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12:00 – 1:30 p.m.
Wednesday, April 14
Keynote Address *by* Dr. Andreas Fath, Furtwangen University, Germany

PLASTIC COCKTAILS IN RIVERS

Plastic use continues to increase worldwide, and most of these plastics are single use. From 1950 until 2015, 8.3 billion tons of plastic were produced. The majority of these polymer products end up in landfills (79%). Only 9% are recycled, and the remaining 12% are combusted. Projecting the production of synthetic polymers indicates a worldwide mass of 34 billion tons will be produced by 2050. Due to the increasing consumption and therefore increasing production of plastic, the pollution of the environment with plastic waste grows likewise. So-called microplastic (MP) particles with a diameter below 500 µm can be detected in almost every stretch of water on the surface of the earth. After swimming and analyzing the whole Tennessee River and the Rhine River we understood that the environmental pollution with plastics is obviously based on the differences in plastic waste treatment in different countries. It is an example of how and in which extent human activities changes the water quality in rivers. The comparison of two cultures demonstrates the significant interaction between people and nature. In that context I consider our contribution as an important work to motivate other environmental water researchers and biologists to continue with microplastic analysis in tributaries and aquatic life. Moreover, microplastics in aquatic systems have the potential to adsorb some of the pollutants from the chemical cocktail found in fresh water and marine systems, with the potential for harmful effects to organisms upon ingestion. Production of Microplastic out of plastic litter could use these adhesion properties to produce filter material. A promising strategy to reduce littering and increase the rate of recycling.

SESSION 1C

POSTER SESSION

SESSION 2A

CHANNEL PROCESSES AND RESTORATION
(Moderator: Bill Wolfe, USGS, ret.)

RAINFALL/RUNOFF EVENTS
(Moderator: Ingrid Luffman, ETSU)

STORMWATER MANAGEMENT
(Moderator: Daniel Saint, TVA)

SEDIMENT AND SOIL STUDIES
(Moderator: Forbes Walker, UT, AL)

SESSION 2B

WATER QUALITY MONITORING
(Moderator: Mary Bruce, Metro Water Services)

SESSION 3C

EDUCATION & OUTREACH
(Moderator: Regan McGahen, TDEC, DWR)

SESSION 1A

FLOOD MITIGATION
(Moderator: Adrian Ward, Barge Design Solutions, Inc.)
1:30 p.m. – 3:00 p.m.

Tennessee Valley Set New Annual Rainfall Record in 2020
D. Guinn

Flood Mitigation for Luxury Apartment Building
Janelle Schlamp

Staying High and Dry: Flood Mitigation on the Mississippi River
Clayton Foster

CHANNEL EROSION
(Moderator: David Blackwood, West TN River Basin Authority)
3:30 p.m. – 5:00 p.m.

Relationships Between Physical-Geochemical Soil Properties and Erodibility of Streambanks: Surficial Geology as an Overlooked Contributor
Badal Mahalder and John Schwartz

A Modified Mini-JET Device for Estimating Erodbility Factors on Agricultural Soils
David Zumr, Michal Vrána, Josef Krása, Tomáš Dostál John Schwartz, and Badal Mahalder

Improving Stream Bank Erosion Estimates by Adjusting the Applied Shear Stress for Different Bank Characteristics
Justin C. Condon and John S. Schwartz

TENNESSEE VALLEY SET NEW ANNUAL RAINFALL RECORD IN 2020

D. Guinn

The Tennessee Valley recorded 67.43 inches of average rainfall as of Dec. 31, 2020, making 2020 its wettest year in history. The total topped the previous 2018 record of 67.01 inches and an easily surpassed the 66.47-inch, second-place floater that wet the books in 2019.

The above-normal precipitation totals persisted throughout the 2020 year, with a one-month exception in below-average rainfall. November logged 2.34 inches, or 38 percent below normal. That shortfall ended a streak of 13-consecutive months of above-average rainfall, which cemented yet another Valley record.

The agency uses all assets to manage lake levels and river flows to balance the competing demands of the reservoir system. TVA's River Management Team works around the clock to manage the Tennessee River system. This includes periods of heavy rain and drought. The agency's River Management efforts provide a variety of benefits, such as flood control, navigation, hydroelectric generation, recreation, and water quality and supply.

The River Management 101 presentation will highlight TVA's mission and operating objectives in managing the above normal rainfall over the last 3 years which have been the wettest on record.

FLOOD MITIGATION FOR LUXURY APARTMENT BUILDING

Janelle Schlamp, PE

Between August 31st and September 1st, 2017, Hurricane Harvey dumped almost 6.5 inches of rain over the upstream end of the Kerrigan sewer drainage basin. The Kerrigan sewer is Nashville's oldest and largest combined sewer tunnel and routinely surcharges. A luxury apartment building is located near a low spot over the Kerrigan Sewer. During the peak of the surcharge caused by Hurricane Harvey, flood water entered the building at several entrances and flooded up to a few feet in the building. Security footage shows the flooding occurred quickly in the middle of the night and receded in less than one hour. Because the flooding was caused by sewer surcharge, drainage improvements on the site would not have prevented the flooding. A passive flood mitigation system was design for the building that would protect from flooding and would not require quick action on the part of the property manager. The property would be protected if the property manager were away or sleeping because the flood protection system initiates on its own. Many proprietary systems were utilized to provide passive protection and preserve the esthetics of the luxury building. Flood resistant glass storefronts, self-activating flood gates, flood resistant doors, removeable flood barriers and permanent flood walls were all utilized to retrofit the building and provide passive protection. The project has been bid and the construction is scheduled to begin in Spring of 2021.

STAYING HIGH AND DRY: FLOOD MITIGATION ON THE MISSISSIPPI RIVER

Clayton Foster, PE

Flood events have become more common along the Mississippi River and neighboring towns and counties are looking for solutions to minimize flooding impacts. Lake County resides in northwest Tennessee along the Mississippi River with Tiptonville as the county seat. The area is primarily agricultural and has been protected for years from devastating floods from the Mississippi River by a levee located along the west side of the county. Localized drainage on the eastern "landward" or "dry side" of the levee drains through an existing pipe located just to the north of Tiptonville. When the Mississippi River stage exceeds a critical level, a sluice gate is closed, and localized stormwater is allowed to pond on the dry side of the levee. Frequently, during an extended Mississippi River flood event and a coincidental storm event, the sluice gate is closed, and flooding impacts the agricultural land along with 21 low- to moderate-income households. Given the limited resources of the community, the town did not have the funding to install a permanent drainage solution. In 2016, the State of Tennessee was awarded a grant from the US Department of Housing and Urban Development to install a permanent pumping solution for Tiptonville. The design of the flood mitigation system has been completed, construction is scheduled to be complete in March 2021.

This presentation will focus on preliminary design through construction including: the alternatives analysis, design solutions, USACE permitting, construction challenges, and lessons learned. A major design challenge was developing an accurate inflow hydrograph from the upstream drainage area. Accurate discharge estimates were critical in the sizing of the large pump station, as a small miscalculation in stormwater inflow would result in a very large increase in inundation area and impact many residential structures. Traditional hydrology methods were first used and yielded a peak inflow with projected inundation elevations that exceeded those of the existing flood conditions. To produce a more realistic hydrologic response, the new HEC-RAS 5.0 two-dimensional (2D) modeling software was used to more accurately represent the discharge of this very flat drainage basin. By using this 2D model, similar results were achieved to the existing conditions which cut anticipated pumping costs in half and freed up funds to be utilized for additional improvements. This is an important project to Lake County and Tiptonville to protect the health and safety of the local citizens and their property from natural disasters.

RELATIONSHIPS BETWEEN PHYSICAL-GEOCHEMICAL SOIL PROPERTIES AND ERODIBILITY OF STREAMBANKS: SURFICIAL GEOLOGY AS AN OVERLOOKED CONTRIBUTOR

Badal Mahalder[1] and
John Schwartz[2]

Erosion of cohesive soils in fluvial environments is dependent on physical, geochemical and biological properties, which govern inter-particle attraction forces and control detachment rates from stream beds and banks. Most erosion rate models are based on the excess shear stress equation where the soil erodibility coefficient (k_d) is multiplied by the difference between the boundary hydraulic shear stress (τ_b) and the soil critical shear stress (τ_c). Both k_d and τ_c are a function of soil properties and must be obtained through in-situ field or laboratory testing. Many studies have generated predictive relationships for k_d and τ_c derived from various soil properties. These studies typically were conducted in watersheds within a single physiographic region with a common surficial geology and/or investigated a limited number of soil properties, particularly geochemical properties. With widely reported differences in relationships between τ_c and soil properties, this study investigated differences in predictive relationships for τ_c among four major physiographic provinces in Tennessee, USA, and 16 physical and geochemical soil properties. Erodibility parameters were determined in the field using a mini jet test device. The four physiographic provinces uniquely clustered statistically from a dataset of 128 sample sites, and these clusters were used to develop predictive models for τ_c to identify dominant properties governing erosion. In these clusters, water content and passing#200 sieve(% soil less than 75 μm) were the dominant controlling properties to predict τ_c in addition to, clay % (< 2 μm), bulk density, and soil pore water chemistry. This study suggests that unique relationships exist for physiographic provinces that are likely due to soil physiochemical processes associated with surficial geology that determine minerology properties of the cohesive soil.

[1] Bangladesh University of Engineering and Technology
[2] University of Tennessee, Knoxville, Department of Civil & Environmental Engineering

A MODIFIED MINI-JET DEVICE FOR ESTIMATING ERODIBILITY FACTORS ON AGRICULTURAL SOILS

David Zumr[1]*, Michal Vrána[1], Josef Krása[1], Tomáš Dostál[1], John Schwartz[2], and Badal Mahalder[2,3]*

INTRODUCTION

A jet test device was originally developed by the USDA National Sedimentation Laboratory in the 1990s as a means to estimate erodibility factors (kd, τC) used in the excess shear stress equation for computing soil erosion rates [$ET = kd*(\tau C-\tau)m$; where ET = cm/s, kd = cm3/N.s, and τ and τC = N/m2, m =1]. The original submerged jet test device was large with the submergence chamber 30 cm in diameter and height, and requiring a large water pump. Because of its size, a Mini-JET device was developed for greater ease in field applications where its submergence chamber is 10.2 cm in diameter and 7 cm in height. The jet test devices have primarily been used to estimate the erodibility factors on stream beds and bank for modeling channel erosion and bank failure processes. Factors were developed for Tennessee streams for four different geological regions, and are presented.

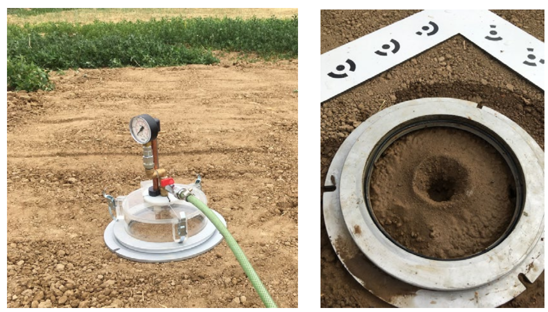

Fig. 1 Modified Mini-JET device (left), scour hole after the experiment (right)

APPROACH

Though the Mini-JET device has been useful for streambank erosion studies, the idea of its use on agricultural soils to estimate erosion was investigated by a research team from the Tennessee Water Resources Research Center and the Czech Technical University in Prague (CTU). The main objective of this research was to determine whether the modified design of the Mini-JET can be used to determine critical shear stresses on non-cohesive and disturbed soils such as soils on agricultural land. Initial field tests on experimental plots near the village of Řisuty (Czech Republic) identified technical issues with the existing version of the Mini-JET device and the field procedures. The two key modifications necessary for low cohesion, surface disturbed soils included a slightly larger submergence tank and field procedures

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[3] Bangladesh University of Engineering and Technology, Dhaka, Bangladesh

using lower hydraulic pressures at the jet. A modified Mini-JET device was constructed at CTU and tested. Under laboratory conditions, the device was calibrated to determine the calibration coefficient for low pressures (1-5 PSI). To provide initial testing, a total of 75 simulations were carried out on two types of soil surface at the Řisuty experimental site.

RESULTS AND DISCUSSION

On the basis of field measurement, a standardized procedure for repeated measurements has been established. The "Jet Test Erosion Spreadsheet Tool" has been used to calculate erosion parameters such as critical stress and erodibility coefficient. The calculated results of erosion parameters showed that the equipment used in this work can be used to measure the erodibility factors even on non-cohesive soils such as agricultural seedbed, when appropriately applied. Further analyses will be focused on determining relations between soil interrill erosion, splash erosion, soil physical properties, and erodibility coefficient defined by mini-JET testing. If successful, the mini-JET device will serve as a simpler tool compared to conventional rainfall-runoff simulation tests to define soil erodibility of different agricultural surfaces.

The Research has been supported by project granted by Ministry of Education, Youth and Sport of the Czech Republic No. LTA USA 19019.

IMPROVING STREAM BANK EROSION ESTIMATES BY ADJUTSING THE APPLIED SHEAR STRESS FOR DIFFERENT BANK CHARACTERISTICS

Justin C. Condon[1]
and John S. Schwartz[1]

Stream bank erosion rates are commonly modeled using the excess shear stress equation $\varepsilon_r = k_d(\tau-\tau_c)^a$, where the exponent a is assumed to be unity. The coefficient of erodibility k_d, and the critical shear stress τ_c [Tau $_c$] are properties of the bank soil and the applied shear stress τ [Tau] is a function of the channel geometry and discharge. This equation appears to overestimate bank erosion likely due to effects of channel morphology and bank vegetation, among other factors. The objective of this study was to determine whether the excess shear stress equation could be parameterized with an α [alpha] coefficient to more accurately estimate stream bank erosion accounting for the effects of channel curvature and bank vegetation. The study included seven stream bank sites at Beaver, Bullrun, and Stock creeks located in Knox County, Tennessee with USGS gaging stations located downstream. Bank erosion pins were placed at four channel morphology/vegetation categories to measure retreat or soil deposition; they were straight and curved channels with and without woody bank vegetation. At each channel cross-section, 18-inch steel pins were installed vertically along the lower, middle, and upper portion of the banks. A mini-jet test device was used to approximate k_d and the τ_c using the Blaisdell method (BM). Flows and stage heights were modeled with HEC-RAS to determine the τ at each pin. Pin erosion averages varied by category and bank position ranging from -0.03 to -0.78 feet during the one-year study period and were used as estimates of site erosion rates ε_r [Epsilon $_r$]. With all the parameters being known alpha parameters in the modified excess shear stress equation were solved for each of the erosion pins for the different channel categories. The alpha values typically varied between about 0.001 and 0.73 showing that excess shear stress equation over predicts erosion. Due to the wide range of alpha values, further research is needed to better assess the factors that influence bank erosion and improve the predictability of bank retreat rates.

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SESSION 1B

HYDROLOGICAL ANALYSES
(Moderator: Rodney Knight, USGS)
1:30 p.m. – 3:00 p.m.

Recalibration at Sinking Pond: Climate Extremes and Hydroperiod Change in a Tennessee Karst Wetland
Jennifer Cartwright and William Wolfe

Development of a 2D Model in St. Arbor Wetland for an Assessment of Levee Breaching
Mackenzie Martin, Collins Owusu, Nusrat Jannah Snigdha, Alfred J. Kalyanapu, and Justin Murdock

Radon in Tennessee Residential Well Water
Ingrid Luffman, Judy Manners, and C. Nicole Bailey

HYDROLOGY AND GROUNDWATER
(Moderator: Brian Waldron, CAESER)
3:30 p.m. – 5:00 p.m.

