinto, M. Gildow, T. Redder, D. Robertson, S. Sowa, M. White, H. Yen

A multi-watershed model approach to guiding agricultural nutrient load reductions for Lake Erie

Harmful algal blooms (HABs) have become endemic to the western basin of Lake Erie. The main driver of Lake Erie HABs is phosphorus loading from agricultural watersheds draining to the western basin, particularly the Maumee River. Through the 2012 Great Lakes Water Quality Agreement, the governments of the U.S. and Canada are recommending new phosphorus loading targets based on load-response curves based on multiple models. Afterwards, the Great Lakes policy community must identify the most feasible and effective policy options to meet the targets. To address this need, we followed a multi-model approach to provide a robust evaluation of potential management plans to give managers more confidence identifying scenarios with the greatest potential to improve water quality in western Lake Erie.

We assembled six modelling groups who have calibrated models for the entire Maumee watershed capable of simulating the impacts of management scenarios on phosphorus loading to Lake Erie. These models were driven by common meteorological data and were validated with consistent water flow and water quality data for the same time period. Then, we completed a suite of scenarios to evaluate potential management plans recommended by agricultural and policy advisory committees. Results identify ranges in nutrient reductions from various management plans, highlight model uncertainty, and help build consensus around the best performing individual and bundled management scenarios. Individual management plans with the greatest reductions in total and dissolved phosphorus loading included fertilizer placement, reduced fertilizer application rates, cover crops, and using filter strips and wetlands to intercept field runoff. Next, we plan to use this multi-model approach to evaluate the impacts of climate change, and develop projections for the length of time various management scenarios will require to meet the target reductions.

Presenter: Austin, David

Return to Neverland: An Ecological Engineering Critique of Total Maximum Daily Loading Nutrient Criteria for Water Quality Reclamation of Impaired Lake and Reservoirs

In 2008, Duarte et al published an influential paper on eutrophication in coastal waters titled, “Return to Neverland: shifting baselines affect eutrophication restoration targets”. The somewhat whimsical title stakes out sharp intellectual ground with regard to the intrinsic limitations of regulatory programs and scientific paradigms governing remediation of culturally eutrophied coastal ecosystems. The authors provide evidence that ecosystem dynamics render naïve the current remediation paradigm of predicting nutrient-impaired ecosystem recovery through meeting nutrient abatement goals.

Essentially the same problem exists for nutrient impaired lakes and reservoirs. A total maximum daily load (TMDL) assessment assumes two things that have a “Return to Neverland” aspect: (1) Remediation occurs when the impaired total limiting nutrient concentrations drop below a regulatory threshold; and (2) Reduction in watershed nutrient loading is sufficient to remediate impairment.

Consequently, the TMDL nutrient program suffers from systemic technical flaws that impair its intent to remediate impairment. Scientifically, TMDL remediation criteria fail to consider key ecosystem dynamics in determining water quality. Programmatically, neither success nor failure of remediation actions informs TMDL actions. Instead, models predict remediation through implementation of best management practices. There is no empirical verification of the efficacy of remediation actions. This presentation proposes an alternative ecological engineering orientation to remediation that considers both necessary and sufficient conditions to meet water quality goals.

Presenter: Ayers, Paul

River Ecology Mapping using Geospatial Sensors and Video

The need to develop GIS-compatible large-scale maps of in river systems led to the development of georeferenced river sensors and video for water quality, aquatic habitat, fish population and streambank erosion mapping. The river mapping system is kayak-mounted with georeferenced above and under water cameras, depth sounder, width and water quality sensors and underwater lasers. GIS maps of river characteristics - substrate (modified Wentworth scale), embeddedness (EPA classification), depth, width and river characteristic (pool, riffle, run) were developed. River thalweg profile rugosity and sinuosity were also determined using depth sensors and GPS respectively. Every linear foot of river can be mapped at a rate of 10 miles per day. The system provides a GIS-based georeferenced database for river and stream inventory. A technique to define optimum habitat locations and habitat suitability indices for aquatic species was developed and implemented. The underwater videomapping system has evolved over the past 10 years and has been used to map 100's of miles of river habitat in Tennessee.

Complemented with a GPS-based snorkel videomapping system (GSVMS) and a Sneak Peek under-structure video exploration technique, site-specific fish population monitoring provide video documented georeferenced information regarding population, size, species distribution, location, and habitat. Georeferenced water quality mapping provides a spatial database. GIS-based video tours of the above and below water river features, providing virtual tours within ArcGIS and Google Earth will be demonstrated.

Presenter: Horne, Alex

Ecological Engineering Water Mega-projects: is it time?

Ecological Engineering has a couple of decades of experience at real projects but the world's water has become more polluted over that time and aquatic wildlife has declined. Piecemeal improvements to watersheds for 50 years have left the USA with about half of its river miles degraded and "dead zones and eutrophication in many of its lakes, reservoirs, estuaries and coastal regions. It is worse in many other countries, especially the developing ones like China and South America. Ecological Engineering has the potential to restore all of these systems "at a stroke" since it deals in ecosystems by definition. Examples will be given for the restorations of the Mississippi and Platte Rivers, and the dead zones of the Gulf of Mexico off New Orleans, Chesapeake Bay, and the Baltic Sea. Cost-benefit ratios can be good if multiple uses (fish, wildlife habitat, recreation) are included.

STREAM RESTORATION I — TUESDAY, JUNE 7, 2016, 10:30-11:50AM CONCURRENT SESSIONS:

Presenter: Mumaw, Kip

Urban Stream Restoration for Permit Compliance: Opportunities and Constraints

In 2014, the Chesapeake Bay Program's Urban Stormwater Workgroup and Water Quality Goal Implementation Team released a guidance document entitled Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects, which included design protocols established to quantify reductions of nutrients and sediments achieved through stream restoration. This guidance document and the use of stream restoration as a strategy to address the Chesapeake Bay TMDL has increased the practice's popularity.

In 2015, the Edith J. Carrier (EJC) Arboretum Stream Restoration Project was undertaken to meet James Madison University's MS4 permit compliance. Using Natural Channel Design (NCD) principles, the project restored 1,080 feet of the headwater tributary of Blacks Run, an impaired urban waterbody in Harrisonburg, Virginia, part of the greater Chesapeake Bay watershed. In addition to streambed and bank stabilization, the design included floodplain reconnection and interconnected wetland cells. While reductions of sediment and nutrients were the primary goals, secondary goals included ecological uplift including the creation of habitat and wildlife corridor, partnership development, and training.

This presentation uses the EJC Arboretum Stream Restoration Project as a platform for discussing the unique opportunities and constraints associated with implementing urban stream restoration for permit compliance. Opportunities explored include pollutant removal, cost effectiveness, funding, partnership creation, oasis effect, and dissemination of learning. Constraints include design methodology, nutrient and sediment reduction accounting protocols, alterations to the watershed, infrastructure conflicts, existing mature vegetation, data acquisition, project boundaries, and verification.

Presenter: Babbit, Greg

Practical applications: Improving Degraded streams in a constrained environment

Modern society has placed a priority on the need for improving degraded streams and associated habitats. This need is evident through current federal, state, and local government policies, regulations, and an abundance of watershed based organizations. An increased value on improving natural resources has resulted in an increase in the number of stream restoration projects nationwide. Many of these projects are funded through mitigation, and some, to a lesser extent, are grant funded. Regardless of funding source, the goals are similar: reduce erosion and sedimentation, improve water quality and establish self-sustaining ecological function. Collectively, we are attempting to undo many decades of poor resource management, but we are doing it in a far different civilization and landscape.

Design methods and applications of stream restoration practices have been somewhat controversial and met with mixed results. Practitioners face challenging projects wrought by constraints. Physical, chemical, biological, social, cultural, temporal and financial constraints can preclude the level of project success. Often, the bar is set high, yet may not be achievable in light of project constraints. This presentation focuses on challenges, constraints, practical solutions, and realistic expectations of project outcomes. Specific project examples from middle and east Tennessee, design approaches, and lessons learned will be shared.

Presenter: Lammers, Roderick

Co-Authors: Brian P. Bledsoe

Can stream restoration remedy the nutrient pollution problem?

Eutrophication of aquatic systems – excessive nutrient concentrations and subsequent accelerated primary production – is a pressing water quality problem in the U.S. and around the world. Stream restoration has been suggested as a potential approach for improving water quality by enhancing the natural nutrient removal and retention capabilities of lotic systems. This presentation summarizes results from a literature review aimed at assessing current understanding of the effectiveness of various stream restoration strategies for enhancing nutrient removal. Generally, many stream restoration strategies can enhance nutrient processing by increasing hydraulic retention time, promoting hyporheic exchange, and creating conditions conducive to denitrification and overbank deposition. However, quantitative results on the efficacy of these restoration strategies are scarce, as are their cumulative impacts on in-stream water quality. To help address this lack of quantitative analysis, we examined two issues in more detail: streambank phosphorus content and streambed denitrification rates. Streambank phosphorus concentrations are highly variable and have implications for nutrient loading from bank erosion. Denitrification is an important nitrogen removal pathway in aquatic systems. We examined factors explaining variability in: (1) total bank phosphorus content and bioavailability and (2) denitrification rates both within and between streams. In both cases, the selected analytical methods were significant predictors of variability between studies. We then explored how inherent natural variability and this issue of consistent analytical methodology complicates quantification of nutrient retention and removal and the implications of this for assigning nutrient removal credits for stream restoration.

Presenter: McMahon, Patrick
Co-Authors: Ken Barry
S***tream Restoration as Green Infrastructure: Integration with Watershed Stewardship***

Over the last 25 years, stream restoration has grown from almost a novelty practice to a routinely performed design and construction service, often with the goal of improving water quality. Recently there has been much discussion and research regarding the effectiveness of stream restoration as a water quality improvement tool.   This presentation will survey recent research regarding stream restoration's effectiveness as a water quality improvement approach, discuss integration of stream restoration with wider watershed management goals. This presentation will also address the influence that disconnection of impervious surfaces on the restoration of our urbanized streams.

WASTEWATER TREATMENT IN AG & COAL — TUESDAY, JUNE 7, 2016, 10:30-11:50AM CONCURRENT SESSIONS:

Presenter: Yarberry, Andrea
Co-Authors: Stephanie Lansing, Robert Diltz, Heather Luckarift, Stephanie Yarwood

Development of an anaerobic digestion starter-kit for disaster relief and military deployment

Anaerobic digestion is a waste recovery technology capable of treating both solid and human waste through microbial conversion of organics to biogas. One hindrance to starting up a digester is finding a suitable microbial seed source, or inoculum, for the digester, especially in remote areas. Ideally, inoculum from an existing anaerobic digester would be available and used, however, when established inoculum is not available, inoculum could be preserved, stored and utilized. The objective of this work was to determine a methodology for the preservation of inoculum that allows for storage, transit and rapid startup of an anaerobic digestion system that can be fed multiple waste streams. In this study, three different inoculum sources were investigated using biochemical methane potential (BMP) tests to determine differences in methane production using fresh inoculum and inoculum after preservation through freeze-drying. This study found that the inoculum can be successfully preserved through freeze-drying and regain methane-production activity, but after an increased lag-time (approximately 10 days). Methane production before and after freeze drying was 8% to 103% higher for the three inocula sources tested. The implications of this effort are that human waste, a primary disease vector, can be treated at scale, while also providing methane for heating, lighting and cooking needs when other fuel sources maybe limited. The results could be utilized for waste treatment in refugee camps, forward base camps for the US military, or in any developing or developed world setting where inoculum sources are not available.

Presenter: Witarsa, Freddy
Co-Authors: Stephanie Lansing, Andrew Moss, Anna Kulow

Poultry Litter Treatment Using Anaerobic Digestion Combined with Chemical/Biochemical Nutrient Removal Techniques

While dairy manure digestion is common, poultry litter digestion is more complicated due to high ammonia content that decreases methane production and the low moisture content in poultry litter. Poultry litter digestion requires the dilution of the influent litter with water to reduce ammonia inhibition and increase the digestibility of the material. Operators often use the digester effluent to dilute the incoming litter to reduce water consumption, but there is a limit to the number of times that the water can be recycled due to accumulating ammonia concentration.

In this study, chemical (ammonia stripping unit) and biochemical (anammox) nutrient extraction systems were tested in their efficiency to remove ammonia from the digester effluent. Laboratory-scale ammonia stripping and anammox reactors were tested using screened and press filtered digester effluent from a pilot-scale digester that was fed with 535 g of poultry litter volatile solids (VS) per day and had methane production of 121 L CH_4/kg VS. Preliminary trials showed that the ammonia stripping system could remove 89% of a spiked ammonia solution, with all of the ammonia captured in the acid scrubber recovery unit when the reactor was operated at 47 ºC and pH of 11.5, with an air flow and liquid recirculation rates of 9.5 and 1.5 L/min, respectively. Further results and conclusions from the ammonia stripping and anammox reactors to treat digester effluent will be presented.

Presenter: Lansing, Stephanie
Co-Authors: Walter Mulbry, Osman Arikan

Small-Scale Anaerobic Digestion Use to Increase Sustainability in the Animal Production Sector

Anaerobic digestion (AD) is a series of sequential microbial processes that transform organic material into methane-enriched biogas. AD relies on solar energy and biological processes to treat waste, which results in the production of renewable energy, reductions in greenhouse gas emissions and directs nutrients from the treatment process back to agricultural production to increase yield. The biogas produced from AD can be used directly for heating/cooking or used in a generator to produce electricity. However, there are barriers facing widespread implementation of AD in the US, including marginal economics, high heating requirements, and the lack of an AD service sector. Our research has examined how to adapt low-cost small-scale digestion from developing countries to the US in order to lower capital costs and heating requirements and provide information to small-scale farmers in the US.

Results from the six (3 m3) replicate field-scale digesters built in Maryland will be presented, including the total energy produced by the digesters (three times the energy needed to counteract heat loss), a financial analysis of the system, and the effect of temperature differentials on system performance. We found that we could reduce AD temperature without sacrificing methane production, providing a means to decrease costs associated with heating small-scale AD. Methane production values at 22 and 28°C were 70% and 87%, respectively, of the methane production values at 35°C. These results are relevant to smaller-scale farmers interested in AD for methane reduction, greenhouse gas reductions, and nutrient management.

Presenter: Jacques Smith
Lead Author: Graves, Duane
Co-Authors: Linxi Chen, Jacques Smith, Robby White, Brianna Wallace

Biogeochemical Conversion of Calcium Sulfite into Gypsum in Flue Gas Desulfurization Waste

Coal combustion generates sulfur dioxide that is removed from flue gas using a flue gas desulfurization (FGD) scrubber. In the scrubber, sulfur dioxide reacts with a lime slurry to form either calcium sulfite hemihydrate or calcium sulfate dihydrate (gypsum) depending on the amount of oxygen in the scrubber. High purity (>80%) gypsum has commercial application in wallboard, cement base, and agricultural soil amendment.

A coal fired power plant in the southeastern US has generated approximately 3 million tons of FGD waste with a calcium sulfite hemihydrate concentration of approximately 40 to 60 percent. Geosyntec developed and lab-tested a novel biological treatment technology to convert the FGD waste into a valuable product with greater than 90% gypsum.