Geochemical and Environmental Tracer Evidence for Production of Modern Water in the Shaw Wellfield, Memphis, Tennessee
Kate M. Moore

Groundwater Pumping Optimization to Minimize Contaminant Movement from the Shallow Aquifer to the Memphis Aquifer Using Stochastic Modeling
Sondipon Paul

Fluorescent Dye Tracing as a Tool for Contaminant Source Tracking in a Highly Heterogeneous and Anisotropic Karst Aquifer, Gallatin, Tennessee
Lee Anne Bledsoe, Chris Groves, and Autumn Singer

RECALIBRATION AT SINKING POND: CLIMATE EXTREMES AND HYDROPERIOD CHANGE IN A TENNESSEE KARST WETLAND

Jennifer Cartwright[1]*
and William Wolfe[2]

Karst depression wetlands throughout the eastern United States are important to regional and global biodiversity but may be threatened by hydrologic shifts under climate change. For example, increased ponding duration since 1970 in Sinking Pond—a 35-acre seasonally flooded karst depression wetland on the Highland Rim of Tennessee—has been implicated in recruitment failure of overcup oak (*Quercus lyrata*). Hydrologic models based on rainfall and temperature records from 1854 through 2002 successfully simulated observed inundation patterns in Sinking Pond and showed that prolonged inundation (more than 200 days per year) was considerably more common after 1970 than before. However, model calibration and validation datasets did not include extreme climatic events such as droughts. A subsequent severe drought in 2007 and 2008 provided an opportunity to recalibrate the Sinking Pond hydrologic model to better represent the drivers of pond inundation across a wider range of climate conditions. Although recalibration of published hydrologic models is relatively rare, this study demonstrates its importance for ecohydrologic studies, as climatic extremes (droughts and intense storms) may become more common under climate change than they were in historical records. This study has potential relevance for a variety of karst-dependent ecosystems in which ecological shifts may be driven by changing hydrologic conditions.

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DEVELOPMENT OF A 2D MODEL IN ST. ARBOR WETLAND FOR AN ASSESSMENT OF LEVEE BREACHING

Mackenzie Martin,
Collins Owusu,
Nusrat Jannah Snigdha,
Alfred J. Kalyanapu*,
and Justin Murdock

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Wetlands, often referred to as Earth's kidneys for their ability to transform waste received from upstream, are crucial in improving water quality, protecting floodplains, and providing a habitat to various flora and fauna. The value of wetlands has not always been recognized though. For centuries, wetlands were often filled, transformed, or plugged. Now, the importance of wetlands is gaining recognition. To remediate and enhance wetland function, the Natural Resource Conservation Service (NRCS) has implemented the Wetland Reserve Program (WRP). The goal of this program being the retirement of agricultural lands, coupled with the transformation of agricultural lands back into wetlands. One particular WRP easement is St. Arbor Easement in Carlisle County, KY. Here, five levee breaches were implemented in Mayfield Ditch, which allows water to flow northward into the easement. *To assess the conservation practice implemented in Mayfield Ditch, a 2D HEC-RAS model of the ditch is proposed.* This model will focus on the effects of levee breaching on the wetland. This model will be developed for Mayfield Ditch, but can also be applied in other locations, specifically where similar conservation practices have occurred.

RADON IN TENNESSEE RESIDENTIAL WELL WATER

Ingrid Luffman[1]*, Judy Manners[2], and C. Nicole Bailey[1]

INTRODUCTION

Radon is a naturally occurring radioactive gas released into soil and groundwater through decay of uranium and thorium-bearing rock. Radon from well water used inside the home contributes to risk of lung cancer and gastrointestinal cancers. Human exposure to waterborne radon occurs through ingestion of radon in drinking water or inhalation of radon or radon progeny off-gassed from water. Of 146,000 US deaths from lung cancer, 21,100 (14.5%) are associated with radon exposure (USEPA, 2003). While radon is not currently regulated under the USEPA Safe Drinking Water Act, proposed Maximum and Alternate Maximum Contaminant Levels of 300 pCi/L (MCL) and 4,000 pCi/L (AMCL, for states or tribes with a multimedia radon program) exist for public drinking water. It is estimated that an MCL of 300 pCi/L would reduce annual radon associated deaths by 70 nationally (USEPA, 2012).

Radon in groundwater is influenced by geology (Bunnell et al., 2007; Hanenberg et al., 2020; Hwang et al., 2017 and others), faulting (Cho et al., 2019; Seminsky and Seminsky, 2019), karst landscapes (All et al., 2008) and well depth (Cho et al., 2019). An estimated 650,000 Tennesseans obtain their household drinking water from private wells or springs. From 1999-2001, Tennessee Department of Environment and Conservation (TDEC) sampled water from 92 wells and springs used as water supply sources. Radon concentrations exceeded the 300 pCi/L proposed MCL in 34 (37%) of wells, with 6 (7%) exceeding 1,000 pCi/L. Highs of 3,103 pCi/L and 2,010 pCi/L were measured in Polk and Sevier Counties, respectively. In 2013, TDEC measured radon in a public school's water supply in Cocke County at 9,910 pCi/L (TDEC, 2014). This motivated the Tennessee Department of Health (TDH) to examine radon concentrations in private water systems in Tennessee. With funding from the Centers for Disease Control (CDC), TDH conducted a study of private wells near public water supply wells known to have radon concentrations above 1,000 pCi/L as determined by TDEC. The purpose of this study was to delineate areas of concern and identify individual households potentially at risk from elevated radon in private well water.

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METHODS

Using known locations of public water supply wells with radon concentration above 1,000 pCi/L, six geographic areas were selected, targeting geologic formations common to the high-radon wells and adjacent formations. Within those geographic areas, 143 well water samples were collected from individual wells selected by door-to-door survey and permission of the property owner. Samples were collected following USEPA standard methods and source (cistern, spring, or well) was noted. Samples were processed at the TDH Division of Laboratory Services using method 7500-RN(B).

The relationship between fault proximity and radon concentration was assessed with the Spearman correlation coefficient because the data were nonparametric. Differences in radon concentration by water source (cisterns, springs, and wells), well depth, geology, proximity to mapped faults, and by sampling clusters (i.e., geographic area) were assessed using the Kruskal Wallis test. Radon concentration was interpolated using ordinary kriging in ArcGIS Pro.

RESULTS

Radon was detected in 100% of the samples (Figure 1); concentrations ranged from 30.2 to 8,878 pCi/L with a mean of 844 pCi/L. Samples from 115 wells (80.4%) exceeded the proposed 300 pCi/L MCL and 18 exceeded the proposed 4,000 pCi/L AMCL.

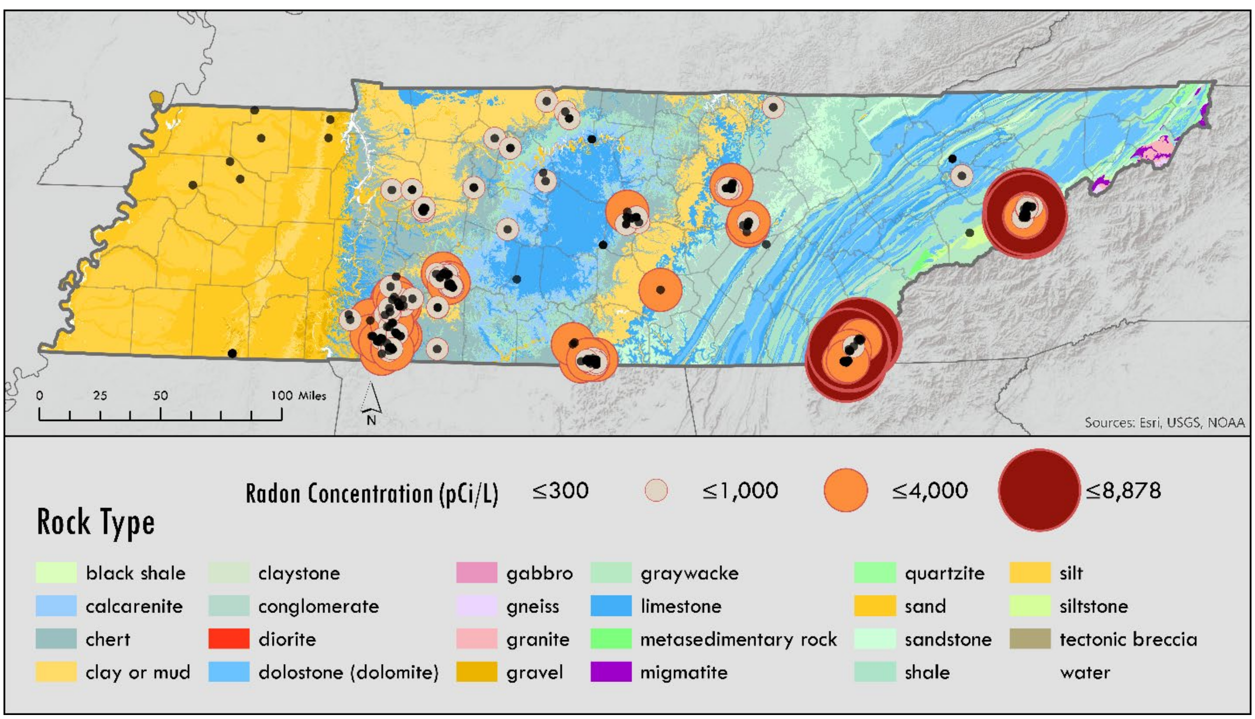

Figure 1. Sampling locations (black dots) and radon concentration in pCi/L overlain on Tennessee geology.

Statistical and spatial analyses show that radon concentration was higher in well water than in other water sources but was not influenced by well depth. Radon concentration was correlated to fault proximity (r = -0.377, p = 0.05), indicating reduced concentration with increased distance from a mapped fault (Figure 2). Kruskal-Wallis tests to assess the impact of well depth were not significant. Groundwater radon in shale, sandstone, and greywacke had significantly higher concentration than in silt. Moreover, groundwater radon in greywacke was significantly higher than in carbonates, clays, conglomerates, chert, and gravel. In particular, groundwater radon in east Tennessee terrigenous clastic sedimentary rocks of the Ocoee Supergroup (pCo), including the sandstones of the Snowbird (pCs) and Great Smoky Groups (pCg), and the argillaceous rocks and conglomerates of the Walden Creek Group (pCw) (Hardeman et al., 1966; King et al., 1958), had the highest radon concentrations (2,500 – 4,700 pCi/L) (Figure 3). Kriging interpolation of radon concentrations statewide produced a broad pattern of higher concentrations in east Tennessee and lower concentrations in the central basin and in west Tennessee (Figure 4).

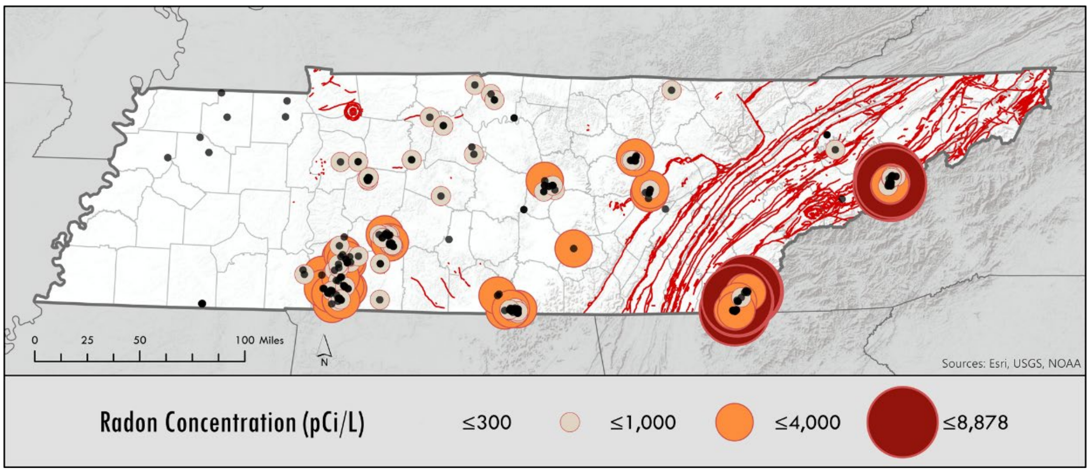

Figure 2. Radon concentration decreased with distance from a mapped fault.

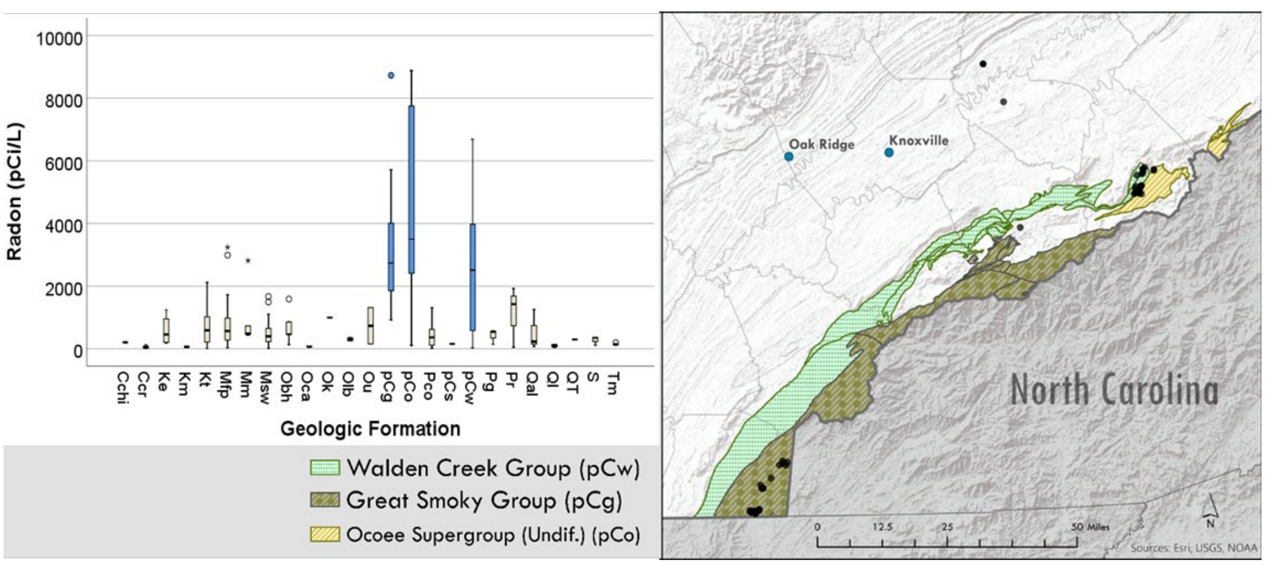

Figure 3. Radon concentration was higher in older Precambrian rocks on the Tennessee-North

Carolina border: the Ocoee Supergroup (pCo) and its members, the Walden Creek (pCw) and Great Smoky (pCg) Groups (shaded in the boxplot).

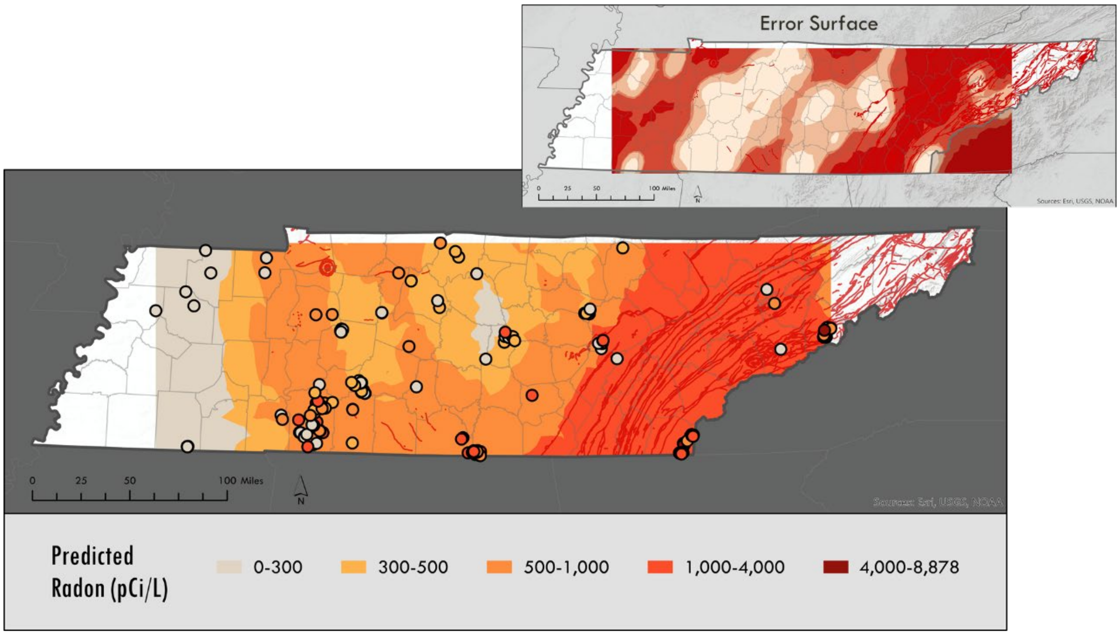

Figure 4. Interpolated radon concentration using ordinary kriging indicates higher concentrations in east Tennessee. Inset map shows error, with darker shades indicating increased uncertainty.

DISCUSSION AND CONCLUSION

Radon concentrations of 10,000 pCi/L in water supplies cause a 1-2 pCi/L increase in radon indoor air concentration (USEPA, 2012). While the highest concentration measured in this study was 8,878 pCi/L, the 18 samples exceeding 4,000 pCi/L could contribute significantly to radon in indoor air. This poses a human health risk because the action level for radon in indoor air (4 pCi/L) is much lower than for groundwater, and water concentrations in excess of 4,000 pCi/L could therefore contribute 0.4 – 0.8 pCi/L to indoor radon (10-20% of the action level).

In our study, the highest groundwater radon concentrations were measured in Precambrian terrigenous clastic sedimentary rocks of the Ocoee Supergroup. These results only partially agreed with a recent study of indoor radon concentrations in Kentucky (Haneberg et al., 2020), which found that not only terrigenous clastic sedimentary rocks, but also the chemical sedimentary rocks limestone and dolostone, were high in radon. Notably, these chemical sedimentary rocks were more likely to exceed USEPA action levels for radon than terrigenous sandstones and siltstones.

The Chattanooga Shale (MDc) is a sandstone and shale formation with a high uranium content (0.004 – 0.008%) historically of concern (Conant and Swanson, 1961; All et al., 2008). However, none of the wells sampled in this study were located in this formation. Given the high density of faults in east Tennessee, and the higher radon concentration measured in this part of the state, further sampling of wells and springs in east Tennessee is recommended. We recommend that future sampling focus on filling sampling gaps and target residential wells in, and in proximity to, the Chattanooga Shale. Moreover, we recommend targeted outreach to communities within targeted geologic units to provide information on water treatment options such as granulated activated carbon and aeration of water supply, and information on indoor air quality sampling. Hot spot identification and risk maps created using geospatial analyses can be useful tools to highlight areas of concern and inform community members about potential risks and options for mitigation.

ACKNOWLEDGEMENT

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GEOCHEMICAL AND ENVIRONMENTAL TRACER EVIDENCE FOR PRODUCTION OF MODERN WATER IN THE SHAW WELLFIELD, MEMPHIS, TENNESSEE

Kate M. Moore, CAESAR, University of Memphis

Geochemical and environmental tracers have been used in past studies to understand groundwater flow paths and the source of modern water (<60 years old) in drinking supply aquifers. To expand upon this work, this study will investigate the confined to semi-confined Memphis aquifer within the MLGW Shaw wellfield in Shelby County, Tennessee. The Shaw wellfield is located near the eastern limits of the Upper Claiborne confining unit where regional groundwater recharge to the Memphis and underlying Fort Pillow aquifer occurs. Past studies have found areas where the confining unit is thin or absent; subsequently, providing a hydraulic connection between the shallow and Memphis aquifers. To assess the hydrogeologic conditions, both the Memphis aquifer and deeper Fort Pillow aquifer were sampled for major solute and trace metal chemistry, 3H/3He, SF6, dissolved noble gases, stable δ2H and δ18O, δ13C, and 14C data. Piper plot analyses indicate two distinct geochemical groundwater signatures: sodium bicarbonate for the Fort Pillow aquifer and mixed cation bicarbonate for the Memphis aquifer. Stable δ13C values are higher in wells with less modern carbon, which supports the interpretation of modern water leakage into the Memphis aquifer. Geochemical and tracer data as well as hydrological boundary conditions suggest that a significant fraction of modern water, likely sourced from nearby Grays Creek, is produced from wells with shallow screen intervals (<100 m depth) in the upper Memphis aquifer.

GROUNDWATER PUMPING OPTIMIZATION TO MINIMIZE CONTAMINANT MOVEMENT FROM THE SHALLOW AQUIFER TO THE MEMPHIS AQUIFER USING STOCHASTIC MODELING

Sondipon Paul,
University
of Memphis

The Memphis Light, Gas, and Water (MLGW) operates ten pumping well fields in the Memphis, Tennessee area for municipal and industrial water supply. The shallow, Memphis, and Fort Pillow aquifers are the three major water-bearing strata beneath the area where the Memphis aquifer serves as the primary groundwater source. The Upper-Claiborne confining unit (UCCU) separates the shallow and Memphis aquifer across much of Shelby County, acting as an upper protective layer for the Memphis aquifer. However, the presence of hydrogeologic windows within the UCCU creates a hydraulic connection and serves as an avenue for contaminant migration from the shallow to the Memphis aquifer. This research aims to minimize the contaminant migration, find suitable locations for future well construction, and reduce other damaging effects to the Memphis aquifer and MLGW's well fields. Several scenarios were developed addressing well depth, seasonal pumping, and well location to satisfy the study objectives. A simulation-optimization technique was developed that resulted in many thousands of numerical simulations for each scenario to identify recurring patterns of contaminant movement and other damaging effects to the Memphis aquifer, stochastically. The simulation model integrated MODFLOW and MODPATH to simulate 3D groundwater flow and advective contaminant movement, respectively, and transferred via FloPy to couple with the optimization model that was custom scripted in Python. The results indicate that optimum well positions (spatially and vertically) and modification to pumping can increase the life expectancy of MLGW well fields, offer sustainable management of the Memphis aquifer, and reduce contaminant migration through 2050.

FLUORESCENT DYE TRACING AS A TOOL FOR CONTAMINANT SOURCE TRACING IN A HIGHLY HETEROGENEOUS AND ANISOTROPIC KARST AQUIFER, GALLATIN, TENNESSEE

Lee Anne Bledsoe, Chris Groves, and Autumn Singer

In late 2018, the Tennessee Department of Environment and Conservation (TDEC) Division of Underground Storage Tanks (UST) began an investigation of the source(s) responsible for contamination of petroleum-impacted seeps along the Town Creek Greenway in the city of Gallatin and identified five potential source properties with possible leakage from underground storage tanks based on soil and water quality testing. Located within the Central Basin section of the Interior Low Plateaus physiographic province, Gallatin is underlain by the Ordovician Leipers and Catheys Formations comprised primarily of limestone with less permeable shales in the upper section, which can inhibit groundwater flow and create very localized hydrologic conditions, characteristic of karst aquifer systems. The Crawford Hydrology Laboratory (CHL) conducted a multi-dye tracer test to determine groundwater flow directions from the five potential contaminant sources. Dye tracing was also employed to test the efficacy of two injection wells planned for use in remediation. Dye recovered from one of the remediation wells confirmed hydrologic connection to the seeps. Traces from two facilities also showed connections to the impacted seeps and results of the other traces offered additional insight into the complex geometry of groundwater flow paths in the study area, identifying upper and lower elevation flow regimes in a highly heterogeneous and anisotropic karst groundwater flow system. These results, along with hydrologic monitoring and evaluation of well log data as well as and geophysical analyses conducted by project partners were used to develop a site conceptual model to guide design and implementation of remediation efforts.

SESSION 1C: POSTER SESSION

Evaluation of Tropical Cyclone Flood Discharges Estimated with Rainfall from Parametric Models for Flood Risk Studies
John T. Brackins and Alfred J. Kalyanapu

The Invasive Alga Didymosphenia geminata *Alters Larval Chironomid Diversity and Feeding Structure Wear*
P.W. Blum, M.W. Green, S.R. Tuberty, and J.N. Murdock

Dissolved Organic Carbon within Stream Waters of Great Smoky Mountains National Park Following Reductions in Atmospheric Acidic Deposition
Jason R. Brown

Factors Affecting Denitrification Estimates within Restored Floodplain Habitats
Robert G. Brown

Automated Flood Forecasting System for Window Cliffs State Natural Area, TN
George K. Darkwah and Alfred J. Kalyanapu

Assessing Karst Springwater as a Private Water Supply Source in Northeast Tennessee: Developing a Sampling Strategy
Lukman Fashina and Ingrid Luffman

Priority Areas for Managed Aquifer Recharge by Infiltration Galleries in Eastern Arkansas
Sarah Houston, Heather Mullenax, Allegra Pieri, Jarod Przybylski, Michele Reba, and Deborah Leslie

Effectively Accounting for the Effects of Urbanization in Stream Quantification Tools
Grace Long

Operation Clean: Capacity Enhancement with Landscape Modification Using an Ecological Approach for Adsorption and Natural Recharge
Beau Neidich, Carmen Harvey, Adam Belton, Abbey Burton, Riley Ellis, Syed Tareq, Jejal Bathi

Reconstructing Historical Wetland Surface Water Hydrographs Through Remote Sensing, Machine Learning, A\and Cloud Computing
Collins Owusu, Nusrat Jannah Snigdha, Mackenzie T. Martin, Alfred J. Kalyanapu, and Justin Murdock

Smart Cities: Using Location-Based IoT and GIS Dashboards to Monitor Flooding
Chelsie Perkins and Ingrid Luffman

Comparison of Water Quality Between Richland Creek and the Little Harpeth River in Nashville, TN, 2019
Joseph Elbon, Aleyna Loughran Pierce, and Katie Madole

Impact of Water pH on Fate and Transport of Carbon Nanotubes
Astha Sinha

Watershed-Wide Stormwater Management in an Underserved Community of Tennessee Through Community-University Partnership
Maci Arms, Hugh Thomas Harris, Alfred Kalyanapu, and Tania Datta

Flash Flooding Prediction of Cummins Falls State Park
Jason R. Gentry and Dr. Evan Hart

Towards Smart Cities: Retrofit of Urban Infrastructure for Sustainable Operation
Carmen Harvey, Beau Neidich, Riley Ellis, Adam Belton, and Jejal Bathi

EVALUATION OF TROPICAL CYCLONE FLOOD DISCHARGES ESTIMATED WITH RAINFALL FROM PARAMETRIC MODELS FOR FLOOD RISK STUDIES

John T. Brackins[1]* and Alfred J. Kalyanapu[2]

From 1960 through as recent as 2018, tropical cyclones (TCs) have produced greater than 1000-year rainfalls over time periods ranging from 1 to 5 days for the states in Federal Emergency Management Agency Region IV (except Kentucky, where the TC rainfall of record produced between a 200- and 500-year rainfall event). Therefore, TC rainfall events have the potential to affect the tail of flood risk statistical distributions, even for inland states. For flood risk modeling purposes, it is important to be able to simulate expected TC rainfall from a joint distribution of parameters like TC track, size, and intensity. Four existing parametric models already attempt to predict rainfall hyetographs from these variables, and an evaluation of the storm-total precipitation fields produced by these models was completed in Brackins and Kalyanapu (2020). In this study, the rainfall from the parametric models serves as the precipitation forcing to a Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) model of the Swannanoa River (HUC10 0601010506), a tributary of the French Broad in western North Carolina. The objective of the current study is *to perform a case study using a HEC-HMS model of the Swannanoa River to determine if rainfall produced by four parametric TC rainfall models allows for sufficient representation of TC flood discharge*. While Brackins and Kalyanapu (2020) demonstrated that the IPET (2006) model was the most skillful at reproducing storm-total precipitation for thresholds above 75 millimeters (3 inches), preliminary HEC-HMS results indicate that the IPET model suffers from serious limitations for weakening TCs which are sufficiently far inland.

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*This research is done entirely independently by the first author. Dr. Kalyanapu serves as the research advisor for the project.
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THE INVASIVE ALGA *DIDYMOSPHENIA GEMINATA* ALTERS LARVAL CHIRONOMID DIVERSITY AND FEEDING STRUCTURE WEAR

P.W. Blum[1], M.W. Green[2], S.R. Tuberty[3], and J.N. Murdock[1]

Didymosphenia geminata (didymo) mats alter the biotic diversity and distribution of freshwater invertebrates, including the reduction of diversity and abundances of mayflies, stoneflies, and caddisflies. However, some macroinvertebrates have increased presence in didymo impacted streams, including oligochaete worms and non-biting midges (chironomids). Interestingly, only chironomids of the sub-family Orthocladiinae seem to experience this increase in abundance, aided by their consumption and/or tolerance of didymo. This transition to consuming didymo may wear the teeth of larval chironomid feeding structures due to the larger size of didymo's frustules (siliceous shells) and potentially impairs their ability to process other food items. This study examined 1) the differences in genera level diversity of larval chironomids in streams impacted by didymo, 2) the contributions of didymo frustules to their diet, and 3) the impact of dietary changes to the wear of menta. Our results suggest that only a few taxa comprise most chironomids in didymo impacted streams, and those genera consume didymo frustules. Mentum wearing was most prevalent in chironomid taxa which consumed didymo cells. These results suggest that utilizing this new food source may result in excessive wear of their feeding structures, but the tradeoff of utilizing the newly dominant food resource appears to outweigh this physical damage.

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DISSOLVED ORGANIC CARBON WITHIN STREAM WATERS OF GREAT SMOKY MOUNTAINS NATIONAL PARK FOLLOWING REDUCTIONS IN ATMOSPHERIC ACIDIC DEPOSITION

Jason R. Brown[1]

Despite recent decreases in atmospheric acid deposition, many watersheds of Great Smoky Mountains National Park (GRSM) have lacked expected corresponding increases in stream water pH. Dissolved organic carbon (DOC) concentrations in stream waters have drawn attention as the possible cause. DOC contributions to stream waters are a major portion of watershed carbon cycling with known influences on broad water quality parameters, such as acidity, nutrients, and dissolved metals (Evans, 2005; Lawrence, 2013). Lawrence & Roy (2020) noted that increased ionic strength within the soil matrix during acidification compressed the diffuse layer which reduced organic carbon solubility and enhanced aggregation of organic matter which has been reversed by the recent reductions in acid deposition. However, whether this biogeochemical process dominates stream acidity is dependent on many potential watershed factors, such as vegetative cover conditions, elevation, slope and soil type, depth and chemistry.

Because of the substantial reduction in acid deposition in GRSM, there is a need to investigate this potential concept and better understand the current streamwater quality conditions. Water sampling and data collection are being conducted in a similar manner of past research by focusing on large-scale influencers including topography, geology, pedology and climate (Neff, 2013). Additionally, comparisons of DOC with other chemical constituents, namely inorganic acids and base cations, will provide a better understanding of the biogeochemical relationships. Ultimately, development of predictive models generated from this research would provide a useful tool for the comprehensive approach to natural resource maintenance being undertaken by GRSM management departments.

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FACTORS AFFECTING DENITRIFICATION ESTIMATES WITHIN RESTORED FLOODPLAIN HABITATS

Robert G. Brown, Tennessee Technological University

Denitrification is the primary pathway of nitrogen (N) removal from floodplain ecosystems through conversion of N to N_2 gas. Spatial and temporal heterogeneity of denitrification rates can be high, calling into question the accuracy of scaling locally measured rates across larger regions. We are using flow-through soil core incubations to assess spatial heterogeneity of denitrification potential across restored floodplain habitats (created shallow water areas, tree plantings, natural regeneration, remnant forest), and correlate variation with soil and habitat characteristics. Denitrification rates were derived from 6-12 intact soil cores collected from 30 habitats across 10 riparian wetlands. We will apply mixed effects models to investigate relationships between habitat type and age, soil moisture, distance from nearest river, and distance between soil cores within habitats, as they influence coefficients of variation and 95% confidence intervals for denitrification measurements. Results will facilitate development of strategies to account for spatial variation in regional scale denitrification estimates derived from measurements in selected local habitats. Specifically, the number and relative positions of soil cores collected for flow-through incubations can be adjusted so that sampling designs are more representative of ecological features that affect denitrification in floodplain habitats.