A sulfur oxidizing bacterial population was identified that would grow in a high sulfite FGD waste slurry. With appropriate nutrients, aeration, mixing, and bioaugmentation with sulfur oxidizing bacteria, gypsum was formed at rates approaching 5% per day with similar loss of sulfite.

FGD waste with as little as 40% gypsum has been converted to a product with over 90% gypsum within 10 to 14 days of treatment. The bioconversion technology offers a sustainable solution for converting the low gypsum content FGD waste into a marketable product that eliminates waste that would otherwise be landfilled. Recovered landfilling costs and revenue from sales of gypsum byproduct yields an economically and environmentally sustainable technology applicable to coal burning industries that currently or previously generated low gypsum content FGD waste.

Presenter: Taborda Rios, July Andrea
Authors: Juan Castano, Marcela Uribe, Jay Martin
Effect of Climate on Wetland Plan Phenology - Case Study of Andean Mountain Wetlands

The study of wetland vegetation and its change over time is an important method to track the effect of climate change on ecosystem function. The aim of this study was to monitor wetland plant phenology using digital cameras in wetlands located in mid-altitude Andean mountains in Colombia. Plots with homogenous coverage of wetland plants were monitored with a photos every 30 minutes for one year. From these images a green chromatic coordinate (gcc) index was calculated through digital image processing (Matlab2010). In addition, the area was instrumented with a weather station (Rainfall, Temperature, Evapotranspiration, Radiation, Wind speed, UV radiation), flow and water level meters, and vegetation sampling plots. The vegetation plots showed a predominance of Axonopus micay (invasive grass), Eleocharis acutangula (wetland plant) and Pentacalia tolimensis (shrub). The gcc index obtained was correlated with climatic and hydrological variables measured. It was found that different days of accumulated rainfall had low correlations with the ggc index (Axonopus micay, 30 days, $r = 0.37$, $p = 0.001$; Eleocharis acutangula 60 days, $r = 0.46$, $p = 1e-6$; Pentacalia tolimensis 60 days, $r = 0.346$, $p = 4e-4$). During the dry months, Axonopus micay (invasive grass) and Pentacalia tolimensis (shrub) had lower ggc values indicating that their photosynthetic activity was more affected than in Eleocharis acutangula. With these results, we are using downscaled future climatic data to explore likely effects of extreme drougths on the vegetation of this wetlands complex.

Presenter: Toms, Christina
Horizontal Levees: An Innovative Approach to Climate Change Adaptation in San Francisco Bay
The built and natural communities that surround San Francisco Bay are under severe threat from climate change. Rising sea levels threaten to flood cities and infrastructure, drown tidal wetlands and associated habitats, and fundamentally undermine the physical and ecological processes that maintain the Bay's delicate ecosystem. To address this challenge, scientists and engineers have proposed "horizontal levees" aimed at providing flood protection, room for the upslope transgression of tidal wetland and estuarine-upland ecotone habitats, and in some cases, tertiary wastewater polishing. This talk will discuss some basic design concepts for horizontal levees, and address some of the engineering and regulatory complexities of designing, permitting, and building these features, such as: Which types of shorelines are most suitable for this kind of treatment? How can designs be reconciled with wetland protection provisions of the Clean Water Act and other regulations? How can adequate sediment to construct these levees be sourced and placed? How can wastewater be utilized on horizontal levees as a habitat-building resource? The answers to these questions demand an ecological engineering approach that places natural systems at the center of the West Coast's most urbanized estuary.

Presenter: Latif Kalin
Author: Celik, Seval

Hydrologic conditions, salinity fluctuations, and forested cover changes along a tidal gradient along the St. Mark River and East River: Distributary rivers of the Apalachicola River in Northwest Florida

Climate change is likely to include changes in precipitation patterns, temperature, sea level, and frequency of disturbance events, which could have strong impacts on a variety of ecosystems, especially in coastal areas. Coastal ecosystems, particularly tidal freshwater forested wetlands, provide diverse ecological and socioeconomic services. These wetlands are influenced by tides, however they remain primarily freshwater because of river flow. Changes in the frequency of saltwater intrusion has been recognized as one of the major factors that may impact tidal freshwater forested wetlands in the future. However, long-term studies on the salinity effects on tidal freshwater wetlands are limited. The overall purpose of this study is to describe the hydrologic conditions, salinity fluctuations, and forested cover changes along a tidal gradient along the St Mark River and East River (distributary rivers of the Apalachicola River in northwest Florida).The salinity intrusion frequency is modeled by Artificial Neural Networks (ANN). Six monitoring stations were established to observe water level and salinity along the East River and St. Mark River. These data are employed to create the ANN model. The water level and salinity data collection began in December 2014 and continued until December 2015. Also, twenty-two forest monitoring stations were established (each river has 11 stations) to document changes in forest composition along a tidal gradient. The model results were associated with the vegetation survey to explore the response of different forest species to salinity and water level fluctuations of sea level rise and variations in fresh water input from the Apalachicola river on the species migration.

ECOSYSTEM SERVICES — TUESDAY, JUNE 7, 2016, 1:30-2:30PM CONCURRENT SESSIONS:

Presenter: Trisha Moore
Lead Author: McDonough, Kelsey
Co-Authors: Hutchinson, Stacy and Moore, Trisha

Understanding the Relationship between Urban Best Management Practices and Ecosystem Services

Increasing attentiveness to climate change and the dependence of human life on natural resources has spurred awareness about the detrimental impacts of human activity on the environment. Ecosystem services, or the benefits that humans derive from ecosystems, have changed more in the past fifty years than in any other comparable period in human history. The dilemma of managing the trade-off between immediate human needs and maintaining the ability of the Earth to provide ecosystem services is considered to be one of the largest challenges of this century. The ecosystem service concept aims to maximize the provision of services across an entire ecosystem to achieve overall ecosystem health through land management, policy, and economic decisions. The intent of this research was to improve such decisions by increasing the understanding about the relationship between urban best management practices and freshwater provision, erosion regulation, and flood regulation ecosystem services. Fifty-six land management scenarios with varying densities of BMP application were simulated using the Stormwater Management Model (SWMM). The ecosystem services resulting from these land management scenarios were quantified using indices developed by Logsdon and Chaubey (2013). Results demonstrate that the application of bioretention cells improve freshwater provision and erosion regulation services immediately downstream from the implementation site, and an increase in erosion regulation services was observed at the greater watershed scale. The culmination of this research will provide decision-makers with the knowledge to make sustainable land management, policy, and economic decisions that maintain water-related ecosystem services into the future.

Presenter: Keys, Tyler
Co-Authors: Nathan Jones, Durelle Scott, Daniel Chuquin
A cost-effective image processing approach for monitoring and assessment of fluvial ecohydrology

The study of interactions between surface water bodies and their riparian ecosystems, known as ecohydrology, is a critical component of water resources management. Currently, monitoring of fluvial ecohydrology is hindered by the coarse spatial resolution of freely available satellite data and the expensive cost of high resolution remote sensing data. Here, we present a cost effective, user-friendly technique for examining the ecohydrologic dynamics of river corridors through the use of digital imagery. Using a digital time lapse camera, we captured hourly images of a headwater Appalachian stream and riparian ecosystem. Then, we utilized a MATLAB based image processing technique to evaluate ecohydrologic parameters (e.g., inundation surface area, floodplain wetness, and vegetation dynamics) in each image. To validate the accuracy of image-based surface area estimations, we created a high resolution LiDAR derived inundation model of the stream to quantify surface areas based on known stage values. The results showed a high level of accuracy (R2 = 0.94; NRMSE = 7.96%), validating the appropriateness of the methodology. Our study highlights the use of time-lapse imagery as a robust method for analyzing the dynamics of river corridors and associated ecosystem services.

Presenter: Rey Sanchez, Andres Camilo
Co-Authors: Timothy H. Morin, Kay C. Stefanik, Kelly Wrighton, Gil Bohrer
The carbon balance in a heterogeneous estuarine wetland in Northern Ohio.

Wetlands are powerful carbon dioxide (CO2) fixers but also the main individual source of methane (CH4), the second most effective greenhouse gas. Wetlands are often heterogeneous landscapes with high diversity of land covers and different paths of CH4 release or CO2 uptake. Understanding the budget of greenhouse gases in different land cover patches within a wetland is important in order to calculate the wetland's total green-house gas budget and to include its net climate change potential in an adequate wetland restoration plan. We studied CO2 and CH4 fluxes from different land covers at the Old Woman Creek (OWC) National Estuarine Research Reserve, at the Lake Erie shore in Northern Ohio. OWC is composed of four main types of land cover: open water, emergent cattail vegetation (Typha Spp), floating vegetation (Nelimbo spp), and mud flats. We measured CH4 and CO2 gas exchange using enclosed chambers at the four patch types monthly during the growing season of 2015. We also measured site-level CO2 and CH4 fluxes through the eddy covariance technique. Site-level fluxes were combined with a footprint model to generate continuous record of CO2 and CH4 emissions and to estimate the contribution of different patch types to the total flux measured by the tower. We conducted an analysis of the spatial and temporal variability of methane and carbon dioxide and discuss the implications of different arrangements of land cover types on carbon sequestration in wetlands.

SUSTAINABLE FOOD SYSTEMS — TUESDAY, JUNE 7, 2016, 1:30-2:30PM CONCURRENT SESSIONS:

Presenter: Wilson, Chris
Co-Authors: Kenneth Wacha, Violet Freudenberg, Thanos Papanicolaou

Assessing the sustainability of current management practices in an intensively managed landscape

To assess management impacts on the functionality of intensively managed agroecosystems under increasing market demands and a variable climate, we developed an integrated, ecological-economic modeling framework equipped with data-informed, biogeochemical indices to illuminate the factors that influence sustainability in these systems. Most current metrics are static, or slow-changing soil characterization parameters that reflect better long-term interactions between landscape features, climate, and biology. However, the ever-changing land management and climate necessitates us to use dynamic parameters that reflect agroecosystem responses to different land management on similar timescales (e.g., seasonally).

Our framework examines the production of different ecosystem services including crop productivity, carbon storage, and net income under three different rotations with varying degrees of tillage intensity. The rotation with the highest tillage produced the highest yields, but also had the highest production costs. The second most intense practice also had high yields, as well as the highest net income. However, these two rotations had high erosion rates, which depleted the long-term, non-labile soil carbon, which is needed to sustain system productivity and health.

One metric, the Carbon Management Index (CMI), provided a good measure of a rotation's sustainability due to its incorporation carbon lability and the implicit accounting of erosion on carbon redistribution. The CMI for the more intense rotations decreased in recent years, showing that they are not sustainable despite being more productive or profitable in the short-term. The least intense tillage rotation had the lowest SOC depletion through erosion and it had the highest CMI with a still-increasing trend.

Presenter: Hayes, Douglas
Co-Authors: Larry C. Wadsworth, Nurul Farhana Omar, Annette L. Wszelaki, J.M DeBruyn, S. Schaeffer

Long-Term Impacts of Biodegradable Plastic Mulches for Sustainable Production of Fruits and Vegetables

Use of thin plastic film as mulch is standard practice for specialty crop growers throughout the U.S, to prevent weeds and conserve water and soil. Unfortunately, most plastic mulch after its typical single-season use is stockpiled or burned illegally due to poor biodegradability and limited recycling options, releasing harmful residues such as microplastics into the environment. Our goal is to ascertain the efficacy of biodegradable plastic mulches (BDMs) relative to conventional polyethylene-based mulches as an alternate management practice. However, concerns by growers and key intermediaries have limited the widespread use of BDMs based on identified adoption barriers: lack of knowledge, high cost, and unpredictable breakdown during their deployment. To overcome these hurdles, we are implementing an integrated and transdisciplinary science- and application-based research design with a whole-system perspective, aiming to improve crop production, reduce post-harvest and environmental costs, and increase economic vitality for growers and consumers. Particular attention is being paid to the life cycles of the BDMs and the soil and soil microbiological ecosystems, and the ultimate fate of the plastic debris which forms. The overall goals and approaches of our project team (from University of Tennessee, Washington State University, and Montana State University) will be described and initial results will be discussed.

Presenter: Diemont, Stew
Co-Authors: Arnow, Eli; Arrington, Austin; Bunge, Avalon; Falkowski, Tomasz; Law, Eugene; Martinez, Isaias

Ecological engineering for food: Succession and wild edibles

Over 14% of people in the US are food insecure. One third of all child deaths globally are attributed to under-nutrition. Reasons for unmet food needs are complex and driven by many factors, including distribution. Agricultural production in the US runs at a net energy loss, which does not bode well for facilitating its sustainability using current techniques. Ecological engineering has made great strides in naturally garnering regulating (such as water quantity management), supporting (such as biodiversity enhancement), and provisioning ecosystem services (in terms of providing clean water). Ecological engineering work focused on the provisioning of food, however, has been limited. Ecological engineering has the potential to significantly contribute to discussions on sustainable food security. I will present our work on urban wild edibles, restoration of hay fields with wild foods traditionally used by local indigenous groups of eastern New York state, and agroforestry systems in Oaxaca and Chiapas, Mexico. I will pay particular attention to the role that succession and wild edibles could play in food security, sovereignty, and resilience. I will also discuss the cultural and regulatory barriers to a more tangible inclusion of edibles into ecological engineering design.

Presenter: Fears, Jessica
Co-Authors: Duane Graves, Linxi Chen, Jacques Smith, Aaron Poresky, Austin Orr

Evaluation of Biofiltration Media for Optimum Stormwater Treatment Under Controlled Outflow Conditions

Significant effort is ongoing across the country to identify appropriate biofiltration media blends that effectively remove pollutants and support vegetation, while minimizing leaching of nutrients and metals. Geosyntec conducted a column study of candidate biofiltration media blends to help select a mix to be used in a major land development project. A column apparatus was constructed to test the effectiveness of five different biofiltration media mixes for treatment of real urban stormwater. The column apparatus was carefully designed to distribute stormwater evenly across columns, maintain constant hydraulic head, operate at a filtration rate of 9 inches per hour, and maintain a saturation zone in each column. The components of the biofiltration media were selected based on previous chemical and hydraulic testing and included combinations of two sands, coconut coir peat, activated carbon, compost, peat, biochar, and zeolite. Composite influent and effluent samples were collected and analyzed for E. coli, nutrients, total and dissolved metals, total suspended solids (TSS), and total organic carbon (TOC). In general, each mix provided TSS removal below the lab detection limit, 80-90% E. coli removal, and substantial metals removal. Some nutrient export was observed for mixes containing compost, but nutrient export was not observed for mixes containing peat and coco coir. Beyond the specific project goals, these results are expected to provide valuable information for developing design specifications for biofiltration media in the future, particularly in areas where bacteria and nutrient removal are important for meeting effluent standards and protecting receiving water bodies.

Presenter: Morse, Natalie
Co-Authors: Walter, Todd
How design affects microbial function and nitrogen treatment in bioretention

Stormwater monitoring was conducted at two bioretention cells in Ithaca, NY. The sites were chosen to highlight differences in real-world conditions – one site was often saturated (wet basin), and the other was quick draining (dry basin). Whole soil genomic sequencing (metagenomics) was also conducted at each site and an adjacent reference location. The aim of this study was to pair stormwater quality data with in-situ microbial function to elucidate the black-box mechanisms controlling nitrogen treatment. While the wet basin had all the ingredients for denitrification, including higher abundance of denitrification genes, it performed poorly for nitrogen treatment. The wet basin exported about 10% (1.5 g) of excess nitrogen (NO3- and NH4+) per storm, while the dry basin reduced nitrogen by about 24% (2.3 g) per storm. These findings highlight how important design is for nitrogen treatment; the wet cell had the potential to denitrify, but due to site constraints the often saturated soils were unable to detain and treat nitrogen.

A parallel field study also revealed it may take longer than we think for denitrification to come on-line in these systems. Surface soils placed within a prime denitrification environment (often saturated bioretention cell), failed to equilibrate with surrounding soil denitrification potential after three months of monitoring. This indicates stormwater systems may require extra time to 'wind-up' and treat incoming nutrients. This is especially important when considering stormwater monitoring, which often follows a new installation.

Presenter: Tamkin, Abigail
Co-Authors: Jay Martin, James Bauer, Yu-ping Chin, Andrew Ward
Using carbon isotopes to measure the reduction of hydrocarbons by bioretention

Hydrocarbons are a prevalent pollutant in stormwater, coming from sources such as automotive fluids, combustion products, and asphalt. Quantifying hydrocarbons effectively is a priority for monitoring urban and suburban water quality, as many hydrocarbons are carcinogenic or mutagenic. Current bulk methods of hydrocarbon measurement are incomplete and may be ineffective in revealing their true presence. We have developed a new isotopic method to quantify total anthropogenic hydrocarbons in a given sample. When compared to conventional methods, such as gravimetric analysis, and GC-FID, this isotopic approach can reveal the gap in knowledge that exists for quantifying these compounds. These analytical methods were compared by analyzing the ability of bioretention cells to reduce hydrocarbons in stormwater in Columbus, OH. Synthetic stormwater or tap water was added to curbside retrofit bioretention cells through a series of controlled, simulated rain events. Underdrains below the curb allow collection of "outflow" drained water from the gardens.
Preliminary data for particulates from the first blank test (tap water only) found 0.087 mg HC/L for the inflow water, 1.06 mg HC/L for the first flush of outflow water, and 0.082 mg HC/L for outflow after 15 minutes. This data will be used as a baseline for tests using the synthetic stormwater as inflow water. Further data from bioretention tests, as well as correlating data using the conventional methods, will be obtained this winter and spring.

URBAN WATERSHEDS — TUESDAY, JUNE 7, 2016, 2:40-3:40PM CONCURRENT SESSIONS:

Presenter: Woockman, Robert
Co-Authors: John Schwartz
Channel Protection: Surplus Stream Power, Channel Erosive Resistance Elements, and Sediment Source Potential

Cost effectively mitigating channel degradation due to excess energy in small stream systems, caused by decreases in initial abstraction or modifications to channel erosive resistance, requires linking planning of stormwater control measure suites with stream rehabilitation needs. Integrated management plans can be accomplished through fluvial audits that observe surrogate measures of a channel's erosive versus resisting forces and continuous simulation modeling (CSM) to identify potential response trajectories. Surrogate measures of channel erosive resistance and surplus stream power are explored to identify influence on developmental states and identify potential grouping. Calibrated CSMs of hillslope processes and in-channel processes are used to validate exploratory field data analysis and explore effective mitigation practices. Ultimately, this research is expected to support stream system rehabilitation in ER67 through adaptation of mitigation practices relative to channel erosive resistance properties.

Presenter: Bell, Colin D.
Co-Authors: Sara K. McMillan, Sandra D. Clinton, Anne J. Jefferson
Urban stormwater control measures effect on watershed hydrology

Stormwater control measures (SCMs) are designed to mitigate effects of urbanization on hydrology, but our ability to predict the cumulative effect of multiple SCMs at watershed scales is limited. The most widely used metric to quantify impacts of urban development, total imperviousness (TI), does not contain information about stormwater control. We analyzed the discharge at 16 urban watersheds in Charlotte, NC spanning a range of TI (4.1 to 54%) and area mitigated with SCMs (1.3 to 89%). We then tested watershed metrics that quantify the degree of urban impact and SCM mitigation to determine which best predicted hydrologic response. At the event time scale, linear models showed TI to be the best predictor of peak unit discharge and rainfall-runoff ratios across a range of storm sizes. TI was also a strong driver of both a watershed's capacity to buffer small (e.g., 1-10 mm) rain events, and the relationship between peak discharge and precipitation once buffering capacity is exceeded. Metrics containing information about SCMs did not appear as primary predictors of event hydrologic response, suggesting that the level of SCM mitigation in many urban watersheds is not sufficient. Over annual timescales, impervious surfaces unmitigated by SCMs and tree coverage were best correlated with streamflow flashiness and water yield, respectively. The shift in controls from the event scale to the annual scale has important implications for water resource management, suggesting that overall limitation of watershed imperviousness rather than partial mitigation by SCMs may be necessary to alleviate the hydrologic impacts of urbanization.

Presenter: Hitchcock, Daniel R.
Co-Authors: Anand D. Jayakaran, Thomas H. Epps, Jessica A. Palazzolo, David L. White
Evaluating Ecohydrological Function and Green Infrastructure to Support Low Impact Development in Coastal South Carolina

In coastal South Carolina, a region experiencing both increased development and climate variability, this research focuses on the definition of ecohydrological criteria for sustainable land and water resource guidance, specifically in upland areas that ultimately drain to tidal creeks and rivers. Water resources management is further complicated as these watersheds typically have shallow groundwater and low gradient topography. Results from several research projects have implications for watershed planning and site engineering, including stormwater management and - more specifically - the development of design criteria for low impact development (LID). Forested water budgets are being refined with the goal of defining pre-development conditions for sustainable land use decision-making. Stormwater control measures, specifically engineered wetlands and bioretention systems, are being investigated to determine hydraulic and water quality performance considering influence of shallow groundwater. An assessment of existing resources (green infrastructure) and their benefits - via ecohydrological services at various scales - can provide guidance toward resource protection with the goal of creating resilient communities - whether by conservation or restoration efforts, or by better site design during land use change.

INNOVATIONS IN ECOLOGICAL ENGINEERING EDUCATION — TUESDAY, JUNE 7, 2016, 2:40-3:40PM CONCURRENT SESSIONS:

Presenters: Cianfrani, Christina and Sarah Hews
Collaborative Learning: Exploring Systems Thinking Using a Living Building

The Integrated Sciences First-Year Program at Hampshire College challenges students to learn about complex systems and systems thinking, improve quantitative skills, make connections among fields of science, design innovative collaborative projects, and create a vibrant science community. The program consists of fall and spring semester courses and a summer research experience. In the fall of 2015, a group of 34 incoming first-year students took one of three courses covering microbiology, hydrology, or mathematical modeling using the Hampshire College Kern Center, a new building built to the Living Building Challenge Standard, as a case study. Students met twice a week to explore the science behind the systems of the living building in their specific discipline. Once a week all three classes met together to complete collaborative projects, share expertise, and form a science learning community. Students designed and built wetland boxes intended to function similarly to the greywater treatment wetlands designed for the Kern Center. Students alternated leading the labs and tested the water quality, characterized the microbial community, and developed a Stella model for the system. For their final project, they created posters and videos describing the entire system to be displayed in the Kern Center. Assessment data for the program was collected using pre/post questionnaires, rubrics, self-evaluations, focus group interviews and anecdotal reports from faculty. The results of these assessments are used to demonstrate the effectiveness of introducing students to problem based research questions, peer mentoring and collaborative research in their first year.

Presenter: Calabria, Jon

Study Abroad: Student Reflections from a Semester Design Studio in the Premontane Wet Forest of Costa Rica

This presentation highlights challenges and successes of guided reflection during a condensed semester long study abroad course that trains aspiring landscape architectural students in Costa Rica. The curriculum consists of taking a project through design development and construction documentation phases. These projects involve stakeholders from campus, who also live in the community of San Luis. During the Fall 2015 semester, students envisioned an Artist in Residence (AIR) campus in an environmentally sensitive area that is likely to undergo a vast ecological shift due to climate change. Students considered design strategies and tested them with landscape performance evaluations to improve ecological function within a built landscape. These experiences were captured through daily, professional journaling and a prompted reflection piece at the end of the semester partially based on the “DEAL” model (Ash and Clayton, 2009). Daily journal entries were recorded in a bound journal and reviewed by faculty and generally discussed biweekly. The beginning phase of the journaling focused on descriptive entries, then subsequent phases articulated academic learning of their chosen profession. Although there is some difficulty with sustained journaling and meaningful reflection, preliminary assessments of the reflection illustrated how students learned the craft of landscape architecture. Over the course of the semester, some of the biggest shifts centered on articulating their academic learning. Although frustrated at times, many students reported a greater awareness of their professional trajectory and how they can become better students of landscape architecture involved with sustainable design in a changing ecosystem.

Presenter: Calabria, Jon

Projective Design as a Research Strategy in Ecological Engineering

When considering research strategies in ecological engineering intended to solve vexing, wicked problems, projective design is not a familiar term to most. Historically, some disciplines have met a sole objective at the cost of others, such as channelization of rivers for flood control that disregard the ecological function of riparian ecotones. Instead of solving for a single objective, perhaps using projective design as a methodology to optimize a solution that satisfies many objectives is meritorious. Design based research is not a new idea, but in the age of rapid model simulations that characterize and predict dependent ecological functions, projective design should be considered as a primary design strategy. That is, using projective design to suggest a variety of alternative design solutions that are subsequently vetted in light of many competing objectives could be an appropriate strategy and worthy of discussion as ecological engineering grapples with ecologically appropriate, resilient solutions. In this session, several examples of projective design will be presented to help participants visualize the benefits of providing a projective design that is subsequently assessed through landscape performance metrics. Projective design offers opportunities to reach an optimized design alternative.

URBAN LANDSCAPES — TUESDAY, JUNE 7, 2016, 3:50-5:10PM CONCURRENT SESSIONS:

Presenter: Jon Hathaway
Lead Author: Winston, Ryan
Co-Authors: Jon Hathaway, Alessa Smolek, Bill Hunt

Modeling bioretention performance under climate change scenarios in Ohio, USA

The impacts of climate change on urban water systems, especially green infrastructure, have been largely unexplored. Quantifying the effects of changing precipitation and temperature patterns on stormwater controls is critical to building resilience into urban drainage networks. Three bioretention hydrology data sets collected in Northeast Ohio were used to calibrate the continuous simulation model DRAINMOD. Precipitation and temperature data derived from dynamically downscaled climate predictions for the mid-21st century (2055-2059) under two climate scenarios (RCP 4.5 and RCP 8.5) were used to assess changes in the bioretention water balance (drainage, overflow, exfiltration, and evapotranspiration) compared to current climate conditions (2001-2004). Future climate scenarios suggested lower annual average rainfall depths, longer dry periods, and hotter temperatures for Northeast Ohio, leading to relatively modest changes to the overall water balance. Volume reduction provided by the bioretention cells was predicted to either increase by 4-6% or decrease by 5-9% under future climate. In all modeled cases, overflow and ET increased as a percentage of the water balance. To maintain current volumes of overflow in future climate scenarios, the bowl storage volume needed to be increased up to 51%. Results from this analysis suggest current bioretention designs may need modification to be resilient to climate change in this region. However, similar analyses should be conducted in other regions where predicted changes to precipitation patterns are more pronounced.

Presenter: Majidzadeh, Hamed
Co-AuthorS: B. Graeme Lockaby, Robert Price, Robin Governo
Effect of urban impervious surfaces on soil carbon dynamic

A significant increase in urbanization will be observed during the next fifty years. It has been shown that urbanization impacts soil carbon (C) and nitrogen (N). Many of previous studies have suggested that urban land use may increase the C storage in comparison to native soil without considering the effect of impervious surfaces such as building, and sidewalks on soil carbon. Few studies that sampled beneath the impervious surfaces are not usable in climate change models, since there is no insight to mechanism of reactions beneath those surfaces. To address this knowledge gap, for the first time, a controlled study designed with three different structures; concrete slabs, mock-up of houses on crawl space, and grassed lawns were installed on 5m x 5m plots.
Soil carbon content beneath concrete slabs and houses was 36 percent or 0.76 Kg/m2 (±0.15; ±95%C.I), and 52 percent or 1.11 Kg/m2 (±0.15; ±95%C.I) lower than grassed reference plots respectively. Higher carbon loss beneath the houses is due to oxidation of surface soil which is not protected by vegetation or concrete. While beneath the concrete slabs longer water poundings minimized the carbon oxidation. Soil oxygen beneath the concrete slab was significantly lower than other treatments. The soil beneath the concrete slab had the minimum microbial activity possibly due to lack of oxygen and food. The soil beneath the houses had higher microbial activity in comparison to concrete slabs, however still fifty-one percent lower than reference plots.

Presenter: Jayakaran, Anand
Co-Authors: T. J. Knappenberger, J. D. Stark, J. M. Palazzolo, D. R. Hitchcock
Rain garden mesocosm and porous pavements performance in Western Washington

Recent advances in several broadly allied scientific disciplines have shown that green stormwater infrastructure (GSI) can to some extent restore the natural pathways that stormwater takes from landscape to stream. Rain gardens and permeable pavements are one of several GSI techniques that are commonly used across the country. In the State of Washington, the use of GSI is mandated for any new or retrofit construction project that meets certain criteria. The talk will focus on performance studies of a 16-raingarden mesocosm array as well as a 9-cell replicated asphalt pavement test facility that are installed at the Washington State University Puyallup Research and Extension Center Campus, Puyallup, WA. The rain garden mesocosms comprise four different soil mixes with four replications each. The mixes differ in their sand, compost, and water treatment residuals content. The asphalt test facility has 9 lined cells - 3 cells are constructed with conventional asphalt and 6 with porous asphalt. Runoff from the impervious cells acts as control and were compared to runoff from the pervious cells. All water applied to the surface and that which infiltrated through the sub-base aggregate was monitored and collected at the outflow. Artificial and natural storm events were used to test both hydrologic and biogeochemical properties of the two systems. Pollutants evaluated were suspended sediments, metals, nutrients, and hydrocarbons. Preliminary stormwater flux and pollutant remediation information from this study will be presented at the conference. Results from the rain garden mesocosm study will be compared with flow and biogeochemical transformations conducted on four rain gardens in South Carolina, installed in four landscape positions, and monitored over a period of two years.