AUTOMATED FLOOD FORECASTING SYSTEM FOR WINDOW CLIFFS STATE NATURAL AREA, TN

George K. Darkwah[1] and Alfred J. Kalyanapu[1]*

Flooding is a devastating natural disaster across the globe whose frequency and impacts have increased over the past few decades. In the United States of America (U.S.) flood is the most prevailing natural disaster, costing about 4.6 billion USD and claiming about 18 lives per event on average. The effects of floods are even worse when evacuation is not done in time due to flash floods that usually occur without conceivable warning. The degree of flood hazards have heightened the need for more accurate flood prediction and simulation models. This study seeks to develop a water level forecasting system for the Window Cliffs State Natural Area, TN. Based on this forecasting system, flood warnings can be issued ahead of time. Machine learning techniques shall be used with available datasets to generate an operational forecasting system. Datasets that can be used in building such a system include upstream water levels, precipitation, antecedent dry periods, temperature, wind direction, and characterized convective weather systems. While some data may not be readily available, the system shall be designed to utilize as minimal data as possible to generate a reliable prediction output. A successful implementation of this flood forecasting system at the Window Cliffs State Natural Area will provide grounds to upscale the design into larger domains.

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ASSESSING KARST SPRINGWATER AS A PRIVATE WATER SUPPLY SOURCE IN NORTHEAST TENNESSEE: DEVELOPING A SAMPLING STRATEGY

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INTRODUCTION

Karst landscapes form through dissolution and surface drainage of carbonate rocks (Williams & Vondracek 2010). It is estimated that karst makes up about 50,000,000 km^2 or 20% of the Earth's land surface (Gvozdetskii 1967; White 1988) and 25% of bedrock in the United States (Williams & Vondracek 2010). Karst landscapes are typified by specific surface and underground features including springs, caves, abrupt ridges, subterranean drainage, dolines etc. (Kaçaroglu 1998; U.S Environmental Protection Agency [USEPA] 1998). Karst springs in East Tennessee form along fractured and faulted zones, and at solutional openings in carbonate rocks of Chickamauga Limestone, Knox, and Conasauga Groups (Sun *et al*. 1963).

Karst springs are a surface water source useful as public water supply, which must meet and maintain certain water quality requirements. Karst springs are also an essential source of private water supply in northeast Tennessee for various end-users. Approximately 10% of households in Tennessee (SafeWatch 2019) rely on private water supply. However, there are no regulatory standards for private (drinking) water quality in the state, unlike the public water system. Users of private water systems are advised, but not required, to test for contaminants in private water sources like springs or private wells. Recognizing that water quality generally is spatially and temporally dynamic, and more prominently so in a karst environment, the aim of this study is to develop a sampling strategy and identify sampling locations to investigate the water quality of roadside springs used for drinking water.

METHODS

The study area consists of seven counties in East Tennessee: Washington, Sullivan, Greene, Carter, Hawkins, Hamblen, and Hancock (Figures 1 & 2). Using a database of known springs from Tennessee Department of Environment and Conservation, springs were mapped in ArcGIS Pro. Because of low precision in this dataset, other candidate springs were identified using Tennessee Hometown Locator, coordinates were entered into an excel database and mapped in ArcGIS Pro.

To assess viability of each sampling location, all springs were viewed in Google Earth and, using Google StreetView, the likelihood of obtaining a sample at each was assessed. Criteria included: 1) evidence of spring on aerial imagery; 2) proximity of spring to public road; and 3) presence of a fence or other barrier. Potential sampling locations (springs) were color-coded according to likelihood of obtaining a sample, and from this, a sampling strategy was developed. Ultimately, 51 samples will be collected from 51 springs so that spatial patterns in spring water quality can be evaluated using spatial interpolation, statistical correlation, or spatial regression. Additional springs will be identified for sampling so that backup sampling locations will be known should some primary locations be inaccessible.

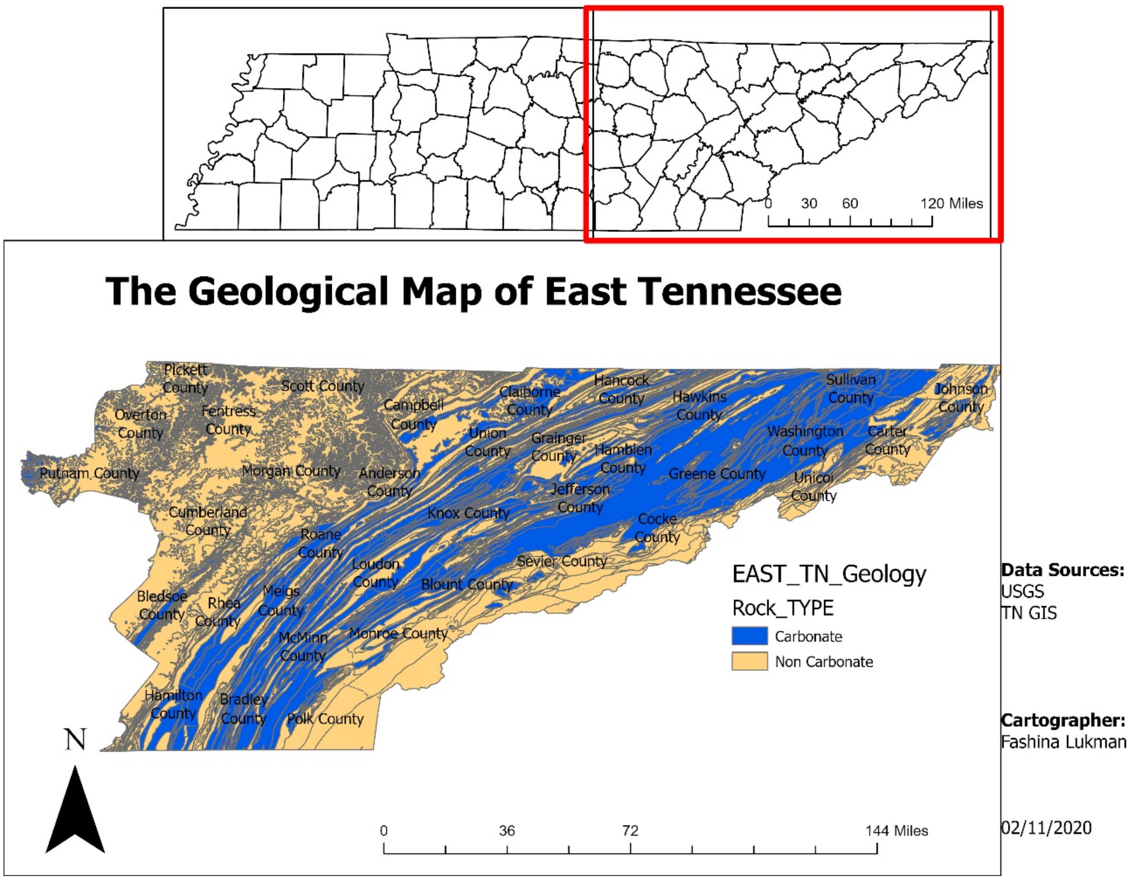

Figure 1: Geological Map of Study Area showing Karst and non-Karst lithologies in East Tennessee.

Fieldwork will be conducted in May 2021. This will involve collection of non-wintertime water samples from the pre-identified sampling sites. These will primarily be publicly accessible roadside locations/sites but may include private property locations within areas of carbonate bedrock lithology, sampled with permission of the owner. Field and laboratory blanks will be collected for Quality Assurance/Quality Control (approximately seventy-one (71) samples in total, with QA/QC).

Water samples from each site will be tested for *E. coli*, radon, and various physicochemical properties (pH, conductivity, dissolved oxygen, chloride, fluoride, sulfide, nitrite, and nitrate). *E. coli* will be assessed using the EPA culture-based IDEXX Quanti-Tray*/2000 laboratory analytical technique at the Department of Geosciences Hydrology Laboratory at East Tennessee State University. Physical properties will be measured *in situ*. Dissolved Oxygen (DO) will be measured with an Oakton DO 6+ meter, turbidity will be measured with an HF Scientific DRT15CE turbidimeter, and pH, temperature, and Electrical Conductivity (EC) will be measured with a Fischer Accumet conductivity meter. An outside lab will assess chemical properties (radon, chloride, fluoride, sulfide, nitrite, and nitrate).

RESULTS

Potential sampling locations are displayed in Figure 2, color-coded by ease of accessibility and likelihood of obtaining a sample. When sampling and water quality analysis is complete, results will be compared to water quality of the streams into which these springs discharge. Key findings will guide the delineation of the studied karst springs into risk regions for microbial, chemical, and radioactive content, and identification of key factors associated with high-risk regions.

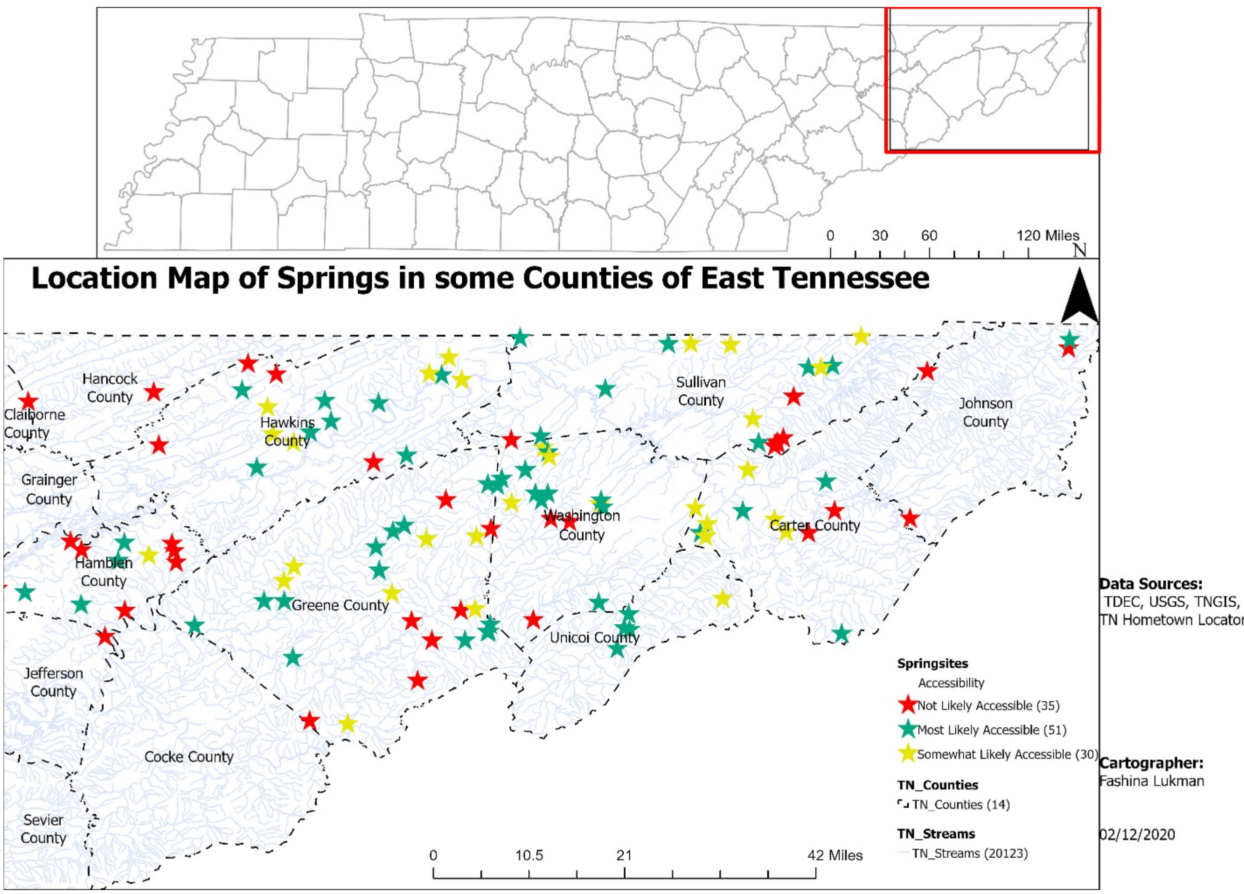

Figure 2: Location Map of Springs in some Counties of East Tennessee.

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PRIORITY AREAS FOR MANAGED AQUIFER RECHARGE BY INFILTRATION GALLERIES IN EASTERN ARKANSAS

Sarah Houston[1], Heather Mullenax[1], Allegra Pieri[1 2], Jarod Przybylski[1], Michele Reba[2], and Deborah Leslie[1]

The Mississippi River Valley alluvial (MRVA) aquifer is one of the main shallow aquifers for agriculture in the United States. The MRVA supplies over 90% of irrigation water in the Lower Mississippi River Basin, due to its accessibility and high yield. Irrigation demand has increased since the early 1900s with continued expansion and inequitable recharge contributions. The overdraft of the MRVA in Arkansas has resulted in the designation of critical groundwater areas. Managed aquifer recharge (MAR) methods intentionally replenish stressed groundwater resources while emphasizing the protection and improvement of groundwater quantity and quality. MAR using infiltration galleries (IG) is being tested in the Cache River Critical Groundwater Area of eastern Arkansas. These IG are shallow, gravel-filled trenches excavated to the upper unsaturated MRVA sand sediments. Recharge source water from a nearby on-farm storage reservoir will flow through the gravel fill as well as through 30 m of unsaturated MRVA sands and gravels before reaching the water table. The IG appears to be a promising MAR method to enhance recharge and store surface water within the MRVA. Identification of other priority areas to install IG is needed to determine the adoptability. As part of a class group project, students will analyze and interpret available geospatial and hydrological data to identify and support ideal IG locations. Prioritized IG sites will have the following conditions, thin confining unit (<4 m) for ease of construction, large depth to groundwater (>15 m) to maximum soil aquifer treatment, and areas near an on-farm storage reservoir.

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EFFECTIVELY ACCOUNTING FOR THE EFFECTS OF URBANIZATION IN STREAM QUANTIFICATION TOOLS

Grace Long

Various Stream Quanitification Tools (SQTs) are used by state and local water resources departments to assess the quality of streams. Comparison of before and after assessments are used to determine the amount of credits or debits applied to a one-time construction disturbance or restoration activity. Most, if not all, of the SQTs used in the US do not effectively account for the functional lift resulting from urban stream restoration.The Tennessee SQT is currently under review and one consideration is for it to be more applicable for urban stream restoration.

Beaver Creek, located in Powell, Tennessee, is an urban stream. Knox County is proposing a stream restoration project on a stretch located near Powell High School. This opprortunity to assess the stream before and after the restoration activity allows for the testing of modifications made to the Tennessee SQT to effectively account for the effects of urbanization.

The pre-restoration SQT assessment has been completed for this stretch of Beaver Creek. In coordination with the Knox County Stormwater Department, restoration design plans are being created. Construction is expected to take place in the summer or fall of 2021. In the meantime, research will be completed to determine which effects of urbanization and how to quantify them should be included in the modified TN SQT. These may include area and type of impervious cover adjacent to the stream, expected urban pollutant load, and use of urban stormwater green infrastucture. After the restoration is complete, a comparison of the modified SQT and unmodified SQT assessments of Beaver Creek will be made to determine which more accurately represents the status of the stream.