STREAM RESTORATION II — TUESDAY, JUNE 7, 2016, 3:50-5:10PM CONCURRENT SESSIONS:

Presenter: Jennings, Greg
Co-Authors: David Penrose, Karen Hall, Darrell Westmoreland, Jason Zink, Mike Geenen, David Bidelspach, Bill Swartley

Stream and Wetland Restoration at Rendezvous Mountain State Forest

Beginning in 2005, North Carolina State University, the North Carolina Forest Service, and North State Environmental, Inc., implemented a comprehensive stream restoration project on Purlear Creek on the Rendezvous Mountain State Forest property in northwestern North Carolina, USA. The goals were to improve water quality and habitat in mountain streams to provide recreational fisheries. This project serves as a demonstration and research site to promote best management practices for restoring and maintaining natural stream functions in watersheds with excessive stream sedimentation resulting from forestry and agricultural land uses. The restoration project included several components: (1) stream channel realignment and floodplain vegetation planting for a 200-m tributary in 2006; (2) restoration of a 2-ha wetland by ditch-plugging and planting in 2006; (3) streambank stabilization and in-stream structure installation in a 500-m reach of Purlear Creek in 2007; (4) stream channel realignment and floodplain vegetation planting for a 600-m reach of Purlear Creek in 2007; and (5) stream channel realignment and floodplain vegetation planting for a 500-m reach of Purlear Creek in 2009. During each phase, engineered plans were created based on local reference streams to restore natural physical and ecological stream functions. During construction, educational workshops were conducted to teach contractors, consultants, and agency representatives about natural stream restoration techniques. Comprehensive project site monitoring includes hydrology, morphology, vegetation, and in-stream habitat. Results to date indicate that the stream system is stable with a growing diverse plant and animal community. Ongoing benthic macroinvertebrate studies indicate rapid reestablishment of stable populations. This presentation will highlight lessons learned during and following project.

Presenter: Cooper, Dylan
Co-Authors: W. Cully Hession, John Galbraith, Durelle Scott

Does legacy sediment removal in stream restoration provide a reduction in floodplain nutrient release potential?

Many streams in the eastern U.S. have been severely disturbed by human activities in the last few centuries. Land use change has altered the flow regime, sediment budget, and physical characteristics of streams across the mid-Atlantic region. These streams are now disconnected from their original floodplain because of the aggradation of legacy sediments from upland erosion and upstream inputs or channel downcutting. Currently, stream-floodplain reconnection is advocated during stream restoration to take advantage of floodplain ecosystem services (e.g. sediment removal, flood peak attenuation, nutrient retention). Here, we seek to quantify the impacts of two common floodplain reconnection approaches that are expected to have distinctly different nutrient release potential due to soil composition/characteristics. The two current floodplain reconnections considered are the following: 1) a conventional stream restoration approach involves streambanks that are graded back or a streambed that is raised to allow for more connection with legacy sediments left on the floodplain; and 2) an ecological restoration approach involves removing the accumulated legacy sediments in order to restore the original floodplain. This original level is found in the existing soil profile at a buried A horizon that indicates a historic floodplain wetland surrounding the stream before human disturbance. Our evaluation of the nutrient release potential from the floodplain soils for each restoration approach will provide the ability to estimate net nutrient retention as a function of restoration approach. This study is taking place at the Virginia Tech StREAM Lab along Stroubles Creek, a third-order stream near Blacksburg, VA.

Presenter: Karina Bynum
Lead Author: Dostal, Tomas
Co-Authors: Karel Vrana, Karina Bynum
Stream Revitalization and Stream Enhancements in the Czech Republic

The conditions of small streams in the Czech Republic and in central Europe in general are not satisfactory. Streams have been straightened, armored, and incised. Agricultural use extends all the way to stream banks and riparian vegetation is often absent. Such conditions are often assigned to previous political regimes and their preference for utilitarian use of land. However, changes to the hydrographic network began in Europe in the 17th century during land use intensification. As such, hydromodification process is understood to always accompany land development. Attempts to revitalize small streams in the Czech Republic began in 1990 with Austria, Germany, Switzerland and Great Britain leading the efforts by a decade. Since then, the evolution of stream revitalization has gone through four distinct phases. The first attempts were comprised of placing grade control structures within the existing channels without any adjustments to the armored banks, or changes to the channel plan form or restoring riparian vegetation. The current state of stream revitalization encompasses entire channel plan form changes, morphology and flow diversification including removing migration barriers as a component of watershed wide revitalization with natural enhancement of floodplain retention function. In recent years, stream revitalizations are increasing the ecological stability of landscape and furthermore they integrate into the flood control and flood prevention in the watershed. This presentation provides detailed analysis of causes of high level of hydromodification of the hydrographic network in Europe as well as the history of evolution of the technological and natural approach to stream revitalization.

Presenter: Turner, Ian

Headwaters restoration of the West Virginia Coalfields: Adapting restoration techniques to high gradient Appalachian streams

Ecosystem Investment Partners, Inc. (EIP) has teamed with Civil & Environmental Consultants, Inc. (CEC) and the Canaan Valley Institute (CVI) in the restoration and creation of over 65,000 feet of high gradient headwater streams in the Coalfield region of southern West Virginia. Upon completion, this project will represent the largest stream mitigation bank in the state. The purpose of this presentation is to discuss the unique approaches EIP and its partners have taken to accomplish watershed-scale restoration in the heavily impacted landscapes of the southern Appalachians. Stream restoration in this region requires novel approaches to the design and construction of functioning, ecologically-sound fluvial systems. The corridor-based design instrument developed by CEC allows for the rapid design of streams in AutoCAD Civil 3D according to specific morphological criteria. These tools, combined with GPS-enabled earth moving equipment, will facilitate precise construction in the field. Slopes greater than 40% are common in this region; equipment that can function at these gradients (and the expertise to operate them) is critical to the project's success. In keeping with the River Continuum Concept, the reconnection of perennial streams to disconnected intermittent and ephemeral tributaries was of utmost importance to the restoration goals of this project. To this end, CEC and CVI have designed alluvial fans across highwall benches in order to rejoin disconnected stream reaches. We believe this project will showcase innovative techniques for how best to achieve sound headwaters restoration in the challenging topography of the southern Appalachians.

TREATMENT WETLANDS — TUESDAY, JUNE 7, 2016, 3:50-5:10PM CONCURRENT SESSIONS:

Presenter: Lewis, Allison
Co-Authors: Rafael Vazquez-Burney, Rick Gorsira, Jeffrey Harris

Supplementing Crews Lake Hydrology through Beneficial Water Reuse

Crews Lake, located in Pasco County, Florida, has suffered decades of hydrologic alteration from surface water diversions and consumptive uses from wellfield drawdown. These detrimental impacts have reduced the upper portion of the lake to a few isolated wetland pockets. In close proximity to the Lake, the Pasco County Master Reuse System (PCMRS), a regional reclaimed water distribution system, exceeds customer demand during wet-weather conditions. With the availability of this water source, rehydration of this lake was a natural solution to solve a significant water shortage. The feasibility of using excess reclaimed water from the PCMRS to restore Crews Lake hydrology and adjacent wetlands was investigated in 2011. In 2015, the concept of the Crews Lake Natural Systems Restoration (CLNSR) project proposed use of hydrologically-altered wetlands in the North Basin of Crews Lake as treatment wetlands to receive up to 5 MGD of reclaimed water, ensuring water quality standards in the South Basin of Crews Lake would be met. This innovative hydrologic restoration, to be permitted under Florida's Wetland Application Rule, is expected to improve lake stage to emulate the proposed Crews Lake Minimum and Guidance Levels. Application of reuse water to approximately 350 acres of created wetlands will significantly benefit the County's water reuse capacity of the PCMRS and have an immediate ecological benefit. This presentation will describe the preliminary engineering design and permitting of the CLNSR project and the expected ecological benefits through restoration of Crew's Lake hydrology.

Presenter: Vazquez-Burney, Rafael

Ecological Design Approaches to Leaky Wetlands for Aquifer Recharge and Water Reuse: The 4G Wetlands

The Pasco County Master Reuse System is the sole method of wastewater effluent management for Pasco County, Florida. Every gallon of reclaimed water produced is reused. Approximately 21 million gallons per day (mgd) is reused daily through irrigation, rapid rate infiltration basins, and industrial reuse. As the County has grown the need for additional reuse capacity has become evident. The feasibility of using constructed wetlands was investigated, and recommendations included an infiltration wetland system for water quality polishing and groundwater recharge.

Through a detailed public-private partnership, a 3,000-acre parcel known as the 4G Ranch was identified as a suitable candidate site the infiltration wetland system. The design of 15 infiltration wetland cells totaling 176 acres to be operated via water level measurements and flow control valves was developed. Model results have shown that an average capacity of 5 mgd (approximately 1 inch of infiltration per day) can be expected. Anticipated benefits include recharge to the aquifers and wetland rehydration in an area of historically significant well field drawdown.

Driven by the 4G Ranch's desire to use the system for recreation, the design includes an ecologically diverse system with areas of shallow, transitional, and deep water that will be operated seasonally to achieve healthy wetland hydroperiods within the cells. This presentation will describe the project drivers, the technical approaches used to quantifying aquifer recharge, expected water quality performance, but will focus on the ecological design approach taken to balance capacity with ecological value.

Presenter: Spangler, Travis
Co-Authors: David Sample, Laurie Fox

An Assessment of Floating Treatment Wetlands for Reducing Nutrient Loads and Enhancing Ecological Health in Coastal Virginia Nursery Retention Ponds

Floating treatment wetlands (FTWs) are an emerging technology whereby native wetland plants are planted on floating mats and implemented to remove nutrients from runoff from both point and non-point sources. This study will assess the effectiveness of FTWs for use in commercial nursery retention ponds; also known as tailwater recovery basins because they receive and store runoff from irrigation for potential reuse. Commercial nursery runoff contains higher concentrations of nutrients than typical urban stormwater. High concentrations of nitrogen and phosphorous can have negative effects on the surrounding ecosystem and aquatic species by causing increases in algal blooms and dead zones. By removing excess nutrients, FTW's can enhance the ecological health within the surrounding environment. Our experiment consisted of 32 mesocosms, each containing one of four different treatments: Pontederia cordata planted in cups supported by a Bee mat (a commercially available raft material), Juncus effusus planted in cups supported by a Bee mat, a Bee mat with no plants, and no treatment (control). Seven day retention times were utilized for the evaluation of the treatment types. Two nutrient concentrations were used: one representing the higher concentration expected at a nursery site and another for normal runoff concentration. Since the experiment is just being finished, laboratory analysis will be completed next. Results will then be analyzed using analysis of variance to identify statistically significant differences in nutrient concentrations; these will be summarized and presented at the conference. Initial results reflect higher treatment efficiency from the mesocosms with plants, particularly those containing Pontederia.

Presenters: Myer, Paul & Peter Haase
Co-Authors: Adrienne Carter, Emily Corwin

Recirculating Free Surface Wetland Treatment System to Reduce Nitrogen from Public School Wastewater to Meet California Standards

The San Lorenzo Valley Unified School District (District) owns and operates the San Lorenzo Valley School Complex in Felton, California. The campus includes elementary, junior high, and high school facilities. The total population of the entire campus is approximately 2,188 students and 119 faculty and support staff. Since 2006 a two-cell 0.2 acre free surface water recirculating wetland system has provided the District with tertiary treatment for their centralized onsite wastewater system, exceeding Waste Discharge Requirements (WDR) issued by the California Regional Water Quality Control Board-Central Coast Region to reduce total nitrogen by at least 50%. In 2001, the District retained Fall Creek Engineering, Inc. (FCE) to perform a wastewater system evaluation and improvement plan to meet the WDR requirements. FCE selected the constructed wetland for tertiary treatment because of its ability to adapt to fluctuating flow rates and remove nitrogen in a carbon limiting environment. The wastewater entering the wetlands is carbon limited and the decaying vegetation in the wetlands provide a carbon source to allow nitrifying and denitrifying bacteria to grow.

Testing since 2006 indicates the wetland is producing high quality effluent, reducing the total nitrogen concentration well over 50%, above the State's requirements. The constructed wetland system continues to be used as a living laboratory, where science students conduct ongoing environmental monitoring while gaining real world experience in environmental enhancement and pollution control. The wetland provides ancillary habitat benefits for wildlife and water fowl with the presence of ducks, snails, turtles, frogs, and small mammals.

GREEN INFRASTRUCTURE APPLICATIONS — WEDNESDAY, JUNE 8, 2016, 9:10-10:20AM CONCURRENT SESSIONS:

Presenter: Tirpak, Andrew

The Health of Trees in Existing Bioretention Areas in Tennessee and North Carolina

Bioretention is a commonly used stormwater control measure (SCM) that can be implemented to improve water quality and reduce runoff volume generated from impervious surfaces through biogeochemical processes. Plants and vegetation have been shown to improve the nutrient removal performance and lifespan of these systems. However, little guidance is given for plant selection within these systems, and often times all varieties of vegetation are considered equal in terms of their contribution to the effectiveness of the system (though some studies have shown this is not the case). Although the numerous benefits of trees in urban areas are understood (i.e. heat island mitigation, air quality improvements, noise attenuation, etc.), knowledge of their potential contributions to stormwater management as an integral component of bioretention is minimal.

The first step toward understanding tree health in bioretention areas is to examine their vitality in existing practices. Thus, field assessments were conducted in over 30 bioretention systems in Tennessee and North Carolina following guidance developed by the United States Forest Service. Tree health was quantified through measurements of crown conditions and leaf chemistry. These assessments were paired with site-specific bioretention characteristics compiled through additional observations and design plan consultations. Findings from these field surveys will be used to determine the overall health of trees in bioretention systems and to identify any design components and species selections that influence tree health. Ultimately, this research will culminate in the development of design specifications and guidance for bioretention systems that will aid in maximizing tree growth and health.

Presenter: Wijesinghe, Dhanuska
Co-Authors: D.R. Hitchcock, A.D. Jayakaran, D.M. Park

Applicability of Wetland Systems to Mitigate Stormwater Runoff in Coastal, South Carolina.

Population growth and the subsequent increase in impervious surfaces over the recent decades create challenges with stormwater management, especially in highly urbanized areas. As a consequence, the occurrence of flooding, algae blooms and bacterial contamination have increased. In the recent past, stormwater wetlands (especially as vegetative based Low Impact Development practices) have gained increased attention for reducing stormwater volume and outflows since they mimic more closely to natural hydrologic processes. A field study has been initiated to determine the applicability of stormwater wetland systems in reducing outflows and contaminants generated via storm events in coastal South Carolina USA. A natural coastal freshwater forested wetland partially influenced by tidal flows and saltwater intrusions, and a recently constructed pond wetland system are currently being monitored to: (a) determine the hydrologic flows and responses to storm events; (b) assess nutrient/bacterial concentration and loads; (c) develop hydrologic and nutrient/bacteria budgets; and (d) calculate stormwater-associated nutrient/bacterial treatment performance. Preliminary data indicate higher bacteria counts were prevalent in the inlets of each wetland system during the dry season of the year (June to September 2014) while the lowest counts were determined during the coolest period of the year (December 2014 to March 2015). This trend was much more evident in the tidal wetland system. Both wetland systems have similar gradients of bacteria counts between inlet and outlet, with bacterial counts decreasing with proximity to wetland outlet. The expected outcome of the study is a comparison of natural and engineered coastal wetland systems specifically with respect to: (a) surface and groundwater contributions to wetland hydrology; and (b) spatiotemporal variations of nutrient/bacterial loadings.

Presenter: Jon Hathaway
Lead Author: McCarthy, David
Co-Authors: Chandrasena, G.; Deletic, A.; Shirdashtzadeh, M.; Henry, B.

Stormwater biofilters for pathogen removal; selecting plants which naturally excrete antimicrobial compounds

Optimisation of stormwater biofilter design and operation has focused primarily on typical pollutants of concern (sediments, nutrients and heavy metals). Relatively little attention has been placed on optimising these systems for faecal pathogens, which are important if stormwater is to be reused/harvested or released into recreational water bodies. We explore how careful vegetation selection for stormwater biofilters can improve pathogen removal. 20 plant species were chosen for the trial, based on a number of criteria (e.g. drought tolerance, plant size, root type, known to exhibit natural antimicrobial compounds in their roots, stems, leaves, flowers, seeds or root exudates). The antimicrobial properties of each plant was tested using (1) seed exudates, (2) seed extracts and (3) seedling extracts. Of the 20 species tested, 9 exhibited antimicrobial properties (according to standard inhibition zone testing) against the chosen indicator organism (E. coli). Melaleuca ericifolia (a common plant used in biofilters in Australia) showed the highest inhibition against E. coli, achieving similar results to our gentimicin (antibiotic) control. Indeed, M. ericifolia’s seed exudates, seed extracts and seedling extracts all exhibited large zones of inhibition, suggesting this plant contains strong antimicrobial properties. The results also demonstrate strong inter-specie differences; we tested 5 Melaleuca species, yet only two showed antimicrobial properties. Similar results were found for the Leptospermum genus, where only L. continentale had antimicrobial properties of the 4 species tested. The results of this work demonstrates that careful selection of vegetation can potentially yield better removal of faecal pathogens in stormwater biofilters.

Presenter: Baltaci, Enis
Co-Authors: Latif Kalin
Effectiveness of Rain Barrels and Permeable Pavements as LID Practices for Flood Control in a Coastal Alabama Watershed

Urbanization is known to cause increases in volume of stormwater runoff and peak flow rates, which leads to changes in natural flow regime and increases the likelihood of flooding. Conventional stormwater management practices mainly focus on reducing peak flow rates; surface runoff volume reduction has traditionally been ignored. Conversely, Low Impact Development (LID) practices seek to increase the area available for infiltration to reduce runoff volume and peak flow as close to the source as possible, and are generally considered to be a more sustainable solution for urban stormwater management. In this study, the effectiveness of two LID practices, Rain Barrel and Permeable Pavements, in mitigating urban flooding was tested within the 7.95 km2 Toulmins Spring Branch Watershed (TSBW) in southwest Alabama. The main motivation of studying the flooding problem in the TSBW was the frequent complains of its residents about chronic flooding. The EPA Stormwater Management Model (SWMM) was first calibrated with observed stage data in multiples sites then was used to identify the areas prone to flooding. Effectiveness of various LIDs in reducing peak flow and runoff volume at these areas was then explored with SWMM. Results indicate that LID controls can have considerable impacts on stormwater management by reducing runoff volume and peak flow rate, potentially returning watersheds to their natural flow regime, thereby preventing the flooding of urbanized area. However, the effectives of LIDs especially for the runoff volume quickly diminish as the return period of the storm increases. Rain barrels were the most economical and effective LID strategies within the TSBW drainage system.

STREAM RESTORATION III — WEDNESDAY, JUNE 8, 2016, 9:10-10:20AM CONCURRENT SESSIONS:

Presenter: Robinson, Jesse

Measuring fundamental stream and wetland functions in a restored stream-wetland complex and un-restored comparison watershed in the Daniel Boone National Forest near Morehead, KY.

It is widely acknowledged that measures of success for stream and wetland restoration should be based on variables linked to fundamental functions. However, for restoration practitioners, it is often unclear how to translate this into assessment techniques- primarily, what variables to monitor, and how frequently these variables should be monitored. For compensatory restoration projects used to offset lawful impacts, these monitored variables are used as performance standards to assess failure/success, further adding to the need for appropriate monitoring. Prior to this study, one watershed in the Daniel Boone National Forest (0.9 sq. miles) was restored to a stream-wetland complex; another adjacent watershed (1.2 sq. miles) remained un-restored and was used for comparison. Both sites were instrumented for one year using continuous monitoring in order to measure key hydrologic and geomorphologic variables, which were supplemented by bi-monthly visits to collect discrete measurements of functional variables. Both continuous (e.g., timelapse photography, stream and groundwater stage, substrate movement) and discrete (sediment sampling, field observations) assessment techniques were used. Results for the restored site reveal significant improvement in the stability of aquatic substrates/habitat, increased interaction with the floodplain and improved connectivity between the stream and groundwater. Discrete measurements revealed important differences in the stability of aquatic substrates/habitat and provided context between monitored cross sections, but were significantly less effective in revealing differences in hydrologic function. In all cases, continuous measurements provided an improved understanding of the interaction between functions at different timescales. The practicality and cost effectiveness of each monitoring strategy used is discussed.

Presenter: Yoon-Jung Cha
Lead Author: Chun, Seung-Hoon
Co-Authors: Ga-Young Kim, Ji-Woo Chung

An application study on river environment assessment system for designation guideline of river project zoning in Korea

River management associated with water resources is controlled by the River Act established in 1961 under the Ministry of Land, Infrastructure and Transport (MOLIT). The River Act adopted the concept of conservation and restoration of river ecosystems. River Act 44 conducts the designation of project zoning (conservation, restoration, or water-friendly zone) for nature-friendly stream construction. Since there are no legal guidelines for quantitative baselines for designation of project zoning, river projects have been mostly conducted without a sufficient consideration of legal efficiency, consistency, or the characteristics of river conditions.
A standardized integrated assessment system for river environment has been developed recently to improve the efficiency of river restoration projects in Korea. The river environment is assessed into 4 categories (physical characteristics, biological characteristics, water quality and amenity) with 39 indicators.

This study was carried out to test the practical usefulness and legal effectiveness of the assessment system on the stream where the 'Master Plan' had been already established, to compare the zoning baselines between real situation and application results. We suggested guideline for river project zones by combination of River Naturalness (physical characteristics, biological characteristics and water quality) with Amenity grade.

All categories were proved as proper to represent the river/stream environment and coincident with project zoning. According to river classification proposed in physical category, the reach lengths (assessment unit) ranged between three to five kilometers long, which differs from legal zoning scale (2 km) partially. It is expected that the developed assessment system can provide quantitative guideline for river project zoning.

Presenter: Duke, Jeffrey
Co-Author: Steve Casey
South Harpeth River Bank Stabilization

The flood of May 2010 caused severe erosion along the South Harpeth River in Williamson County, Tennessee. The projected scope of work included stabilizing the right bank with longitudinal stone toe protection and live siltation along with the installation of a 10 ft. bankfull bench.

The goals of the project were:
• Not to increase 100-year flood depths,
• Stabilization of eroded streambank,
• Create a riparian corridor and buffer,
• Protect existing residential properties, and
• Plan for a future streamside park.

The project was selected as an area of the South Harpeth River that was in need of water quality improvements and bank stabilization. Williamson County participated in a FEMA-sponsored property purchase program to remove structures from the floodway and allow for the development of a future streamside park. The strategic placement of natural structures that had higher shear resistance where necessary (e.g. longitudinal stone toe protection at the toe vs. jute matting on the upper banks) allowed for a “greener” and more permittable project. The longitudinal stone toe protection placement with live stakes provided the means for long-term toe protection because the stone can self-launch into future scour holes and the live stakes will spread soil stabilizing roots into the toe of the slope. The channel stabilization and re-vegetation plan will provide long term stability by reducing vertical banks and providing a floodplain area to dissipate the energy of flood flows. A stable channel with access to a floodplain will reduce flood velocities and prevent excessive scour of aquatic habitats.

Presenter: Jennings, Greg
Co-Authors: Jason Zink, David Penrose
Grassy Creek Restoration to Provide Hellbender Habitats

Grassy Creek is a tributary to the North Toe River in northwestern North Carolina with water quality and habitat impairments due to sediment, stormwater runoff, and loss of riparian buffer. A 1-km segment of Grassy Creek in Spruce Pine, NC, was restored in 2015-2016 with the goals of improving water quality and habitats, specifically for the Significantly Rare hellbender and other aquatic fauna, including trout. Ecosystem restoration components include: (1) stream channel realignment and floodplain re-connection to provide natural equilibrium bankfull morphology; (2) in-stream structures including log and rock vanes for habitat enhancement and erosion reduction; (3) streambank wood toe revetments to reduce erosion in meander bends and support habitats; (4) planting native riparian vegetation and removal of invasive plants; and (5) installation of constructed stormwater wetlands to collect and treat runoff from adjacent impervious surfaces. During construction and planting, educational workshops were conducted to teach contractors, consultants, and agency representatives about natural stream restoration techniques. A nature trail was installed parallel to the restored stream reach with signs to educate the public about water quality, hellbender habitat, and stormwater control. Project success is being monitored using water quality samples and biological community assessments of fish, macroinvertebrates, and hellbenders. Results to date indicate that the stream system is stable with a growing diverse plant and animal community. This presentation will highlight lessons learned during and following project implementation while highlighting the need for long-term monitoring studies to evaluate ecosystem restoration performance.

NOVEL METHODS IN WATER QUALITY MODELING — WEDNESDAY, JUNE 8, 2016, 9:10-10:20AM CONCURRENT SESSIONS:

Presenter: Cantor, Jacob
Co-Authors: Leigh Anne Krometis, Emily Sarver, Nicholas Cook

Exploration of strategies to track the downstream impacts of human sewage in underserved rural communities

Monitoring pathogen contamination in receiving waters is critical for the protection of public health. Fecal contamination by human sources is generally considered a primary health concern as many waterborne pathogens (viruses in particular) exhibit host specificity with humans. Standard water quality assessments generally only include evaluation of total coliforms or E. coli, which are common to all warm-blooded animals, and so provide limited information regarding specific upstream source remediation needs. The inclusion of library-independent, established source-specific markers in monitoring efforts can greatly aid in watershed assessment.

The genetic marker HF183 from Bacteroides spp. has been well established as strongly indicative of the presence of human fecal contamination; however, to date, the majority of studies have documented HF183 detection downstream from relatively large centralized wastewater facilities, with usefulness in rural watersheds not well documented. The present study investigates water quality in small streams in central Appalachia known to have multiple discharges of untreated household waste (e.g. straight pipes). Efforts to document the extent of downstream impacts of these discharges included: 1) analysis of monthly water samples above and downstream wastewater discharge points via traditional methods for E. coli and molecular methods for HF183 to identify potential correlations in detection; and 2) completion of a geospatial statistical analysis to examine changes in microbial detection quantities based on season and distance from known contamination sources. Demonstration of successful use of molecular detection of HF183 in rural communities will provide water quality managers with a means to justify investment in local wastewater infrastructure.

Presenter: Hazen, Terry

Paradigm change? Predicting water geochemistry from microbial community structure

At the Department of Energy's Oak Ridge field site, over 20 years of historical and published data for more than 800 groundwater wells is available in a computer queryable database. In this study, we conducted a survey of 99 groundwater well clusters in order to (1) characterize key microbial populations at geochemically distinct locations, and (2) identify associations between environmental gradients and microbial communities. To optimize geochemical diversity, wells were selected using k-medians clustering to group 818 wells into 100 clusters by 14 geochemically similar measurements. At each well, in situ groundwater measurements were recorded and unfiltered and filtered groundwater samples were collected for both geochemical measurements and analysis of microbial communities. Nucleic acids were collected by filtering water through a 10.0µm pre-filter and 0.2µm-membrane filter and then extracted using a Modified Miller method. Evaluation of divergence of microbial communities across all the wells indicates the microbial communities are fairly distinct. Comparison of microbial communities within each well shows taxa are not as divergent compared to across all wells. Metadata correlations of all the wells show many of the geochemical parameters are independent of each other. To evaluate potential microbial-geochemical associations, a random forest classification system was used and trained on the OTU abundances to predict continuous values for each geochemical parameter. Results indicate that with careful design and a large dataset, the groundwater microbial community structure can be used to accurately predict the water geochemistry.

Presenter: Ellis, Kathryn
Co-Authors: Timothy Callahan, Dianne Greenfield, Denise Sanger, Joshua Robinson
Hydrological assessments of tidal creeks to inform nutrient management recommendations

The purpose of this study is to provide regulatory agencies with information about the hydrology of tidal creeks by developing mathematical relationships between time, stage, and discharge. Currently, there are no stage-discharge or time-discharge relationships for these creeks, or many other similar creeks in the South Carolina Coastal Plain, so this information will fill an existing gap. The results will be used to evaluate biological responses (e.g., algal blooms) in coastal waters to identify linkages to flow and nutrient (nitrogen and phosphorus) dynamics in the waters; in other words, can nutrient delivery rate (mass flux) predict biological responses in coastal wetlands? There are four study sites: two in the Ashepoo-Combahee-Edisto (ACE) Basin and two in the Charleston Harbor system. Opportunistic sampling, with the goal to encompass as large a range of measurements as possible, is occurring over a two year period (2015-2016) to measure volumetric discharge in each creek with an acoustic Doppler current profiler (ADCP) unit. Additionally, the discharge data, combined with information from a related effort to collect nutrient and phytoplankton data, will be used to calculate presumptive Total Maximum Daily Load (TMDL) estimates for these sites. A runoff model will be used to estimate the potential water entering the creeks from the land surface; this quantity will be compared to the total volume of water that enters or exits the creeks (the tidal prism) to better understand how runoff may affect the environmental health and algal ecology in these creeks.

Presenter: Messer, Tiffany
Co-Authors: Martin Doyle, Michael R. Burchell, II, Francois Birgand
Do First Order Nitrate Removal Models Accurately Predict Nitrate Removal in Wetlands and Streams?

Traditionally, nitrogen removal kinetic models in streams, wetlands, and other ecological systems follow a first order removal rate model focusing solely on dissolved inorganic nitrogen (DIN) under the assumption that dissolved organic nitrogen (DON) is not bioavailable instantaneously in aquatic systems. However, photodegradation of DON in stream systems may actually provide additional sources of DIN that is absent in traditional nitrogen kinetic models. Photochemical mineralization, the process of dissolved organic matter (DOM) absorbing sunlight, thus reducing the molecular weight of the material, has the ability to affect the bioavaliability and quality of organic carbon and form photoproducts (e.g. ammonium). Therefore, this study provides insight to begin developing a better understanding of the impacts of photodegradation of DOM, particularly in the Neuse River Basin. Additionally, the study investigates the impact of photodegradation of DOM under varying radiation and water quality conditions at the microcosm scale.

INNOVATIONS IN GREEN INFRASTRUCTURE — WEDNESDAY, JUNE 8, 2016, 10:40-NOON CONCURRENT SESSIONS:

Presenter: Robinson, Joshua
Co-Author: Nolan Williams

Towards a Methodology for Quantifying the Storm Event Hydraulic Performance of Modular Green Roofs

Vegetated “green” roofs are growing in popularity for their many environmental and aesthetic benefits. In dense urban areas and other sites where stormwater infiltration is infeasible, green roofs can perform important and valuable stormwater management functions by retaining rainfall and detaining runoff. Although these qualitative stormwater benefits are commonly understood and accepted, the quantitative hydraulic performance of green roofs during individual storm events is not. As a result, design professionals are reluctant to claim stormwater management benefits when designing new projects that include green roofs, and regulatory officials are reluctant to allow green roofs to satisfy stormwater permit requirements.