OPERATION CLEAN: CAPACITY ENHANCEMENT WITH LANDSCAPE MODIFICATION USING AN ECOLOGICAL APPROACH FOR ABSORPTION AND NATURAL RECHARGE

Beau Neidich, Carmen Harvey, Adam Belton, Abbey Burton, Riley Ellis, Syed Tareq, Jejal Bathi

The University of Tennessee at Chattanooga is a metropolitan campus located in the heart of downtown Chattanooga and is home to more than 11,000 students and growing. This urban landscape nestled at the foot of several surrounding mountains and bounded by the Tennessee River is susceptible to significant flooding and water pollution. These common problems stem from Chattanooga's combined sewer system and the substantial amount of surface runoff generated by stormwater volume that cannot directly infiltrate into the extensive concrete and asphalt regions of the city campus. We thereby propose Operation **CLEAN**: **C**apacity enhancement with **L**andscape modification using an **E**cological approach for **A**bsorption and **N**atural recharge around the Engineering, Mathematics, and Computer Science (EMCS) building on campus. Features of Operation CLEAN green infrastructure (GI) interventions such as downspout disconnections, permeable pavement, underground cisterns, and retention areas integrated with real time sensor enabled operations. With active student and community engagement, Operation CLEAN will implement an outdoor environmental lab highlighting the innovative green design elements of the project complete with educational signs, a cost-friendly source of water for irrigating the greenhouse, and a retention basin complemented with picnic tables, benches, and native plant species. Overall, Operation CLEAN meets the current stormwater control regulations set by the City of Chattanooga for new developments while pushing towards an inspiring future of innovative green infrastructure for stormwater management and water pollution mitigation.

RECONSTRUCTING HISTORICAL WETLAND SURFACE WATER HYDROGRAPHS THROUGH REMOTE SENSING, MACHINE LEARNING, A\AND CLOUD COMPUTING

Collins Owusu, Nusrat Jannah Snigdha, Mackenzie T. Martin, Alfred J. Kalyanapu*, and Justin Murdock

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Wetlands are vital in the sustainability of ecosystems by performing functions such as cleaning of polluted waters, providing habitat for flora and fauna, assisting with downstream flood peaks, and recharging groundwater aquifers which warrant the need for the protection and restoration of degraded wetlands. The Wetland Reserve Program (WRP) by the Natural Resources Conservation Service (NRCS) evaluates the performance of restoration practices implemented on the easements in West Tennessee and Kentucky enrolled in the program. This study aims to provide baseline hydrological parameters such as water depth and hydroperiod before the restoration period which can be used in a comparative analysis to ascertain wetland enhancements. Cloud-based computing platforms such as Google Earth Engine (GEE) provides open-access satellite data streams and computing resources for environmental monitoring and mapping. The study intends to utilize the GEE platform to analyze time series of historical Landsat, Sentinel-1, and Sentinel-2 satellite images to detect and classify surface water in the wetlands to construct a time series of the dynamics of surface water. Machine learning algorithms will be employed to fill in the gaps between satellite revisit times using precipitation and temperature parameters as input. This will enable us to generate a continuous dataset for statistical analysis as against the current water level monitoring being undertaken by the WRP using HOBO MX2001 water level loggers.

SMART CITIES: USING LOCATION-BASED TO IOT AND GIS DASHBOARDS TO MONITOR FLOODING

Chelsie Perkins[1]* and Ingrid Luffman[1]

INTRODUCTION

Brush Creek, flowing through historic downtown Johnson City, Tennessee is prone to flooding. Current flood notifications are reactive, and there is a need for smart but affordable real time monitoring. Monitoring stream stage in real time is essential to quickly coordinate a response to rising water and flood threats. This project aims to provide a timely and proactive flood risk monitoring system that comes at a low cost to Johnson City. In this paper, we describe development of a real-time location-based IoT sensor network to monitor stream stage, and design of a real-time GIS dashboard to visualize local precipitation and stage, and send out automated warning texts if one or both measurements exceed a flood threshold.

APPROACH

A system of ultrasonic sensors will be installed at a bridge crossing over Brush Creek in Founders Park, Johnson City to measure stream stage at Brush Creek. This stream stage measurement system will use an Internet-enabled Arduino microcontroller to obtain and transfer measurements (Figure 1), as it is a low-power yet versatile device (Mehta et al., 2019). Ultrasonic sensors and cellular network connection will be used for data collection and transmission (Moreno et al., 2019). Solar panels will charge a lithium ion battery to power the microcontroller. A real-time clock module will instruct the Arduino to obtain sensor measurements at five-minute intervals, which consist of travel time from sensor to water surface and back. Between these measurements, the microcontroller will enter a sleep mode to conserve power. Time-stamped measurements will be sent as text messages to a Google Voice number. Every fifteen minutes, a scheduled Python script will be executed on a network-connected host computer to download new data, correct for temperature, and calculate the distance traveled for each measurement received, then append these measurements and their timestamps to the project's database. Precipitation and other weather data are collected every 5 minutes by a weather station located within the watershed at East Tennessee State University and operated by the Department of Geosciences. Time-stamped precipitation and temperature data will be added to the project's database using another scheduled Python script, and combined with stage data based on time stamp.

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An operational dashboard has been chosen as the method to communicate precipitation and stream stage data in an interpretable way. The current design includes separate charts showing the trends of both measurements, a map of the monitored location(s), and a status message comparing current water levels to various flood stage indicators, including bankfull status and sidewalk flooding. As with data collection, python programming will be used to automate the dashboard updates with the most recent data, allowing data to be viewed in

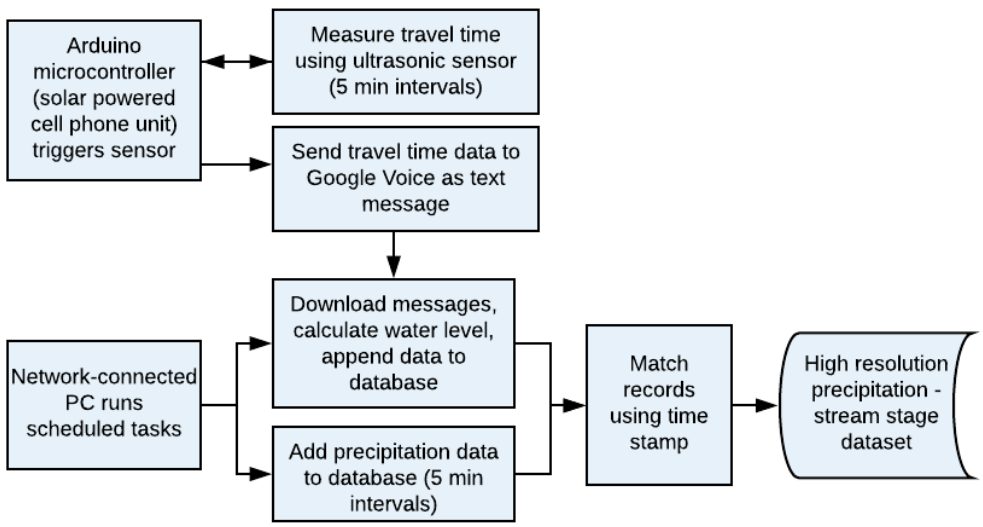

Figure 1. Data collection workflow.

real-time as measurements are received. This will work in conjunction with the dashboard refresh interval feature which will update the data dynamically within the dashboard. This process will trigger a full refresh of the dashboard each time the database is updated, with no need for manual data entry (Mehta et al., 2019). Final design of the dashboard, and triggers for status messages will be determined after consulting with experts from the Department of Public Works at the City of Johnson City. Historic data from past flooding events will also be examined, as will contributed data from an on-going community science project at the same site. Preliminary design of the dashboard is shown in Figure 2.

Figure 2. Preliminary dashboard design.

We anticipate that the system will include an opt-in service to send a text message notification when water level exceeds a user-defined threshold, permitting customization by different end users. The text message will contain the current stream stage (water level) and a time stamp, and may be sent at regular hourly intervals while stream stage exceeds the threshold. Users may include city personnel, downtown business owners, and interested members of the community..

RESULTS AND DISCUSSION

This project will provide Johnson City personnel, business owners, and residents with an improved stream stage monitoring system which operates autonomously and in real-time. The opt-in notification option will provide an earlier notification of rising water levels and potential for flooding, providing the potential for a more proactive rather than reactive response to heavy precipitation and flooding.

Obtaining high resolution stream stage and precipitation data on this ungauged stream will also permit study of the rainfall-stage response for Brush Creek, particularly in the historic downtown area, which is experiencing unprecedented economic revitalization. The dashboard will be the forward-facing piece of the research, but from a research perspective, data collected will help to fill in data gaps in the current database of community contributed water level data, which resulted from an existing community science project at Founders Park. These data are sparse during night-time hours and during inclement weather, and the IoT sensor system described in this paper is our answer to filling these gaps. It is not expected to replace the community science data, but instead will complement it.

We acknowledge that similar IoT sensor systems are available commercially. However, this project seeks to demonstrate that a low-cost do-it-yourself water level monitoring system is viable for small cities or communities, creating “smarter” cities that use technology to reduce economic losses associated with flooding through quicker response times, effectively communicate with diverse stakeholders, and improve quality of life.

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COMPARISON OF WATER QUALITY BETWEEN RICHLAND CREEK AND THE LITTLE HARPETH RIVER IN NASHVILLE, TN, 2019

Joseph Elbon, Aleyna Loughran Pierce, and Katie Madole

INTRODUCTION

Rivers contain 0.49% of the volume of the world's fresh water (Gleick, 1993). While this seems like an infinitesimal portion, rivers support the Earth in an abundance of ways. Historically, humans have always settled near moving bodies of water because of their uses such as irrigation, sources of fresh water, and food sources. Additionally, rivers are home to immense biodiversity in plants, animals, and other organisms, which depend on rivers and streams that host unique habitats vital to these organisms' health and existence. However, as human civilization further develops and advances, these bodies of water have started to become polluted and particularly, for some species, uninhabitable. In particular, as the population of the greater Nashville area increases and urban growth intrudes on natural areas, such as streams and rivers, water health can become questionable due to an influx of pollutants. These natural bodies of water have a significant impact on communities and ecosystems, as they are commonly used to catch groundwater and boost biodiversity.

APPROACH

To compare urban streams to more rural waterways, this study compared water quality from Richland Creek, which runs through a suburban area of Nashville, to the Little Harpeth, which runs through a nature reserve outside of the city. Several different metrics were evaluated in the two creeks, including nitrate, phosphate, and dissolved oxygen levels. Measurements were taken weekly at a single point in both creeks for sixty-second intervals for ten weeks over the span of five months. Water samples were collected weekly for testing at the lab. For statistical analysis, Kruskal-Wallis Non-Parametric ANOVAs were utilized to compare raw water quality data, such as flow. ANCOVAs were conducted to examine the relationships among various pairs of metrics in both streams to understand the dynamics of eutrophication. Additionally, the average of the water quality metrics calculated was compared to EPA standards if they were available (Tennessee Department of Environment and Conservation, 2013). Lastly, a principle component analysis (PCA) was conducted to observe variance in water quality by date in both streams and to determine the degree to which two common independent variables impacted the data collected. All water quality metrics were entered into a PCA, sorted by date, and then divided into two components.

RESULTS AND DISCUSSION

Contrary to expectations, the results revealed no statistically significant differences between the streams among any of the metrics measured, highlighting that despite Richland Creek having a closer proximity to the effects of urbanization, the more rural stream, Little Harpeth, still had similar water quality, as supported by Paul and Meyer (2001). These results raise questions about how the effects of urbanization and human impact may still be affecting water quality, even in more remote areas. Notably, nitrate levels (11.1 mg/L) exceeded the maximum EPA nitrate level standard allowed for fishing and recreational use (10 mg/L) in Richland Creek, indicating potential eutrophication (Tennessee Department of Environment and Conservation, 2019). Furthermore, Richland Creek's proximity to urbanized areas could be connected with the higher observed nitrate levels.

Additionally, Analysis of Covariance (ANCOVA) tests were conducted based on all water quality metrics data. When conducting the ANCOVA using the variables flow and nitrate, it was found that flow had a significant impact on nitrate ($p = 0.03$). Although there was no statistical difference between flow and nitrate in each stream or between the flow of each stream, Richland Creek was observed to have a stronger trend of nitrate increasing as flow increases than the Little Harpeth ($R^2 = 0.42$ and $R^2 = 0.12$, respectively). Further, an ANCOVA comparing nitrate and phosphate highlighted that although there were no statistically significant differences, Little Harpeth demonstrated more consistent nitrate values (8 mg/L) despite phosphate increasing which varied from the trend typically seen in these comparisons as well as Richland Creek (Richland Creek $R^2 = 0.19$, Little Harpeth $R^2 = 0.01$). Additionally, a principal component analysis (PCA) revealed variations in the metrics among the sample collection dates, indicating that more frequent measurements are necessary in order to draw conclusions. Richland Creek's dates were more clustered on the bottom half of the graph, meaning they were more similar. In contrast, Little Harpeth's dates were more spread apart and thus, less similar than Richland Creek. The PCA depicts both streams on opposite sides of the x-axis, suggesting that the streams may not be as different as previously hypothesized. Lastly, suggestions were provided for stream remediation based on field observations and lab results.

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IMPACT OF WATER pH ON FATE AND TRANSPORT OF CARBON NANOTUBES

Astha Sinha[1]

Carbon nanotubes (CNTs) are engineered particles (i.e., particles in the size range of 1–100 nm) that are widely used in electronics, optics, aerospace, medical, and industrial applications. With a wide range of known toxic effects, CNTs are considered as emerging contaminants of concern requiring their control in the environment such as in water media. However, the fate and transport of the CNTs in the environment are expected to depend on many complex parameters including chemistry and conditions of the environmental media. To understand the fate and transport and hence to control them in the water media, the effect of water pH (2-12) on the CNTs structural properties, specifically multiwalled carbon nanotubes, was evaluated using spectrometric measure. The highest absorbance was noticed in the pH 10 solution. The higher absorbance could indicate tighter structures, because nanotubes could have assembled into tighter hexagonal structures, increasing its tensile strength. Also, the higher absorbance is potentially caused by higher solubility of the CNTs in the water at pH 10.

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WATERSHED-WIDE STORMWATER MANAGEMENT IN AN UNDERSERVED COMMUNITY OF TENNESSEE THROUGH COMMUNITY-UNIVERSITY PARTNERSHIP

Maci Arms, Hugh Thomas Harris, Alfred Kalyanapu, and Tania Datta

Effective stormwater management of a community requires a comprehensive understanding of the watershed where it is located. Many studies have implemented the watershed approach to stormwater management. However, when reviewing the literature, a glaring disparity can be observed between urban communities and smaller underserved communities. Most work on watershed planning have focused on large urban areas, while very little effort has been put forth to understand and address stormwater issues in smaller underserved watersheds. Considering this disparity, our study initiated the development of a watershed-wide stormwater management plan for the town of Gainesboro, a small, underserved community in Jackson County, Tennessee. The town experienced significant flooding in June 2018 from water logging as well as Doe Creek, the nearby stream overflowing, that impacted the town's Emergency Management Services building, the Jackson County Public Library, and surrounding residential and commercial areas. However, prior to this study, limited data were available to determine the factors contributing to the flooding. Through a Community-University Partnership Program (CUPP), relevant hydrological, socio-demographic, meteorological, land-use, soil and topographical data were collected. Historic flow data of the Doe Creek and its tributaries, flood maps, and sewer maps were also obtained. Preliminary assessment indicated the town's poor stormwater management infrastructure as a plausible reason for the flooding. To address this stormwater pipes were also surveyed. All geospatial data are organized in a geodatabase. Its analysis in the future will allow for an informed understanding of the stormwater issues in Gainesboro, with the aim of developing effective mitigation measures.

FLASH FLOODING PREDICTION OF CUMMINS FALLS STATE PARK

Jason R. Gentry and
Dr. Evan Hart

Cummins Falls State Park is host to thousands of visitors hiking down to the stream bottom and up the gorge to the falls. Dangerous flash flooding caused by heavy rains are of concern. Since October 2019 a state installed rain and stream gauge system monitors the watershed for rainfall accumulations and stream rises. The purpose of our study is to analyze the data captured by the monitoring system compared with a hydrologic model developed in HEC-RAS. We seek to determine rainfall amounts posing a problem for the park and how long for heavy rains to move through the watershed. The data of stream stage and rainfall was processed to observe trends between rainfall and stage. A HEC-RAS model was built of the lower West Blackburn Fork and lower East Blackburn Fork merging into the Blackburn Fork continuing to the area below the falls. This model is in refinement for accuracy, but will run some simulations. No predictions are assessed from HEC-RAS yet, but with refinement and the addition of rainfall HEC-HMS models, we plan to run varying storm situations to predict rises and travel times in the future. Since November, updates to the monitoring system enabled us to observe one rapid rainfall event and graph the results. From these results, we can conclude that once final calibrations are performed, the rainfall and stream gauge system will give the park time to lead visitors from the areas below the falls before flooding occurs, thereby increasing the enjoyment of Cummins Falls.

TOWARDS SMART CITIES: RETROFIT OF URBAN INFRASTRUCTURE FOR SUSTAINABLE OPERATION

Carmen Harvey, Beau Neidich, Riley Ellis, and Adam Belton (undergraduate student presenters), Jejal Bathi, Ph.D., P.E., University of Tennessee

Stress on natural resources in urban areas has been increasing continuously in proportion to increasing urban density. Managing water resources through an ecotechnological approach is important for stormwater management and water pollution mitigation. Retrofitting existing infrastructure by well-established Green Infrastructure (GI) combined with emerging technological advancements in informational system can provide a sustainable solution for managing urban water resources. In such effort, our research is exploring application of GI retrofit integrated with upgrade of ponds with remote sensing and artificial intelligence support systems for their optimized operation. For example, our retrofit study for an urban area has projected to reduce runoff volume for a one-inch rain event by 29% on annual basis. Our poster will present details of our study area, our approach for GI retrofit of non-point source areas and retrofit of a pond for automatic operation based on weather forecast. In addition, we will present our hydraulic modeling simulation model set-up and results.

SESSION 2A

CHANNEL PROCESSES AND RESTORATION
(Moderator: Bill Wolfe, USGS, ret.)
8:30 a.m. – 10:00 a.m.

Comparing Cultural Objectives and Design Criteria Between Stream Revitalization in the Czech Republic and Stream Restoration in the United States
John S. Schwartz, Tomas Dostal, Petr Koudelka, and Karina Bynum

Investigation of Pleistocene and Pliocene Fluvial-Terrace and Alluvial Deposits in Eastern Shelby County, Tennessee
Md Saddam Hossain

Mind the Details: Stream Restoration Details Contribute to Success
Michael Pannell and Ken Barry

RAINFALL/RUNOFF EVENTS
(Moderator: Ingrid Luffman, ETSU)
10:30 a.m. – 12:00 p.m.

Nonlinearity in the Watershed Rainfall-Runoff Response in Highly Channelized West Tennessee Rivers
Aashis Sapkota and Claudio I. Meier

Low-Cost, Real-Time Water Level Monitoring Network for Falling Water River Watershed
Alfred J. Kalyanapu, Chris Kaczmarek, Vaibhav Ravinutala, and Phisuthisak Ngernkuakul

The City of Orlando Streets and Stormwater Division Uses Technology to Achieve Data Defensibility and Guarantee Public Safety During Heavy Rain Events
Michael Casey

STORMWATER MANAGEMENT
(Moderator: Daniel Saint, TVA)
1:30 p.m. – 3:00 p.m.

Urban Floodplain Reconnection through Regenerative Stormwater Conveyances
Gillian Palino, Jessica Thompson, John Schwartz, and Jon Hathaway

Case Study – Unique Stormwater Management with High Flow Bioretention Systems
Glen Payton

Quantifying the Hydrologic and Water Quality Impact of a Real-Time Controlled Dry Detention Basin
Aaron Akin and Jon M. Hathaway

SEDIMENT AND SOIL STUDIES
(Moderator: Forbes Walker, UT, AL)
3:30 p.m. – 5:00 p.m.

Measurements of Shear Stress Variability around Boulders: Implications for Sediment Transport in Mountainous Streams
Micah A. Wyssmann, John S. Schwartz, and James G. Code

Identification and Analysis of Hydrocarbon Plume at Tennessee State University Agricultural Research Farm
Hannah Quick, Jessica Oster, Tom Byl, Christopher Vanags, and Cameron de Wet

Analysis of the Winchester Towhead/Below Island 9 Reach of the Mississippi River
Darian S. Chasteen

COMPARING CULTURAL OBJECTIVES AND DESIGN CRITERIA BETWEEN STREAM REVITALIZATION IN THE CZECH REPUBLIC AND STREAM RESTORATION IN THE UNITED STATES

John S. Schwartz[1], Tomas Dostal[2], Petr Koudelka[2], and Karina Bynum[3]

Much can be learned by comparing approaches to stream restoration design criteria between the United States (US) and the Czech Republic (CZ) where it is termed stream revitalization. The practices of rehabilitating streams in both countries start from different historic backgrounds, land and waterway uses, watershed governance, cultural perspectives about nature and the landscape, and project objectives. Most of the CZ has a history of intensively managed land and water with changes to the drainage network beginning in the 17th century and covering most areas. Streams were straightened, armored, and have incised over time. The US similarly have modified the drainage network tough in contrast still has vast tracts of wildlands are interspersed with agriculture and urban uses. A general cultural perspective in the US is that land and water resources are limitless. Recognizing resource constraints, the CZ has five water (watershed) districts managing flood protection, channel conveyance, water quality and ecological health. In the US, water management governance is separated among federal, state, and local agencies. At the federal level, the Clean Water Act largely prescribes restoration objectives. Differences in history and governance have led to different approaches to design. Stream revitalization in the CZ relies on a non-reference reach approach and hydrological engineering models for multiple flow stages, including channel and floodplain flow capacities. There is a design focus on flow diversification, floodplain connectivity for natural enhancement integrated with flood control/prevention, and ecological stability. In contrast, in the US a reference reach approach has dominated the practice, termed natural channel design, which uses a geomorphic analog and referenced to a visually-determined bankfull stage to estimate flow capacity. Although ecological objectives are often stated, many projects are geomorphic reconstruction with the premise that ecological recovery will occur – a field of dreams scenario often phased as "build it and they will come." Differences in restoration/revitalization approaches between the US and CZ are largely founded in design criteria for planform and floodplain geomorphology, and habitat considerations. Practices in both countries are supported differently through training. In the CZ, training is dominated by the academic community and supported by professional workshops, whereas in the US training is dominated by Rosgen courses.

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By comparing US restoration and CZ revitalization, viewing the practices through different cultural lenses, the presentation describes potential areas for improvements for both design framework.

INVESTIGATION OF PLEISTOCENE AND PLIOCENE FLUVIAL-TERRACE AND ALLUVIAL DEPOSITS IN EASTERN SHELBY COUNTY, TENNESSEE

Md Saddam Hossain, CAESER, University of Memphis

Pleistocene and Pliocene fluvial-terrace and alluvial deposits have been widely studied in regards to the climate, tectonic and geomorphic processes responsible for their development. In this study, we evaluate the distribution and stratigraphic characteristics of the fluvial-terrace and alluvial deposits in the eastern part of Shelby County, Tennessee, with an aim to better understand the relationships of these terrace deposits to adjacent and overlying sedimentary units and their role in subsurface water flow. Sedimentological analysis was conducted by field observation and grain-size analysis of samples. Analysis of geophysical log records is used to construct cross-section profiles within a stratigraphic context. From a geologic cross-section across the Wolf River at 35 km from its mouth, three fluvial terraces are identified based on the lithological characteristics and the elevation with respect to the Holocene flood plain. The identified terraces are correlated to the Humboldt, Hatchie and Finley terraces, of which Humboldt and Hatchie terrace deposits lie at elevations of 17-28 m and 9-16 m above the modern Wolf River floodplain, respectively. The top of the Finley terrace is 7 m above the modern floodplain, whereas the base of the associated terrace deposits are buried beneath the Holocene floodplain. Modern alluvium appears to overlie the fluvial terrace deposits along the Mary's Creek floodplain, indicating a direct hydrologic connection between the fluvial-terrace deposits and the alluvial aquifer, whereas along the Wolf River floodplain, the Holocene alluvium is inset within underlying Eocene deposits, suggesting no direct hydrologic connection between the fluvial-terrace and alluvial deposits in this part of Shelby County.

MIND THE DETAILS: STREAM RESTORATION DETAILS CONTRIBUTE TO SUCCESS

Michael Pannell[1], CPESC, and Ken Barry, PE, D. WRE[2]

Basic stream restoration details have been available for three decades. Applying details to a particular project requires careful consideration of design constraints, material availability, contractor capabilities, and vendor recommendations. Application of details will often involve consideration and coordination of rock and log sizes with channel dimension and flow parameters, planting species selection to ensure viability and stability, long term morphology considerations, and cost and constructability including clear instruction to the contractor. This presentation will review the modification of several details for various actual restoration conditions including constructed riffles, step pools, cross and j-hook vanes, and bank treatments.

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NONLINEARITY IN THE WATERSHED RAINFALL-RUNOFF RESPONSE IN HIGHLY CHANNELIZED WEST TENNESSEE RIVERS

Aashis Sapkota[1]* and
Claudio I. Meier[1]

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INTRODUCTION

A watershed's rainfall-runoff response involves several underlying physical processes, each carrying some degree of nonlinearity. The number of processes involved and the space and time domain over which they extend make the study of runoff generation highly complicated. While observed rainfall-runoff events can be fitted with many numerical models, the choice of form of nonlinearity and parameter values can have major effect on design estimates where significant extrapolation is involved. From past studies on the nonlinearity of watershed responses (example: Amorocho, 1963; Caroni et al., 1986; Ding, 2011; Jakeman & Hornberger, 1993; Saghafian, 2006), there seems to be an agreement on the complexity of quantifying it. Defining watershed non-linearity from the underlying non-linear physical processes, or through a data-based characterization of rainfall intensity and river basin sizes, is a rather complex process.

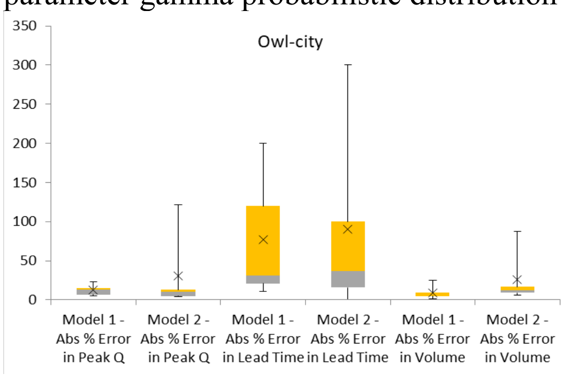
West Tennessee tributaries of the Mississippi River, covering an area of almost 9000 square miles, are among the most geomorphologically altered in the United States (Shankman & Samson, 1991; Simon & Rinaldi, 2000). Being mainly agriculture-based economy, the region witnessed widespread river modifications to increase land productivity and decrease crop losses during floods. However, straightening and dredging of the river channels and construction of levees altered the flow and sediment transport dynamics, resulting in geomorphic adjustment (Robbins & Simon, 1983; Simon & Rinaldi, 2000). This calls for consistent effort on understanding the flows in these rivers and improvising the tools we use to predict them. We select three watersheds of varying sizes: South Fork Forked Deer River near Owl City (718 sq. mi.), North Fork Forked Deer River at Trenton (73.5 sq. mi.), and North Fork Obion River near Martin (372 sq. mi.) for this study. As described by Jakeman & Hornberger (1993), there are mainly two ways of progressing and adding insight in the sciences of the natural environment. The first is to develop a physical understanding of local processes at the point-scale and then move up to the larger watershed scale, which is more favored by the scientific community. The second is to find relationships directly at the larger scale and find patterns that can be explained with conventional scientific understanding. Our study takes the second approach by defining data-based unit hydrographs for various rainfall-runoff events and makes analyses of the watershed response.

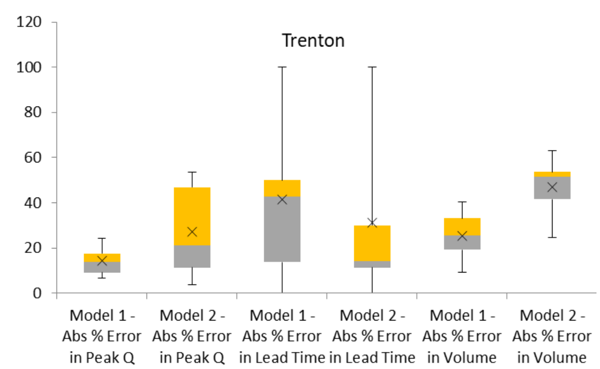
APPROACH

Using USGS streamflow data, and NCAR/EOL Stage IV radar-based rainfall data, we compare hydrological responses in these rivers for selected rainfall events. The unit hydrograph (UH) concept is based on the principle of linearity of watershed response and is a widely used tool in engineering. For deriving UHs for all events (30-35 events for each watershed), effective rainfall hyetographs and direct-runoff hydrographs are calculated, and UHs are derived based on the methodology described in Sapkota & Meier (2020). A model with adjustable UHs, referred here as Model 1, is developed by using the correlation between starting baseflow before any rainfall event and the shapes of derived UHs. Model 2 is another approach that simply uses average UH and average runoff-coefficient from all the selected events in the watersheds. For new rainfall events that are not used in the development of UHs, we compare (Figure 1) the runoff predictions with model 1 and model 2. Absolute error in determining peak flow magnitude, timing, and flood volume is compared against the USGS flow data.

RESULTS AND DISCUSSION

Model 1 based on adjustable UHs is compared with mode 2 in Figure 1. The performance is strongest in estimation of peak flow magnitude (average error 13%, 15%, and 9% with model 1 compared to 31%, 28%, and 17% with model 2, respectively for Owl-city, Trenton, and Martin), compared to the timing and volume estimations. In fact, the prediction of peak flow timing is slightly better with model 2 at Trenton. This discrepancy exists because the model has a time unit of 1-hour and therefore the time values are not continuous enough. However, Owl-city and Martin stations still show model 1 performing better with peak flow timings. Further analysis with more events will probably strengthen the results. In general, model 1 performs better overall compared to model 2, showing that non-linear approach better describes the watershed response that the linear one. We also make comparisons of the extent of nonlinearity by comparing the spread of the shape factors of each event UH that is fitted with equivalent 2-parameter gamma probabilistic distribution function.





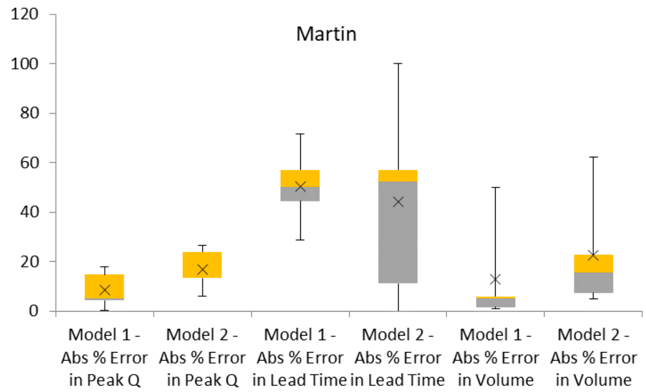


Figure 1 Absolute percentage error in peak flow magnitude, peak flow timing, and flood volume determination with model 1 representing flexible UH method and model 2 representing fixed UH method; for South Fork Forked Deer River near Owl City, North Fork Forked Deer River at Trenton, and North Fork Obion River near Martin with 5 events each.

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LOW-COST, REAL-TIME WATER LEVEL MONITORING NETWORK FOR FALLING WATER RIVER WATERSHED

Alfred Kalyanapu[1], Chris Kaczmarek[2], Vaibhav Ravinutala[3], and Phisuthisak Ngernkuakul[4]

Streamflow monitoring in the United States (US) is a cost-intensive venture, and usually performed by government agencies like the US Geological Survey (USGS). With reduced resources across the federal agencies towards environmental monitoring, agencies and stakeholders are challenged to respond with cross-cutting, collaborative and low-cost alternatives for streamflow monitoring. One such alternative is using low-cost environmental sensors and developing a real-time sensor network using IoT (Internet of Things) devices. With this technology, smaller watersheds (e.g., HUC-8 and HUC-10 level) can be equipped with low-cost sensors at many locations and a clear picture of hydrological response can be achieved. Therefore, the objective of our project was to develop a low-cost, real-time streamflow network for the Falling Water River (FWR) Watershed. To achieve the project objectives, the following three tasks were proposed: (i) Assemble a low-cost, real-time enabled water level sensor, (ii) Field-test of the sensor prototypes, and (iii) Install the sensors and expand the sensor network. The project area is the FWR Watershed in the middle Tennessee region, which covers Putnam, White and Dekalb counties, is home to the City of Cookeville, the urban center in the Upper Cumberland Plateau. The project team developed a collaborative partnership with its stakeholders including the Tennessee Division of Environment and Conservation, Tennessee Department of Transportation, Burgess Falls State Park, City of Cookeville, and Friends of Burgess Falls. During the course the project, the team successfully developed a low-cost sensor prototype, tested it at various environmental conditions and finalized on two design variants. The sensors are currently installed along the main channel and tributaries of the Falling Water River, which also include portions of the Window Cliffs State Natural Area. With continued support from the stakeholders, the number of sensors are projected to increase resulting in a dense sensor network across the watershed. This

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will over time enable the stakeholders to have a spatially variable hydrological response of the Falling Water River Watershed.