Building on the efforts of Kaye and Martin (2014), this project seeks to 1) quantify the hydraulic performance of green roofs during individual storm events and hypothetical “design storms” and 2) develop a methodology for rainfall-runoff modeling that can be widely adopted by civil engineers and municipalities seeking to include green roofs as part of a stormwater management plan that meets local ordinance requirements.

This presentation will include a summary of the state-of-the-practice for hydraulic design of green roofs; an overview of the laboratory experiments underway at Clemson University, and an introduction to the modeling and design methodology using actual project examples.

Presenter: McAndrew, Brendan
Co-Authors: Changwoo Ahn, Johanna Spooner, Andy Sachs

Carbon and nitrogen capture performance of a floating treatment wetland as a measure for sustainable stormwater management in an urban environment

The paper presents a case study of floating wetland application as a measure for sustainable stormwater management for a major stormwater detention pond on the George Mason University campus in Fairfax, Virginia. A floating treatment wetland (FTW, ~50m2), constructed using a thin, buoyant foam mat with 1,600 individuals of five native species: american water plantain (Alisma subcordatum), fox sedge (Carex vulpinoidea), blueflag iris (Iris versicolor), common rush (Juncus effusus), and pickerelweed (Pontederia cordata), was launched early May 2015 on the campus stormwater pond. Water quality was monitored during the summer growing season followed by harvesting all plants and sediments mid-September. Results showed that 1,658 g of carbon (TC) and 191 g of nitrogen (TN) was captured by the FTW. Total plant biomass increased by 1,853 g; a 56% increase from pre-deployment. The plants assimilated 58% (958 g) and 34% (66 g) of TC and TN, respectively. Non-plant parts of the FTW retained 3,320 g of sediment containing 699 g TC and 126 g TN. The presence of nitrogen in this sediment indicates that a biofilm formed, aiding in nitrogen assimilation. Differences in plant assimilation were observed with Carex capturing the most TC (384 g) and TN (25 g), while Alisma captured the least (34 g TC/3.03 g TN). Differential capture of nutrients was observed between the shoots and roots of each plant, although no pattern was observed. Further implication of the results will be discussed in using a FTW for sustainable stormwater management.

Presenter: Stovall, Matthew

Design and Construction of a Regional Stormwater Detention Facility with Inclusive Stream and Wetland Elements

Subjects CBWSC was retained by the City of Chattanooga and Hamilton County Tennessee to provide design services for Enterprise South Industrial Park (ESIP). As a part of this effort BWSC prepared a detailed concept design for a Regional Stormwater Facility (RSF) along Poe Branch. This detailed concept design and supporting documentation was used to obtain ARAP and 404 permits from TDEC and the USACOE. This presentation will describe the design and construction of the second phase of the RSF for the Enterprise South Industrial Park which had been conceived and permitted. The intent of the RSF is to provide regional detention storage for ESIP.

This project restored approximately 2,750 linear feet of the existing Poe Branch by creating approximately 3,700 linear feet of new stream channel constructed using current stream restoration technologies. The stream restoration was designed and constructed utilizing the latest Rosgen Design Guidelines. Construction was performed by an experienced and qualified stream contractor, selected from a list of prequalified stream contractors. This list of prequalified stream contractors was provided to the general contractor as a part of the requirements of the contracted work. In addition to the stream construction, the project included the mitigation, preservation and construction of approximately 25 acres of additional wetlands and preserves approximately 2 acres of the existing 3.3 acres of wetlands. The work also provided approximately 330 acre-feet of storm water detention storage for the Enterprise South Industrial Park. This portion of the project was designed not only to provide stormwater detention storage for the current configuration of ESIP but provides for future build-out of the industrial park. Aspects of the project that are of particular interest include:

• Flow control was utilized on the north culvert inlet to minimize flooding during the full construction period until the final stabilization of the reconstructed stream and wetlands.

• Use of a combination of traditional stabilization mixes for temporary cover and native species for final stabilization.

• Incorporation of lessons learned from past stream and wetlands restoration projects on ESIP to improve design and performance of this project.

• Focus of the design effort on creating an environmentally elegant facility for regional detention while maintaining project cost at construction norms

STREAM RESTORATION IV — WEDNESDAY, JUNE 8, 2016, 10:40-NOON CONCURRENT SESSIONS:

Presenter: Tsakiris, Achilleas
Co-Author: Thanos Papanicolaou

Science based restoration using boulders

Large immobile boulders are often placed in mountainous stream reaches for restoring degraded streams in order to improve fish habitat, control sediment transport patterns and dissipate flow energy. Due to their large size, these boulders mostly remain partially submerged, but become fully submerged during floods, exhibiting low and high relative submergence, respectively. The boulders interact with the approach turbulent flow and modify the bed shear stress distribution around them, which in turn alters the incoming sediment transport patterns. This study aims to identify the dominant vortex structures that result from this interaction under high and low relative submergence conditions and assess the effects of these vortex structures on the bed shear stress field. In doing so, the turbulent velocity within two sets of orthogonal planes around a boulder was measured using Particle Image Velocimetry (PIV) under high and low relative submergence conditions. Preliminary findings show that arch and "inboard" vortices dominated the wake of the fully submerged boulder, whereas a pair of counter-rotating von-Karman vortices formed downstream of the partially submerged boulder. The inboard and von-Karman vortex structures appear to change the directionality of the bed shear stress vector around the boulder, pointing it towards and away from its centerline, respectively. This reversal is consistent with sediment depositional patterns around the boulders, observed in prior experiments with fully and partially submerged boulders. This research highlights the effects of large boulders on transported sediment through their controls of the surrounding turbulent flow with important implications on stream restoration designs.

Presenter: Tullos, Desiree
Co-Authors: Cara Walter

Scale of flow field observation influences apparent velocity use and energy expenditure in juvenile coho salmon

This study investigates how the scale of observation influences interpretations of how fish exploit the hydraulic environment in streams. We constructed a 1:1 scale model of a full-channel log jam in an outdoor experimental channel. Our objectives were to evaluate how spatial resolution of the flow field observation influences: 1) apparent hydraulic characteristics of the stream; 2) statistical patterns of use of the hydraulic environment by fish; and 3) associated estimates of energy expenditure. Velocities were measured with Acoustic Doppler Velocimetry at a 10 cm grid spacing, while fish locations and tailbeat frequencies were documented over time using underwater videogrammetry.

As predicted, the mean and variance of velocity generally decreased with coarsening resolution of the flow field observations, illustrating how observed velocities are compressed into a narrower and lower range at coarser scales relative to finer scales. Deviations from this trend were observed at local hydraulic features where turbulence was elevated around roughness elements. Results also highlighted how coarser-resolution observations can lead to misrepresenting selectivity of fish to be higher, and for lower velocities, than expected relative to higher resolution studies. By comparing energy expenditure estimates using velocities derived from tailbeat frequencies to those derived from spatially-matched velocity observations, we found that the compression of velocities can lead to underestimating energy expenditure, but that this effect is also sensitive to the location being sampled. Results suggest the need for careful attention to and communication of scale of observation in investigating and managing the habitat needs and bioenergetics of aquatic biota.

Presenter: Wyssmann, Micah
Co-Authors: A. (Thanos) Papanicolaou, Achilleas Tsakiris, Casey Kramer
Stream Restoration Influences of a Boulder Array: Bedload Transport Delay and Depositional Characteristics

Arrays of boulders occur naturally in mountainous gravel-bed streams and affect the flow and sediment transport characteristics of a reach. As such, artificial boulder arrays have been engineered for use in stream restoration projects because of their influences to promote stream stability, provide habitat functions and allow for fish passage. To aid in restoration design, the goal of this study is to utilize data from controlled laboratory flume experiments to improve understanding of array effects on bedload by: 1) assessing mean transport rates to improve current predictive methods, and 2) analyzing the depositional characteristics of particles around boulders, which are dependent on relative submergence. For the first objective, stress decomposition is implemented to modify existing bedload formulae that were originally developed for unobstructed flows. Previous stress decomposition methods have accounted for the stress borne by individual boulders, but here the reach-scale effects of the collective array on bed shear stress are also incorporated. This results in improved estimates, but there is still an order of magnitude discrepancy with observed fluxes. For the second objective, images taken at the conclusion of bedload tests are used to assess depositional locations and areas. Here, it is shown that sediment deposition around boulders occurs primarily in the downstream wake region for high relative submergence conditions (H/d_b = 3.5), whereas it occurs primarily in the upstream 'stoss' region for low relative submergence conditions (H/d_b = 0.8). Further, overall depositional area is assessed with respect to reach-scale bed shear stress.

Presenter: Ellis, Phillip
Hydraulic Engineers Toolbox: process and design solutions

Stream and wetland restoration projects are captivating. The breadth of knowledge inherent during ecological restoration is one of the primary appeals of these projects. However, with that breadth of knowledge, comes a complex combination of stakeholders, designers, and regulators. In order to have a conversation about appropriate goals and metrics, all parties should have a cursory understanding of the individual components that make up these fascinating projects.

This presentation will provide a cursory understanding of the hydraulic engineer's approach and process. Hydraulic analysis and design process resembles a fractal. When observed from a distance, or post-project, the design solutions are seemingly simple, elegant and reproducible. Although, if one takes a deeper look into the design process, a dizzying iterative analysis is revealed. An even closer look at the empirical means and methods will soon leave even the most technical of observers in a state of aggravation.

Through this presentation we will provide a candid and systematic approach to hydraulic engineering design for stream rehabilitation projects. This approach will then be applied to a case-study for a typical scenario: bank migration and property loss resulting from sediment imbalance in an alluvial channel.

WASTEWATER TREATMENT & RESOURCE RECOVERY — WEDNESDAY, JUNE 8, 2016, 10:40-NOON CONCURRENT SESSIONS:

Presenter: Kemmerling, Lindsey, Co-Authors: Dawn Reinhold, Rebecca Bender, Ronald Aguilar, David Hidalgo, Connor Bartle, Jacob Cochrane, Amanda Godar, Hannah Guyer, Lindsey Kemmerling, Taylor Koonce, Madeline LaBelle, Wei Liao, Sydney Preston, Aubrey Proctor, Jason Smith, Renee Swartz, Katerina Tsou, Justine Williams

Bacteria, sunlight, and dirt: Making the most of human wastewater

Much of the biodiversity on Earth is at risk due to human destruction of natural ecosystems. One such cause of this destruction is a lack of effective wastewater treatment systems, polluting clean water, perticularly in developing countries.

Michigan State University joined with the Gender Equity Office of the Costa Rica Institute of Technology in their work with the Shuabb Aborigine Women's Association to develop an ecotourism site in Talamanca, Costa Rica. A water treatment system was needed to provide for guests and to prevent negative human impacts.

Our team has designed a wastewater treatment and energy production system utilizing basic mechanical and biological processes. First, water is directed from a nearby creek to a smaller settling tank. It is then distributed to the kitchen (where it is filtered), showers, and latrines. The black water is piped downhill to a solar-assisted anaerobic digester, where bacterial colonies remove pathogens and produce usable biogas. As water exits anaerobic treatment, it enters a constructed wetland where bacteria and plants work to further purify the water output of the digester. This water then flows through a drainage ditch and safely returns to the watershed.

Not only is clean water necessary for a balanced and functioning ecosystem, but for human health as well. Our ecosystems engineering team believes such integrated design can promote ecotourism while protecting natural ecosystems. Such a water purification system can combat larger global issues and promote sustainable development.

Presenter: Roy, Eric

Phosphorus recovery and recycling with ecological engineering: existing approaches and key challenges

Phosphorus is essential to life on Earth and frequently limits the productivity of ecosystems, including agroecosystems. Currently, a substantial portion of the global human population relies on finite phosphate rock resources used for inorganic fertilizer production. Concern over the poor management of these vital resources has stimulated interest in phosphorus recovery and recycling from waste streams. Existing heterogeneity in spatial patterns of human settlement, agriculture, and the availability of resources calls for a diverse array of phosphorus recycling strategies. Ecological engineers working on phosphorus management have most commonly aimed to create phosphorus sinks on the landscape, thereby alleviating downstream eutrophication. Looking ahead, ecological engineering approaches will increasingly be needed that go beyond phosphorus retention and link eutrophication control efforts with strategies to support the productivity of food systems. This presentation will include a brief overview of human impacts on the global phosphorus cycle and a survey of existing ecological engineering techniques for phosphorus recovery and recycling. A systems approach for assessing the feasibility and sustainability of phosphorus recycling with eco-technology will be outlined, along with several key challenges related to energy, scaling, and interdisciplinarity.

Presenter: Huynh, Khang
Co-Authors: Emily Banach, Dawn Reinhold

Fate and accumulation of triclosan in soil-plant systems receiving treated wastewater irrigation

Wastewater reuse for agricultural purposes has been rapidly increasing worldwide due to shortages of clean water. However, the potential health risk caused by trace residues of emerging contaminants in this source of irrigation water is still a concern. In the present study, we tested soil-plant systems receiving synthetic wastewater containing trace amounts of triclosan (TCS), a commonly found antimicrobial in treated wastewater. Both 14C and nonlabeled-TCS were used to track the transformation, metabolism, and transport of TCS in soil and four vegetable species (cabbage, onion, pepper and tomato). Preliminary data revealed that 14C-TCS was accumulated mostly in the 0-10 cm soil layers (78.8 – 93.3%), and was extensively transformed, presumably to methyl-triclosan. Additionally, the accumulation of 14C-TCS in the soil was found to constantly increase with time, which was not observed for the non-labeled TCS. The results consolidated our hypothesis that TCS underwent extensive transformation in soil following reclaimed wastewater application. On the other hand, the presence of plants in the system significantly affected the levels of TCS detected in soil samples at the conclusion of the experiments. The concentrations of TCS in the control (soil without plants), pepper and tomato soil columns were 6.2±2.2, 3.0±1.0 and 2.1±0.7 μg/kg, respectively.
Currently, we are working on analyzing the remaining soil, earthworm and plant samples in order to achieve a better understanding of the transformation, metabolism, and transport of TCS in our soil-plant systems.

Presenter: Brennan, Rachel

Eco-Machine Aquaponics: Capturing Nutrients from Wastewater for Sustainable Food Production.

Current wastewater treatment and food production methods often require massive amounts of energy, and can release excess nutrients and untreated contaminants into aquatic systems, promoting eutrophication and destroying water quality. Continuing population growth and economic development will only increase the demand for nutrients to maintain food production and the severity of the resulting water pollution. Certain aquatic plants can reverse this process by hyperaccumulating nutrients from wastewater and contributing to treatment. Once these nutrients are incorporated into plant biomass, they can easily be harvested and reused for sustainable agriculture and aquaculture. This transformation of nutrients as a liability in wastewater, into an asset for sustainable agriculture, simultaneously reduces eutrophication and enhances food security.