Key terms: Surface water, Streamflow monitoring, Hydrology, Emerging Technologies, Sensor Network, Low-cost technology

THE CITY OF ORLANDO STREETS AND STORMWATER DIVISION USES TECHNOLOGY TO ACHIEVE DATA DEFENSIBILITY AND GUARANTEE PUBLIC SAFETY DURING HEAVY RAIN EVENTS

Michael Casey,
Aquatic Informatics

The City of Orlando Streets and Stormwater Division is responsible for maintaining and improving drainage facilities to prevent flooding and ensure all receiving water bodies meet state and federal water quality standards. They keep two million people safe from flooding as an effect of heavy summer rainfalls and periodic tropical events. Their purpose is their community; to provide timely & accurate information to empower quicker decision-making and guarantee public safety.

This presentation will highlight how the City of Orlando took the burden of unmanageable amounts of data and created an opportunity for innovation; turning to technology to make data accessible to citizens and actionable to professionals. The City adopted Aquarius—a SaaS solution to enable the acquisition, processing, modeling, and publishing of water information in real-time—to manage the regular high-intensity rain events that cause localized flooding during normal summer rain events.

With a push of a button, the City can now create and retrieve customized intensities to evaluate isolated street flooding—eliminating hours of manual effort. By utilizing alerts and notifications based on custom levels, they remain highly proactive in forecasting potential problems–ensuring citizen safety and welfare. The data is easily accessible online in real-time to prioritize and focus efforts. In 2019, the city made critical parts of this data open to the public.

The new platform has ultimately boosted the value of the City's monitoring operations by making data easy to share with citizens, actionable to professionals, and defensible in case of litigation.

URBAN FLOODPLAIN RECONNECTION THROUGH REGENERATIVE STORMWATER CONVEYANCES

Gillian Palino[1], Dr. Jessica Thompson[2], Dr. John Schwartz[3], and Dr. Jon Hathaway[4]

In natural systems, stormwater moves to streams and river networks by way of floodplains, wetlands, and riparian forests which offer treatment and runoff detention. As watersheds are urbanized, these natural flowpaths are short circuited by storm drains and pipes that bypass these ecosystem services. This causes increased peak flows in receiving waters with erosion, volume control, and pollutant problems. Regenerative stormwater conveyances (RSCs) are an emerging design solution for urban runoff to decrease flow energy, increase infiltration rates, and remove pollutants. Positioned at the stormwater outfall, RSCs are comprised of an open channel step-pool system lined with vegetation and are sized to fully contain the 100-year storm. These pools are separated by riffle and weir boulder structures to safely convey water during large storm events. Scientifically informed design guidance and studies that help identify linkages between RSCs and local groundwater systems are limited. An investigation of an RSC on South Doyle Middle School campus in Knoxville, TN found using three-dimensional hydraulic modeling that the first two step-pools are most critical for dissipating erosive flows, and that a pool depth of 0.46m was most optimal for minimizing velocity. These results will be utilized in the design of an RSC on Beaver Creek in Knoxville, TN. The objectives of this project are to use additional 3-D hydraulic modeling to optimize pool dimensions and hydrologic performance, investigate the RSC's ability to reconnect the urban floodplain by reducing channel capacity (thereby allowing larger storms to spill onto the surrounding floodplain), and monitor runoff-groundwater exchange.

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CASE STUDY – UNIQUE STORMWATER MANAGEMENT WITH HIGH FLOW BIORETENTION SYSTEMS

Glen Payton[1]

Description: High-flow bioretention systems in small precast concrete boxes have been a frequent solution for urban stormwater management in many highly regulated areas of the US, like Southern California, the Pacific Northwest, and the Chesapeake Bay Watershed. More recently, high-flow bioretention systems capable of treating larger drainage areas than those smaller systems have been seamlessly integrated into site development projects to provide triple bottom line * benefits for jurisdictions and developers. This presentation will discuss a few case studies demonstrating successful implementation of these principles where a high flow bioretention system has been deployed to improve water quality in highly-regulated, urbanized environments as well as offer recommendations for effective use of these systems in Tennessee.

*Triple Bottom Line= Environmental, Economic, and Social benefits

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QUANTIFYING THE HYDROLOGIC AND WATER QUALITY IMPACT OF A REAL-TIME CONTROLLED DRY DETENTION BASIN

Aaron A. Akin[1] and Jon M. Hathaway[2], Ph.D.

Retrofitting static stormwater infrastructure, such as detention basins, with controllable valves on the outlet to increase or change detention times has been investigated as a solution for urbanization, climate change, and degraded infrastructure. While the hydrologic benefits of these retrofits are well documented, limited case studies exist which quantify the impact to a receiving stream's water quality following water release after this increased detention period. The purpose of this study was to investigate and quantify the hydrologic and water quality impact of a real-time controlled dry detention basin on a receiving stream when releasing water following an increased detention period. To accomplish this, a dry detention basin was retrofitted with a controllable valve while water quality and flow instrumentation was installed in the receiving stream downstream of the detention basin. When rainfall was detected, the basin's valve would close and detain all water for 72 hours following the end of rainfall. After this detention period the valve was opened, and the impact of the released water was quantified using real-time continuous measurement of turbidity, dissolved oxygen, temperature, water depth, and discharge. A total of ten events were analyzed between August 15,2020 and November 15, 2020 and included the transition from warm to cold weather conditions. Early analysis of the data concluded that the water quality impacts to the receiving stream occurred within the natural diurnal cycle and may actually improve some water quality parameters, such as dissolved oxygen, during warm weather. Additional case studies are recommended to further quantify these impacts.

Keywords: Real-time control, smart stormwater, water quality, detention basin

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MEASUREMENTS OF SHEAR STRESS VARIABILITY AROUND BOULDERS: IMPLICATIONS FOR SEDIMENT TRANSPORT IN MOUNTAINOUS STREAMS

Micah A. Wyssmann,
John S. Schwartz,
and James G. Coder

In mountainous streams, such as those in the Great Smoky Mountains, large boulders atop the riverbed significantly modify the flow field with implications to local and reach scale sediment transport characteristics. Recently, studies have also shown the important role that boulder submergence has on the location and size of sediment depositional patches that form around boulders. While this behavior is presumably is due to effects that submergence has on flow characteristics around boulders, there are few quantitative turbulent flow measurements at such conditions that could be used to evaluate this hypothesis. To address this limitation and provide improved understanding of flow structure and sediment transport patterns around boulders, new laboratory volumetric particle image velocimetry (PIV) measurements are being conducted at the Hydraulics and Sedimentation Lab. The experimental setup uses a laboratory flume with a rough bed of gravel-sized particles and a single isolated boulder to mimic typical conditions for a boulder located in a mountainous stream. The data are analyzed here to provide maps that display the bed shear stress variability around the boulder in order to identify locations of high erosion or deposition potential. The findings from this research will improve understanding the bed morphological development and predictions of sediment entrapment volume around boulders within mountainous streams.

IDENTIFICATION AND ANALYSIS OF HYDROCARBON PLUME AT TENNESSEE STATE UNIVERSITY AGRICULTURAL RESEARCH FARM

Hannah Quick[1], Jessica Oster[1], Tom Byl[2,3], Christopher Vanags[1], and Cameron de Wet[1]

In 2018, students describing soil cores on the Tennessee State University agricultural research farm, near the Cumberland River in Nashville, discovered a layer of clayey soil with a strong gasoline-like scent. Following this initial discovery, several soil cores and groundwater samples have been taken at the site, further confirming the presence of a hydrocarbon contaminant in both soil and water within the surrounding area. Here, we describe a field-based analysis of the plume which aims to identify the plume's source, extent, and spread through the use of soil and water sampling, soil descriptions, and elevation measurements. Water samples from two wells at the western and eastern edges of the plume (water level depth of 0.7 m below ground surface and 0.5 m below ground surface, respectively) were found to contain measurable amounts of compounds such as tert-Butylbenzene (C6-C10). Analysis of soil samples identified C12-C40 hydrocarbons; in the soil, the contaminant is located at a depth of 0.9 m at the western edge of the plume (downslope), and at a depth of 2.6 m at the eastern edge (upslope). Understanding the extent of the plume is important for identifying whether nearby areas might be affected. Additionally, determining the extent and spread of the plume is necessary for identifying where it likely originated. Potential sources near the site include a truck fueling station to the east and fuel tanks to the north west. Future work could include further analysis of the soil to determine the effects of vapor in spreading the plume.

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ANALYSIS OF THE WINCHESTER TOWHEAD / BELOW ISLAND 9 REACH OF THE MISSISSIPPI RIVER

Darian S. Chasteen, USACE, Memphis District

The Winchester Towhead/Below Island 9 reach of the Mississippi River is located in the extreme Northwest Corner of Tennessee and extends from approximate River Mile 903 to Mile 898. This area is home to the Northwest Tennessee Regional Harbor; and is characterized by banks that are protected with stone and Articulated Concrete Mattress, as well as stone Navigation structures consisting of Transverse and Lateral Dikes. These structures were constructed under the direction of the Corps of Engineers from 1972 to 2004 and have provided a safe and dependable navigation channel for the Towing Industry for decades. Following nearly 3 years of extremely long durations of high water, sediment deposition has become a problem and threatens navigation during moderately low river stages. Recently, in August of 2020 the Corps had to close the main navigation channel and perform emergency maintenance dredging.

Subsequent high-water events will exacerbate the issue unless Channel Improvement structures are modified or new structures are constructed. The USACE Memphis District has begun a detailed investigation of the reach including hydrographic survey, sediment, and velocity analyses. The investigation will also evaluate existing and future structures with hydrodynamic and sediment modelling.

This paper will outline the history, initial assessment of the reach, and will establish the foundation for future modelling which will be used to analyze alternatives and presented at future symposiums.

SESSION 2B

WATER QUALITY MONITORING
(Moderator: Mary Bruce, Metro Water Services)
8:30 a.m. – 10:00 a.m.

The Use of High Definition Stream Survey to Document Channel Conditions for the City of Cleveland's MS4 Stormwater Permits
James Parham and Brett Connell

Diurnal Changes in Water Quality Parameters, Big East Fork Creek, Franklin, TN
Hannah Zanibi and John C. Ayers

Proactive Data Collection for Flood Warning
Chuck Kozora

WETLAND RESTORATION
(Moderator: Andrea Ludwig, UT)
10:30 a.m. – 12:00 p.m.

Spatial Variation of Nutrient Uptake in a Restored West Tennessee Agricultural Wetland
Morgan Michael

AS/GIS-Based Analyses for Wetland Restoration Evaluation: A Case Study of St. Arbor Slough Wetland
Nusrat Jannah Snigdha, Alfred J. Kalyanapu, Justin Murdock, Owusu Collins, and Mackenzie Martin

Nutrient Recovery Trajectories of Restored Riparian Wetlands in Agricultural Watersheds
Justin Murdock, Robert Brown, Spencer Womble, Shrijana Duwadi, Morgan Michael, and Alfred Kalyanapu

STREAM MITIGATION
(Moderator: Jennifer Dodd, TDEC-DWR)
10:30 a.m. – 12:00 p.m.

Evaluating the Stream Quantification Tool (SQT) on North Carolina Piedmont Streams
Sara R. Donatich, Barbara A. Doll, and Jonathan L. Page

Applicability and Use of the Colorado Stream Quantification Tool
Brian Murphy

Review of the Tennessee Stream Quantification Tool
John S. Schwartz

WATER QUALITY
(Moderator: Jim Kingsbury, USGS)
10:30 a.m. – 12:00 p.m.

Influence on Taste and Odor Response in Tennessee: Results of a Survey of Water Utility Management
Pamela A. Hoover and Janey V. Camp

Standard Algal Growth Assays to Evaluate the Effects of Phosphorus-Enriched Water on Primary Production May Underestimate the Impact of Phosphorus Enrichment Due to Nitrogen Limitation
Jefferson G. Lebkuecher and James M. Mauney

Antibiotic Resistant Bacteria in Urban Karst Groundwater Systems in Bowling Green, Kentucky
Rachel Kaiser

THE USE OF HIGH DEFINITION STREAM SURVEY TO DOCUMENT CHANNEL CONDITIONS FOR THE CITY OF CLEVELAND'S MS4 STORMWATER PERMITS

Dr. James Parham[1] and Brett Connell[2]

Municipal responsibility under the Tennessee phase II MS4 general stormwater permit compliance is intended to minimize stormwater runoff and protect its citizens from various water pollution issues. The City of Cleveland, TN contracted Trutta Environmental Solutions to document the streambank and channel conditions within the city's boundaries using the High Definition Stream Survey (HDSS). HDSS method is adaptable to different sampling protocols including the Maryland Stream Corridor Assessment Survey Protocols which was used in the past by the city. Using the HDSS platform on both kayak and backpack, all necessary information was collected on 30 miles of stream in only 4 days with a crew of 2 technicians. In addition to completing MS4 Permit requirements associated with documenting the stream channel conditions, the city now has extensive geo-referenced, baseline condition video of its streams to track progress on the issues documented during this initial survey.

The HDSS approach was created to rapidly gather continuous geo-referenced data in a single pass for a broad range of stream and streambank conditions by integrating GPS, video, depth, water quality and other sensors. Once the data are collected, the videos are combined to create a virtual tour with four simultaneous views of the river survey (front, left bank, right bank and underwater). Other information such as side-scan sonar and a dynamic overhead map are also included when applicable. Because each second of video is linked to a specific GPS point, this allows for the identification, selection and prioritization of streambanks for restoration. The results can also be used to monitor restoration results, determine the extent and distribution of instream habitat, define the geomorphic condition for the stream, identify infrastructure impacts, and provide a powerful "virtual tour" experience.

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DIURNAL CHANGES IN STREAM WATER QUALITY PARAMETERS, BIG EAST FORK CREEK, FRANKLIN, TN

Hannah Zanibi*[1] and
John C. Ayers[1]

To see if nutrient concentrations in a pristine stream change diurnally, we made water quality measurements and collected filtered water samples every four hours from October 2 to October 4, 2020 on Big East Fork Creek in Franklin, TN, a tributary of the Harpeth River. Only one farm is located upstream from the sample site, and it is a small organic farm. Nutrient concentrations are similar upstream and downstream from the farm, suggesting little nutrient runoff from fertilizer application. Parameters that showed the expected changes resulting from photosynthesis during the day and respiration at night included pH, the partial pressure of CO_2, the carbon isotope composition of dissolved inorganic carbon (DIC), and concentrations of Ca, Mg, Fe, Se, DIC and S. However, the nutrients P, K and N do not show clear diurnal signals. For P, this may be due to strong oversaturation in apatite. High P concentrations likely result from input from groundwater flowing through the phosphatic Bigby Cannon limestone. Potassium concentrations primarily reflect lithological rather than biological control. More information is needed to understand the complex biogeochemistry of N.

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PROACTOVE DATA COLLECTION FOR FLOOD WARNING

Chuck Kozora, OTT Hydromet

As water managers and engineers, it’s important to understand our watersheds, urban landscapes, and their response to extreme events like heavy precipitation and rising surface water levels. Of the numerous tools at our disposal, there are many benefits to a flood warning system, including knowing in time where flooding issues could occur, enabling reactive action, and protecting lives while minimizing damage.