Our goal is to critically evaluate the technical and economic feasibility of combining two processes: 1) ecological wastewater treatment (i.e., Eco-Machines) with 2) self-sustaining aquaponics, to produce a safe and nutritious source of food to local communities. The key to the seamless integration of these two processes is the capture of nutrients from wastewater into high-protein aquatic biomass (ex., Lemnoideae, or duckweed) that can be easily harvested and fed to fish, thereby reducing dependence on conventional fishmeal. Co-location of aquaponic systems with wastewater treatment plants further reduces energy consumption that would otherwise be required for commercial feed production and transportation. This engineered ecosystems approach represents a new paradigm for holistic wastewater treatment and integrated agriculture, and provides an example for future development of sustainable infrastructure at the food-water-energy nexus.

MEASURING IMPACTS OF GREEN INFRASTRUCTURE — THURSDAY, JUNE 9, 2016, 8:30-9:50AM CONCURRENT SESSIONS:

Presenter: Bynum, Karina

Ecological Benefits of Tennessee Multi-functional Stormwater Requirements The Obed River Case Study

Land development and urbanization changes the hydrologic characteristics of the landscape. Increased runoff volumes, flow rates and velocities increase the frequency of bank-full and flooding events causing channel erosion. In 2006, the EPA identified hydromodification as a leading cause of impairment of nation's waters. In 2008, the report on Urban Stormwater Management in the United States concluded that the current approach to stormwater management did not yield significant water quality improvements. The conventional practices for site development and stormwater system design and management are the primary reason for continued hydromodification and water quality impacts to receiving streams. Green infrastructure has become a permanent part of stormwater management in the United States when the EPA incorporated the 2008 findings of the National Resource Council on Urban Stormwater Management in the United States. Green infrastructure plays an integral role in ecological stability of a landscape, in the support of biodiversity and directly affects the living standard of a society. After 12 years, Tennessee small municipal stormwater is entering the third permit cycle to treat and manage urban runoff in 100 jurisdictions across the state. Municipalities in Tennessee now include green infrastructure in their stormwater permit requirements along with with the traditional stormwater conveyance and detention regulations. The presentation reviews the ecological benefits of permanent stormwater as required in the Tennessee Municipal stormwater permits along with the design standards and incentives. A case study for the Obed River highlights the ecological benefits of Tennessee stormwater requirements.

Presenter: McMillan, Sara
Co-Authors: Erin Looper

Influence of stormwater control measures on in-stream denitrification rates

Stormwater control measures (SCMs) are implemented in urban watersheds to reduce the quantity and improve the quality of runoff entering streams. Channelization and stream degradation due to urbanization limits the capacity for headwater streams to remove additional nutrients and SCMs have the potential to improve these conditions through reduction of scouring peak flows and changing water chemistry. Because performance monitoring typically ends at SCM outlets, it remains unknown how ecosystem quality and function within urban stream networks are influenced by mitigation via SCMs. To address this gap, we measured denitrification enzyme activity (DEA) to assess nitrogen (N) removal potential and as an indicator of ecosystem function. We measured DEA on stream sediments upstream (US) and downstream (DS) of the SCM-stream confluence in two urban and two suburban watersheds seasonally and before/after storm events in Charlotte, NC. We compared DEA at US and DS across sites, which showed that SCMs have greater potential to enhance DEA at low levels of total imperviousness (TI). We observed longitudinal increases in DEA, which coincided with inputs of additional SCMs along the stream reach or in-line features. Following storms, DEA decreased at both US and DS sites and recovered to pre-storm rates 1-3 weeks suggesting that SCMs do not fully attenuate peak floods but may provide additional resources for rapid resetting of microbial communities. Our results suggest that particularly in watersheds with low TI, SCMs may act synergistically to reduce runoff and pollutant loads within the watershed as well as enhance in-stream processes.

Presenter: Clinton, Sandra
Co-Authors: Sara McMillan

Seasonal patterns in stream macroinvertebrates in urban watersheds with stormwater control measures

Urbanization decreases the abundance and diversity of macroinvertebrates in streams. Stormwater control measures (SCMs) are implemented to mitigate these impacts and improve overall stream health; however, few data exist quantifying whether SCMs positively influence stream ecosystem function. We investigated seasonal changes in community composition of stream macroinvertebrates from 2011 – 2013 in 4 small watersheds (2 suburban, 2 urban) in Charlotte, NC. Samples were collected immediately upstream and downstream of the confluence of the SCM outlet and the stream channel and at two additional locations downstream using NC DENR Qual 4 methods. Macroinvertebrates varied over space and time at all sites and showed patterns similar to other urban streams with dipterans dominating at all sites. EPT taxa were consistently found at both suburban sites; however, they were rarely observed at urban sites. There were differences in community structure among sites indicating that there are factors contributing to the maintenance of local invertebrate communities in each watershed. We tested multiple watershed metrics that quantify the degree of urban impact and SCM mitigation and found that total imperviousness (TI) was the variable that best predicted changes in macroinvertebrate diversity. We observed a negative linear relationship between richness and TI; however, there were seasonal and annual differences. When summer data were analyzed separately, regardless of year, there was no relationship between TI and richness. In addition, TI explained as little as 20% (Fall 2011) and as much as 60% (Spring 2013) of the variation in richness.

Presenter :Jaber, Fouad
Co-Authors: Sa'd A.H. Shannak

Impact of green infrastructure on stream bank shear stress at watershed scale

Stream bank erosion is a naturally occurring process that includes the removal of soil particles due to change in stream flow rate resulting from the discharge of runoff into the stream. The goal of this study was to investigate the impact of Green Infrastructure (GI) in reducing stream bank erosion in the Blackland Prairie ecosystem. A sub-hourly SWAT model was developed to predict stream flows. The model was calibrated and validated using data from Blunn Creek in Austin, TX after performing a sensitivity analysis. A methodology was developed to represent detention pond, bioretention and permeable pavement into SWAT. An analysis of shear stress and excess shear stress for stream flows in conjunction with different levels of adoption of GI practices was then done and the potential stream bank erosion for different median soil particle sizes using real and design storms was estimated. Calibrated stream flows for a 2-year period using the 15-minute time step had an R2 of 0.78 and an NS of 0.78. The 2-year validation period had an R2 of 0.70 and a Nash Sutcliffe (NS) of 0.67. Results showed that combining permeable pavement and bioretention resulted in the greatest reduction percentages in runoff volumes, peak flows, and excess shear stress under both real and design storms. Bioretention alone resulted with the second greatest reduction percentage while a detention pond alone had the least reduction percentages.

WATERSHED PROCESSES — THURSDAY, JUNE 9, 2016, 8:30-9:50AM CONCURRENT SESSIONS:

Presenter: Giannopoulos, Christos
Co-Authors: Benjamin Abban, Athanasios Papanicolaou

Characteristic time scales of sediment at the catchment scale: Implications to stream ecology

Spatial and temporal variability of sediment delivery at catchment scale hinders the effective assessment of Best Management Practices (BMPs), harms water quality and has implications to nutrient cycle. We focus on the mobilization and residence time of the finer fraction of sediment that affects particulate organic matter transport and transformation as well as water quality. The variability in the suspended sediment travel times is attributed to various factors, such as land management, several landscape attributes such as soil chemistry and surface roughness, and weather forcing and variability. This study aims to develop a method to estimate these travel times by collectively taking into account all of the aforementioned dominating parameters. We postulate that a catchment geomorphology approach is needed.

The hypothesis adopted herein is based on Hack's law for single basins, which relates the main stream length of a catchment to its drainage size and network. It is suggested that different areas of a watershed present distinct emergent patterns of suspended sediment concentration and discharge, depending on the downstream distance from the headwaters. Each emergent pattern reflects the dominance of a subset of parameters to the sediment output in contrast to all others, thereby distinctly affecting the travel times. At the locations where pattern changes, exists a crossover point. In order to provide a sound expected value of travel time, the travel sediment velocities need to be integrated between intervals where the same pattern prevails. Suspended sediment travel times are calculated by means of sediment concentration measurements and through inferences based on decays on beryllium-7 (7Be) radionuclide tracers.

Presenter: Govenor, Heather
Co-Authors: W. Cully Hession, Leigh-Anne Krometis
Commonalities in Benthic Stressors across the United States

Biological monitoring of invertebrate communities is a key component of stream monitoring under the Clean Water Act in nearly all states, and is one approach used to determine if the biological integrity of state waters is being protected. Monitoring methods, interpretation of field data, and metrics used to evaluate community health vary widely across the county leading to a lack of consistency in the approaches used to identify impaired waters and in how those impairments are reported to the U.S. EPA. Further, states differ in the approaches used to determine Total Maximum Daily Loads (TMDLs) to address the stressors implicated in the impairments. The objective of this research was to determine the most commonly identified stressor of benthic macroinvertebrate communities in the U.S. Through discussions with EPA and state regulators, and evaluation of nearly 1000 approved TMDL reports, we identify the stressors associated with benthic impairments and discuss trends in the approaches used to restore those waters as they have evolved since the TMDL program was initiated.

Presenter: Abban, Benjamin
Co-Authors: Thanos Papanicolaou, Christos Giannapoulos
Evaluating the Effects of Grassed waterways at the Watershed Scale Using a Coupled Hillslope and Instream Model

Grassed waterways (GWW's) are common land management practices utilized by watershed managers to minimize the negative impacts of excessive sediment delivery on instream water quality by effectively reducing the conveyance of sediment and sediment-borne pollutants. They have been found to slow water flow, increase infiltration rates, and promote sediment deposition due to the dense grass roots. The objective of this research is to investigate the scale-dependent efficiency of GWW's within an agricultural watershed. It is hypothesized that GWW's provide localized erosion protection, thus the impact of implementing GWW's is likely to decrease with increasing catchment size. To test our hypothesis, "thought" experiments are conducted using the Water Erosion Prediction Project (WEPP) model to determine water and sediment fluxes at different spatial scales. Preliminary results indicate that the efficiency of the GWW's decreases as the area of interest increases. The results are however limited by areal restrictions on the range of applicability of WEPP (typically less than 26 km^2) due to limited instream routing capabilities. This prevents further GWW assessment at the watershed scale, which is where most management decisions are made. Thus a new model is proposed that couples the WEPP model for water and erosion prediction on hillslopes with the 3ST1D model for flow and sediment transport within channels. The better coupling of the hillslope and instream domains will facilitate GWW (and other Best Management Practices) evaluation at watershed scales by improving water and sediment yield estimates at large scales.

Presenter: Trisha Moore
Lead Author: Bigham, Kari
Co-Authors: Tim Keane, Jason Vogel

Repeatability and Sensitivity Analysis of the Rosgen BANCS Model Developed to Predict Annual Streambank Erosion Rates

Excess sediment in streams is a leading cause of stream impairment in the United States, resulting in poor water quality, sedimentation of downstream waterbodies, and damage to aquatic ecosystems. Numerous case studies have found that accelerated channel and bank erosion can be the main contributor of sediment in impaired watersheds. An empirically-derived “Bank Assessment for Non-Point Source Consequences of Sediment” (BANCS) model can be developed for a specific region to rapidly estimate annual lateral bank retreat rates, based on both physical and observational measurements of a streambank. This study aims to address model criticisms by evaluating the model’s repeatability within and between users and identifying highly sensitive and/or uncertain model inputs. Ten stream professionals with experience utilizing the BANCS model individually evaluated the same six streambanks twice in the summer of 2015, based on current model streambank assessment methodology. To determine the model’s repeatability, individual streambank evaluations will be statistically analyzed with a mixed model. A "one-at-a-time" design approach was implemented to test sensitivity of model inputs. Preliminary statistical analysis of individual streambank evaluations suggest that the implementation of the BANCS model may not be repeatable between users, based on current streambank assessment methodology. This may be due to highly sensitive model inputs, such as streambank height and near-bank stress method selection, and/or highly uncertain model inputs, such as bank material. By identifying model inputs that require accurate measurement and analysis in order to obtain true and repeatable model outputs, these findings may improve future BANCS model implementation and creation.

ECOSYSTEM MODELING — THURSDAY, JUNE 9, 2016, 8:30-9:50AM CONCURRENT SESSIONS:

Presenter: Messer, Tiffany
Co-Authors: Martin Doyle, Michael R. Burchell, II, Francois Birgand
Do First Order Nitrate Removal Models Accurately Predict Nitrate Removal in Wetlands and Streams?

Traditionally, nitrogen removal kinetic models in streams, wetlands, and other ecological systems follow a first order removal rate model focusing solely on dissolved inorganic nitrogen (DIN) under the assumption that dissolved organic nitrogen (DON) is not bioavailable instantaneously in aquatic systems. However, photodegradation of DON in stream systems may actually provide additional sources of DIN that is absent in traditional nitrogen kinetic models. Photochemical mineralization, the process of dissolved organic matter (DOM) absorbing sunlight, thus reducing the molecular weight of the material, has the ability to affect the bioavaliability and quality of organic carbon and form photoproducts (e.g. ammonium). Therefore, this study provides insight to begin developing a better understanding of the impacts of photodegradation of DOM, particularly in the Neuse River Basin. Additionally, the study investigates the impact of photodegradation of DOM under varying radiation and water quality conditions at the microcosm scale.

Presenter: Shepard Watkins, Kate
Co-Authors: Shaye Sable
Development of a food web model for estuaries in southeast Louisiana [Part 1]

A comprehensive aquatic systems model (CASM) was developed for the coastal Louisiana food web across three basins to predict changes in species biomass in response to proposed river diversions. The CASM food web was made up of 34 taxa including phytoplankton, periphyton, zooplankton, benthic infauna, Caridean shrimp, brown and white shrimp, blue crab, oysters, bay anchovy, gulf menhaden, largemouth bass, red drum and spotted seatrout. Multiple life stages were simulated for many species. Daily growth was simulated with bioenergetics-based equations for each consumer population. The model was driven by simulated temperature, salinity, chlorophyll, and marsh vegetation data from the Louisiana Master Plan models from 1995 to 2010. Producer biomass was estimated from the chlorophyll data. Temperature was used to modify consumption, and daily species biomass growth was modified by salinity and the presence of marsh vegetation. The CASM was run in 49 polygons to predict the distribution of each population across the model domain, and the results of each polygon were combined to produce biomass estimates for the three basins. Basin-wide biomass was calibrated to monthly biomass estimates from Louisiana Department of Wildlife and Fisheries and National Oceanic and Atmospheric Association sampling programs. The CASM approach is particularly valuable for evaluating species responses within the food web to coastal restoration efforts because it simulates bottom-up processes (hydrology, water quality affecting prey growth and distribution) and uses a daily time step, which is valuable for evaluating the effects of short term management actions (e.g. seasonal or pulsed operations the river diversions).

Presenter: Shepard Watkins, Kate
Co-Authors: Shaye Sable

A food web model for estuaries in southeast Louisiana to evaluate coastal restoration projects (Part II)

The comprehensive aquatic systems model (CASM) developed to represent the estuarine food web across three coastal basins in Louisiana was used to evaluate key species responses to proposed large-scale Mississippi River diversions. We used the PEST software to calibrate the biomass predictions to data collected by Louisiana Department of Wildlife and Fisheries and the NOAA National Marine Fisheries Service. Spatial plots of the predicted biomass against the mean temperature, salinity, primary production, proportion of marsh vegetation, consumption rate, and predation mortality were used to verify the species distribution patterns were realistic. Several restoration alternatives were simulated by the DELFT-3D model that accounted for different river diversion locations and operational plans (intermediate versus high flow). The daily temperature, salinity, and Chl a generated at the DELFT nodes, and maps of marsh vegetation and open water generated by the LA-VEG module within DELFT at 1 km2 resolution, were averaged for the 49 CASM polygons and the food webs were run over 5 to 50 years. The relative changes in key species biomasses (e.g., brown shrimp, blue crab, red drum, gulf menhaden) over time for the entire system and within the thee coastal basins were evaluated by comparing the predicted seasonal and annual biomass results from the different diversion alternatives to a future-without-project scenario with no river diversions. Species responses were primarily driven by primary production and bottom-up effects on the food web, although responses were more complex for the larger predatory estuarine species with varied diets and wide-ranging salinity and habitat preferences.

Presenter: Kalin, Latif
Co-Authors: Mohamed Hantush, Sabahattin Isik, Amir Sharifi, Mehdi Rezaeianzadeh
WetQual: A Physically Based Wetland Nutrient Cycling Model

This abstract describes the Wetland Water Quality Model WetQual. The processes-based WetQual model can simulate the hydrology and water quality including nitrogen, phosphorous, carbon and sediment cycles in natural and constructed wetlands. WetQual can be used in continuously flooded environments or in wetlands going through wetting and drying cycles. The model explicitly accounts for oxygen dynamics and impact of oxidation-reduction reactions on nitrogen transformation and removal. The model partitions a wetland into water and sediment layers. The sediment layer is further partitioned into aerobic and anaerobic zones. The chemical, biological and physiological processes that take place in each compartment are fully coupled through ordinary differential equations. In addition to physical transport processes of advection, mixing, sedimentation/ resuspension, diffusion and burial, the model considers the following biochemical and physiological processes: nitrification, denitrification, mineralization, nitrogen fixation, atmospheric deposition, volatilization, plant uptake, and plant growth/death. Based on the conservation of mass principle and reaction kinetics, a coupled system of ordinary differential equations is formulated for the water column, aerobic layer and anaerobic layer. The model is transient in time but complete mixing is assumed in each compartment. A graphical user interface (GUI) developed for WetQual to process input and outputs is also presented. The GUI allows the WetQual model to be run either in a deterministic or stochastic mode as well as perform sensitivity and uncertainty analysis. Finally, application of WetQual to two wetlands, one on the U.S. East Coast and other on the West Coast is presented.

Presenter: Ludwig, Andrea
Co-Authors: John Schwartz, Brad Collett, Garrett Ferry, Tim Gangaware, Curtis Stewart

Integrating Extension, Teaching and Compliance Using Green Infrastructure at the University of Tennessee

At the University of Tennessee (UT), an integrated effort between teaching and Extension faculty along with Facility Services staff have created unique opportunities for various levels of learning to occur on campus while hitting regulatory goals for environmental protection. UT is a relatively urban campus adjacent to downtown Knoxville (population approximately $190,000) and along the Tennessee River (drainage area approximately 8963 mi2), encompassing 580 acres and hosting over 100,000 people on campus during certain times. Since 2012, UT has operated a municipal separate storm sewer system general permit, and as such, has enforced a post-construction stormwater management program as well as created public education and involvement opportunities to raise awareness of urban stormwater runoff impacts. A campus stormwater master plan was created through the work of graduate students to characterize campus in terms of stormwater impacts and retention opportunities. In 2013, UT was awarded one of four grants funded by a consortium of state agencies to implement green infrastructure to manage stormwater runoff. This grant funded the creation of rain gardens and constructed stormwater treatment wetlands on campus to protect the tributaries of the Tennessee River as well as showcase these technologies to the general public. The design, construction and maintenance of these practices were largely student-driven and will continue to provide an opportunity for experiential learning in university courses in the future. This presentation will showcase the work completed through this effort, highlighting the integration strategies that faculty and staff implemented to maximize learning.

Presenter: Fritz, Bridgette
Co-Authors: Emily Zefferman, Michael McKinney, Tommy Cianciolo
Knoxville Urban Wilderness: Managing abandoned urban lands for recreation and conservation

Many older urban areas have an increasing problem of “abandoned” lands as former land uses (e.g., residential, industrial, agricultural) are no longer economically viable. A growing solution, relatively new in the USA, is to use these areas as an “Urban Wilderness” (UW) for recreation, biodiversity conservation and education. Outdoor activities are badly needed in most urban areas and wild spaces provide substantial economic benefits for local land owners and businesses. Knoxville, Tennessee, USA, provides an excellent example of the UW model. The Knoxville Urban Wilderness (KUW) is a collection of land parcels owned by city, county, and state government, non-profit foundations, and private landholders. These parcels comprise 1717 acres representing a variety of previous land uses, including mining, farming, residential, and logging. The KUW brings in an estimated $8 million per year to the local economy, and costs relatively little to maintain. However, despite its current success as a recreational and economic entity, the KUW is still evolving, including two major needs to be addressed. First is the need for a coherent management strategy that balances the goals of recreation and conservation in the context of several different land owners. Second is the urgent need for a biological inventory of the KUW to improve management goals. Using “bioblitzes” and “citizen scientists”, we have significantly added to the inventory of known species in the KUW, and mapped major areas of invasive plant species. Several more such events are planned, to promote community involvement along with a growing biological data base.

Presenter: Thompson, Jessica
Co-Authors: John S. Schwartz, Jon M. Hathaway

Regenerative Stormwater Conveyances: Restoring Natural Flows and Engaging the Community

Regenerative Stormwater Conveyances (RSCs) are an innovative approach to repairing bank erosion from stormwater outfalls, while simultaneously treating stormwater runoff, providing groundwater recharge, and establishing floodplain connectivity. RSCs utilize shallow aquatic pools consisting of a sand/wood chip media to promote microbial action and infiltration; riffle weir grade control structures constructed from large boulders and cobble, to dissipate energy; and established native vegetation to promote microbial activity, nutrient reduction, and evapotranspiration. Their dual functionality allows small storms to infiltrate and travel through the system as shallow groundwater flow, and large storms to travel through the series of step pools to reduce erosive velocities prior to discharge.

In this study, two RSCs were designed, constructed, and monitored to evaluate performance. Concurrent with surface flow samples collected at the inlet and outlet, exfiltration and seepage will be quantified through the placement of monitoring wells within and along the system perimeter to accurately establish infiltration rates and shallow groundwater travel rates. Secondly, a model has been developed for the system using a TIN surface created from LiDAR imagery and the computational fluid dynamics (CFD) software program, Flow3D. This model allows a detailed understanding of the flow characteristics within the RSC. Lastly, in addition to research outcomes, the two RSCs will act as educational and demonstration sites, and serve as retrofit restoration projects for two degraded watersheds.

GREEN ENERGY — THURSDAY, JUNE 9, 2016, 10:10-11:10AM CONCURRENT SESSIONS:

Presenter: Horne, Alex

Renewable energy has a unique advantage for ecological engineering.

The Achilles heel of the two most promising renewable energies is intermittent supply. Solar power does not work at night, under clouds, and is limited in winter at higher latitudes. Likewise, the wind does not always blow at optimum speeds. Battery technology is improving but is costly and uses a lot of exotic (& toxic) metals. However, ecological engineering has a unique advantage since it can use ecosystems as “batteries”. Examples will be given from pumped constructed wetlands (14 day water storage & release) and reservoirs with hypolimnetic oxygenation systems (2 month oxygen storage & release).

Presenter: Mangrum, Diamond

Co-Authors: Freddy Witarsa, Stephanie Lansing

Effect of Separation on Poultry Manure Digestion

There is a need for more innovative renewable energy sources that treat waste and recycle the carbon and nutrients from waste back onto the fields. Anaerobic digestion can be used to treat waste such as animal manure while providing an alternative to fossil fuel energy use. Anaerobic digestion is a natural biological process that uses microorganisms to decompose organic matter in environments with little or no oxygen with biogas produced during the process. In this experiment, the difference in biogas production of poultry manure was determined when the entire fraction of poultry manure was digested, which includes wood chips and wood shavings, and when only the liquid fraction of the waste is digested after separation. Ground poultry litter was obtained from a poultry farm in Eastern Shore, MD. The litter sample was either screened using a 1mm solid mesh screen to remove solids and capture the liquid portion that passed through the screen, or left unscreened. Biogas and methane production for the two types of manure will be measured in triplicate 30 mL glass digestion bottles, for 30 days to determine if there is a significant difference in the amount of methane obtained. If the screened manure produces greater than or equal quantity of biogas compared to unscreened manure, clogging in the digester can be prevented using liquid manure. The results and conclusion from this ongoing experiment will be presented.

Presenter: Choudhury, Abhinav
Co-Authors: Stephanie Lansing, Kaitlyn Selmer, Walter Mulbry

Hydrogen Sulfide Removal from Biogas using Banana Peel Ash

Hydrogen Sulfide (H2S) is a corrosive and toxic trace gas present in methane-enriched biogas produced from anaerobic digestion systems. H2S is produced by sulfate reducing bacteria that compete with methanogens for resources. When the biogas from anaerobic digestion is used for energy production, the H2S in the biogas stream must be removed to reduce generator maintenance costs. One method of H2S removal is absorption of the gas into an alkaline scrubbing solution. The primary drawbacks of this method are high equipment and operating costs and disposal of the corrosive chemicals, making farm implementation difficult. This study was conducted to test the effectiveness of banana peel ash (BPA) as a low-cost alternative scrubbing method for H2S in biogas. An experiment was conducted using biogas from a dairy manure digester diverted into two gas washing bottles, one containing BPA in Deionized water (pH 12.19) and the other containing a 0.5 M potassium hydroxide (KOH)(pH 13.88) to compare to conventional methods. Preliminary results showed an instantaneous effect and the BPA solution captured 95.28% (by mass) of the H2S present in the biogas for 15 minutes at a flowrate of 0.83 L/min, while the KOH solution removed 98.85% (by mass). The BPA solution reduced the H2S from 3723 ppmv in the untreated biogas to 71 ppmv. Further tests will use a modified reactor system to maximize the contact time, create turbulence and reduce the gas bubble size in order to increase the efficiency. The results and implications of this ongoing experiment will be presented.

Presenter: Krenz, Trip
Co-Authors: Stephen Schoenholtz, Carl Zipper

Periphyton biofilms and benthic algae in constructed coalfield streams: structural and functional responses to altered top-down and bottom-up controls.

Construction of streams on reclaimed coal mines is a mitigation technique intended to offset mining-induced losses of streams. Periphyton, a key component of the organic matter (OM) resource-base, should be considered when reestablishing these lotic ecosystems. We examined structural and functional attributes of periphyton on artificial substrates in eight low-order constructed streams on mined areas and in four forested reference streams, evaluating short-term (five periods, each ~2-months) and long-term (two periods, 9 and 11 months) comparisons between stream types. We evaluated stream-type comparisons in total periphyton biomass as ash-free dry mass (AFDM), viable algal standing crop as chlorophyll-a (chl-a), senescent autotrophic OM as phaeopigments (phaeo), and two non-taxonomic structural indicators: autotrophic index (AI) and chl-a/phaeo ratio. To evaluate functional disparities between stream types, we compared accrual rates as AFDM and as chl-a across short-term periods. Mean AFDM and chl-a densities in constructed streams were approximately 2x to 4x greater than reference levels, regardless of deployment duration. Relative to reference levels, constructed-stream periphyton were less proportionally dominated by viable algae and were replete with autotrophic detritus. Short-term algal accrual in constructed streams was typically faster than reference levels; differences were most pronounced during summer and fall. Light availability during leaf-on seasons is likely a major factor driving periphyton disparities between stream types; stream-temperature differences were also important during fall. Results suggest that provision of shade through development of riparian tree plantings could reduce benthic irradiance and abate warm stream temperatures, and therefore, may foster reference-like autochthonous OM dynamics in constructed streams.

Presenter: Goodwin, Tommy
Co-Authors: Tommy Goodwin, Joel Burken

Integrating Phytoremediation, Bioremediation, and Zerovalent Iron to Increase Groundwater Remediation Efforts for Chlorinated Solvents

Chlorinated solvents are common groundwater contaminants that persist in aquifers. Many technologies have been developed to cleanup chlorinated solvents. Phytoremediation, bioremediation, and permeable reactive barriers are three remedial actions that have been shown to reduce concentrations of chlorinated solvents in groundwater systems. This study integrates three remedial technologies in different combinations to demonstrate the remediation potential of this integrated approach. Willow cuttings (Salix sp.) were planted in all reactors and concurrently served as monitoring tools, bioaugmentation of DHC (Dehalococcoides sp.) and zerovalent iron (ZVI) were applied separately and in combination. Characteristics studied between seven unique reactor combinations included plant health, degradation rates, and water uptake. Plant sampling, termed phytoforensics, was used to assess degradation efficiency. Results revealed that plant sampling does show degradation profiles and offers a low impact, low cost approach to monitoring perchlorethene (PCE) degradation processes in the subsurface. The degradation of PCE by DHC and ZVI was shown to occur through phytoforensics. Translation of wind and solar energy into groundwater removal by plants has also shown benefits.

Presenter: Kristoffer Henderson
Lead Author: Graves, Duane
Co-Authors: Leroy Leonard, Tyler McNabb, Jessie Fears, Kris Henderson, Mark Miller, Duane Wanty

Phytoremediation Complements Enhanced In Situ Bioremediation for Optimized Groundwater Remediation

A manufacturing facility operating in Middle Tennessee from 1973 until 2003 used chlorinated solvents tetrachloroethene (PCE), trichloroethene (TCE), and 1,1,1-trichloroethane (TCA) for cleaning and degreasing processes. Operations contaminated groundwater beneath and downgradient of the manufacturing areas (source area). The groundwater flows toward the Cumberland river allowing dissolved chlorinated solvents to migrate across the property and onto neighboring offsite property. Geosyntec implemented two ecological-based remedial technologies at the site: (1) enhanced in situ bioremediation (EISB) and (2) phytoremediation.

EISB was implemented in two locations to generate a barrier to intercept and treat contaminated groundwater at the downgradient perimeter of the site. Emulsified vegetable oil (EVO) and the dechlorinating culture KB-1® Plus were injected into groundwater using direct push technology (DPT). Phytoremediation was implemented near the source area where soil contamination was present. A combination of 256 hybrid poplars, weeping willows, sand bar willows, and red stem dogwoods were planted. Tree roots uptake soil leachate containing dissolved contaminants, thereby interrupting the input of chlorinated solvents into the groundwater.

One year after implementing EISB, solvent concentrations have been reduced by over 100-fold in some areas. Enhanced treatment of soil and elimination of leaching is not anticipated until the trees have matured for three to five years. This timeframe coincides with the anticipated remediation of groundwater. EISB was implemented with no major issues; however, special considerations including a modified TreeWell® design were critical to protect the newly planted trees from unusually high groundwater levels in the phytoremediation area.

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