In this presentation, I will discuss urban flooding and the value of data collection for flood warning and protection. Together, we’ll examine what an ideal flood warning system might look like in your community and how data can help convince your community about the importance of being prepared for a flooding emergency.

With this presentation, attendees will:

- Receive an overview of flooding in the U.S. and factors that contribute to flooding
- Understand the role of data collection
- Learn the importance of flood warning systems and their components
- Case Study: Town of Le Veta, CO

SPATIAL VARIATION OF NUTRIENT UPTAKE IN A RESTORED WEST TENNESSEE AGRICULTURAL WETLAND

Morgan Michael,
Master's of Science
in Biology

Nutrient (nitrate & phosphate) runoff in the Mississippi River Basin, as a result of decades of agricultural practices, contributes to the formation of "dead zones" (coastal areas with hypoxia) in the Gulf of Mexico. Riparian wetlands have the potential to reduce nutrient delivery from agricultural areas to the Mississippi River and Gulf of Mexico. Here we evaluate nitrate and phosphate retention rates of 60 cores sampled from four habitats shallow water areas (SWA), remnant forest (RF), tree planting (TP), and natural Regeneration (NR) in a west Tennessee restored wetland easement. Our objective is to assess nutrient uptake potential in sediment cores through continuous flow incubation in an environmentally controlled chamber. Water inflow/outflow nutrient samples were collected at 6, 24, and 48 h, and triplicate samples for dentification rates at 24, 48, and 72 h. Nutrient and denitrification samples were analyzed with a Seal Autoanalyzer and Membrane Inlet Mass Spectrometry, respectively. The top 5cm of each core is analyzed for organic matter content and above ground vegetation. Understanding the differences in how habitat variation, of the restored wetland, mitigates the effects of excessive nutrient runoff, is key to the future management practices of other restored wetlands.

RS/GIS-BASED ANALYSES FOR WETLAND RESTORATION EVALUATION: A CASE STUDY OF ST. ARBOR SLOUGH WETLAND

Nusrat Jannah Snigdha[1], Alfred J. Kalyanapu[1*], Justin Murdock[2], Owusu Collins[1], and Mackenzie Martin[1]

Wetlands play an integral role in ecological integrity. They exhibit unique ecosystems with complexity due to variability in natural phenomena. Due to degradation and loss of natural wetlands, conservationists emphasize the necessity of wetland restoration to preserve ecosystems and wildlife. However, measuring restoration success has always been challenging due to seasonal stressors, inaccessibility, and cost. To address these issues, our objective here is to apply Remote Sensing (RS)/Geographic Information System (GIS)-based analyses to evaluate restoration success by estimating multiple hydrologic and vegetation indicators for St. Arbor Slough, Kentucky, USA. St. Arbor Slough is a forested wetland and a part of the Wetland Reserve Program (WRP) which is currently being monitored to assess the effectiveness of wetland restoration practices implemented by the Natural Resources Conservation Service (NRCS). To achieve this objective, spatiotemporal change analyses will be performed by using multispectral imagery and GIS-based estimation of indicators such as evapotranspiration, surface water, visible saturation, plant coverage, plant biomass, and landscape metrics during the growing seasons (April–October) from 2001–2020. We intend to estimate indicator values for pre-restoration (2001–2016) and current monitoring (2017–2020) periods to quantify differences over time. The anticipated results can be beneficial in large temporal scale analyses preceding assistance in decision-making for restoration practices. This approach could also be useful when available baseline data are inadequate and further implemented as a cost-effective approach to homogenous wetlands.

Keywords: wetlands, restoration success, ecological integrity, hydrologic and vegetation indicators, remote sensing, multispectral imagery, GIS-based analyses

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NUTRIENT RECOVERY TRAJECTORIES OF RESTORED RIPARIAN WETLANDS IN AGRICULTURAL WATERSHEDS

Justin Murdock[1], Robert Brown[1], Spencer Womble[1], Shrijana Duwadi[1], Morgan Michael[1], and Alfred Kalyanapu[2]

Agricultural watersheds contribute a substantial proportion of nutrients exported by rivers in the Lower Mississippi River Basin (LMRB). Several anthropogenic factors in LMRB watersheds contribute to increased nutrient export, including channelization and levee construction that disconnects the river and its floodplain, and the conversion of riparian floodplain wetlands into agricultural production. The USDA Natural Resources Conservation Service established the Wetlands Reserve Program (WRP) more than 20 years ago to restore marginal agricultural land back to functional wetland ecosystems. The goal of our research is to quantify these restoration outcomes across 40 restored riparian wetlands in western Tennessee and Kentucky, focusing on events when floodplains reconnect to the river. We are measuring easement nutrient reduction as a function of time in the program (i.e. wetland successional stage) and restoration practices including hydrology and vegetation modifications. This presentation details results from the first two years of a four-year study. Key findings to date include high denitrification rates in soils across most habitat types regardless of initial soil moisture, and greater retention of nitrogen and phosphorus during the initial flooding stage in easements older the seven years of age. The ecosystem services provided by these restored wetlands appears to reach far beyond that of just the creation of wildlife habitat, and includes the potential for substantial water quality improvement in local and downstream agroecosystems.

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EVALUATING THE STREAM QUANTIFICATION TOOL (SQT) ON NORTH CAROLINA PIEDMONT STREAMS

Sara R. Donatich[1]*, Barbara A. Doll[2], and Jonathan L. Page[2]

In Tennessee and other states, the Stream Quantification Tool (SQT) is used to quantify functional change of stream mitigation projects. The SQT is an application of the Stream Functions Pyramid (Harman et al., 2012), which asserts that stream functions are hierarchical; hydrologic processes are depicted as the fundamental support for hydraulic, geomorphic, physicochemical, and biological processes, and all functions are affected by climate and geology. To test the ability of the North Carolina (NC) SQT (3.0) to accurately detect and quantify function, 23 of 26 metrics were assessed on 19 reference, nine restored, and six degraded streams in Piedmont, NC (*n*=34). Natural variability of reference reach conditions for Piedmont, NC were compared to the SQT's performance standards. Twelve (12) standards appeared reasonable and adjustments were suggested for 10 metrics. A case study comparison of paired restored and degraded streams (n=6) revealed that restored sites exhibited greater function primarily due to hydraulic and geomorphic improvements. Substantial changes in physicochemical and biological function were generally not observed. Multivariate statistics and regression analyses were performed to test the ability of the SQT to predict biology, the top Pyramid level. Results moderately support the Pyramid framework. Reach-scale metrics were more important than watershed hydrology, providing encouragement for projects limited by watershed condition. The degree to which SQT metrics support biology is not explicitly addressed in SQT scoring, and future investigation into the implicit weights applied during scoring is recommended. Lessons learned from this study can help inform the development and maintenance of all SQTs.

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APPLICABILITY AND USE OF THE COLORADO STREAM QUANTIFICATION TOOL

Brian Murphy, P.E., D.WRE,
Colorado State University, Dept. of Civil and Environmental Engineering, PhD Candidate

This presentation will explore the application of the Colorado Stream Quantification Tool (CSQT) – its foundation, application, opportunities, and challenges. The presentation will provide an overview of the scientific basis behind the CSQT as well as the areas where science appears to contradict it due to the tool's emphasis on stream form and reliance on reference reaches. The presentation will also include considerations to improve methods and metrics for use in the CSQT.

The Federal Final Compensatory Mitigation Rule (2008), under Clean Water Act (CWA) Section 404, promotes functional assessments to determine the appropriate amount of compensatory mitigation to replace the loss of wetland and stream functions due to unavoidable impacts to aquatic resources that result from activities permitted under CWA Section 404. To provide predictability and consistency with these compensatory mitigation requirements, the U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (EPA) developed the Colorado Mitigation Procedures (COMP) that establishes regulatory requirements for using stream and wetland functional assessments for impacts and mitigation. To be more consistent with the Federal Final Compensatory Mitigation Rule and the COMP, the USACE and the EPA developed the CSQT that identifies stream functions and establishes standard protocol for data collection and inputs to quantify potential stream function impacts that may result from proposed projects that require permits under CWA Section 404. The protocol is also intended to determine potential beneficial effects on stream functions that may result at mitigation sites, including for-profit mitigation banks.

The CSQT has the potential to positively encourage the use of the latest best engineering practices for stream improvement projects and, generally, CSQT is a reasonable tool for application in certain, simple stream types. A state-wide quantification tool, however, with a one-size-fits-all approach is challenging for practitioners to implement, may not accurately reflect lift and loss, and may result in inappropriate use as assessment and design tools. Further, in its current form, the CSQT may not explicitly measure and assess stream functions of more complex or dynamic stream systems, especially streams in urban or highly altered landscapes. Incorporating measures of active physical processes and the linkages between functions within CSQT is critical to gaining a full understanding of system dynamics and to accurately determine debits and credits of projects that affect streams across Colorado.

REVIEW OF THE TENNESSEE STREAM QUANTIFICATION TOOL

John S. Schwartz, Ph.D., P.E., Dept. of Civil and Environmental Engineering, University of Tennessee, Knoxville

The U.S. Army Corps of Engineers (USACE) and Tennessee Department of Environment and Conservation Division of Water Resources (TDEC) currently require compensatory mitigation for certain permitted impacts to Tennessee's streams. The USACE require compensatory mitigation for unavoidable impacts to aquatic resources under Section 404 of the Clean Water Act and/or Sections 9 or 10 of the Rivers and Harbors Act of 1899. Tennessee's Aquatic Resources Alteration Permit (ARAP) rules establish TDEC's mandatory requirements for mitigation under Rule 0400-40-07-.04(7), and modified in 2018 requiring mitigation sufficient to compensate for the loss of resource values from existing conditions. In 2008, the USACE and the U.S. Environmental Protection Agency (USEPA) issued joint regulations clarifying mitigation compensation requirements for losses of aquatic resources {USACE: 33 CFR Part 332/40 CFR Part 230, Subpart J.; and USEPA: 33 CFR Part 230]. The new rule recognizes three mechanisms for providing compensatory mitigation: mitigation banks, in-lieu fee programs, and permittee-responsible mitigation. The 2008 rule established performance standards and criteria for the use of permittee-responsible compensatory mitigation, mitigation banks, and in-lieu programs to improve the quality and success of compensatory mitigation projects. It provided guidance on planning, implementation and management of compensatory mitigation projects by emphasizing a watershed approach in selecting project locations; requiring measurable, enforceable ecological performance standards; and specifying regular monitoring for all projects. Historically per the 2004 federal guidelines, the USACE and TDEC employed a ratio driven credit and debit system based on the activity or work proposed to determine stream resource value loss and lift.

Mitigation methods include restoration, enhancement, preservation, creation, or other effective measures, and prioritizes these activities to be implemented as close to the impact location as practicable. Stream mitigation projects often involve an approach designed to restore natural channel geomorphology, which consists of returning a severely degraded, disturbed, or altered stream, including adjacent riparian buffer and flood-prone area, to a natural stable condition based on reference conditions or other appropriate standards. Successful projects should result in a channel transporting water and sediment load in dynamic equilibrium, and produce productive habitat components that are self-sustaining long term. The amount of compensatory offset (or "credit") generated by a mitigation project depends on the hydrologic, hydraulic, geomorphic, water quality and biological lift that results from a mitigation project, as shown through post-project monitoring.

The Tennessee Stream Quantification Tool (TN SQT) were developed and to be used for evaluating the functional change between an existing and proposed stream condition. One of the goals of these tools are to produce objective, verifiable and repeatable results by consolidating well-defined procedures for objective and quantitative measures of defined stream functions. The Tennessee Debit Tool (TN Debit Tool) is a methodology developed to calculate the functional loss (debit) of permitted impacts to stream ecosystems. The TN SQT was developed to provide an objective, consistent, and transparent method for quantifying the functional lift (or loss) associated with stream mitigation and restoration projects by scoring sites before and after the implementation of restoration activities. Because the TN SQT scores an existing condition and a proposed or post project condition, it can be used to calculate functional lift and loss if both conditions are monitored. The TN Debit Tool operates with the same basic principles.

Finalized in 2019, the TN SQT has been implemented for over a year now. Practitioners, academics, and some state agencies have found various issues with the first version of the TN SQT. Issues include the following: 1) numerical computation of the existing condition score in the spreadsheet unintentionally weights metrics per the five TN SQT categories of hydrology, hydraulics, geomorphology, water quality, and biology; 2) reference conditions for various metrics may not represent the proposed restoration site geomorphic processes, particularly related to urban streams; 3) disincentivizes restoration in urban streams where a majority of the impacts to aquatic resources occur; 4) metric assessment methodology dictates design restoration methodology limiting mitigation in some locations; 5) several metrics rely on bankfull field determinations which can be problematic in disturbed watersheds, and does not provide alternatives to using bankfull; 6) some metrics reflect watershed scale processes that cannot be changed from reach-scale mitigation projects, thus "watering down" metrics that reflect improvements functional condition, 7) habitat metrics are not directly assessed but rather appear as surrogate measures, and 8) how project reaches are defined is not clear. There are other issues but the eight above covers some of the major ones. Because of these issues/concerns, USACE and TDEC formed a TN SQT Review Working Group. This Working Group consisting of the USACE, TDEC, and consultants have been meeting since August 2020, and ideas for revision have been discussed. This presentation will summarize the work-in-progress for the TN SQT version 2.0.

INFLUENCES ON TASTE AND ODOR RESPONSE IN TENNESSEE: RESULTS OF A SURVEY OF WATER UTILITY MANAGEMENT

Pamela A. Hoover, P.E., and Janey V. Camp, Ph.D., P.E., GISP, CFM, Vanderbilt University

Across the United States, drinking water utilities are faced with the challenge of planning for and responding to variations in source water quality, which can be impacted by both natural and anthropogenic processes including local weather conditions. Water treatment plant operators must respond to the daily changes in the water quality including presence of compounds that emerge due to algal blooms, organics, and organisms in the waters which may be difficult to remove and cause unpleasant tastes or odors in the treated waters. While not a real safety concern, consumers judge the safety of their drinking water by the presence of taste and odors. Preliminary findings from a survey of Tennessee water treatment plant operators about their perspectives on taste and odor management indicates that operators may rely heavily on the robustness of the plants and operator experience. Further, the results indicate that the majority of WTPs are not highly concerned about taste and odor events over time, including treatment efficiency, and do not anticipate changes in the future. These perspectives could lead to problems for the future as systems face new challenges related to climate, land use, and, even work force turnover. A summary of an analysis of the survey results to determine influencing factors on taste and odor management will be presented. The survey findings are intended to inform models to improve decision support for water utility management and response to changes in source water conditions for the future.

STANDARD ALGAL GROWTH ASSAYS TO EVALUATE THE EFFECTS OF PHOSPHORUS-ENRICHED WATER ON PRIMARY PRODUCTION MAY UNDERESTIMATE THE IMPACT OF PHOSPHORUS ENRICHMENT DUE TO NITROGEN LIMITATION

Jefferson G. Lebkuecher[1]
and James M. Mauney

Standard algal growth assays were used to evaluate the potential for primary production of water collected from Pigeon Roost Creek near Cookeville, Tennessee. Water was sampled 1 km upstream of the Cookeville Wastewater Treatment Plant discharge into Pigeon Roost Creek ($PR_{upstream}$) and 2 km downstream ($PR_{downstream}$). Relative to water at the $PR_{upstream}$ site, water at the $PR_{downstream}$ site had > 7-fold higher [total phosphorus], yet < 1.5-fold higher [total nitrogen]. Phosphorus (P) and nitrogen (N) additions to growth assays using the unicellular green alga, *Raphidocelis subcapitata,* indicate carrying capacity was P limited in water from the $PR_{upstream}$ site. Carrying capacity was significantly greater and N limited in water from the $PR_{downstream}$ site. Nitrogen addition to water collected from the $PR_{downstream}$ site significantly increased carrying capacity. The results indicate reduction of the N:P ratio of Pigeon Roost Creek changed the nutrient that limits carrying capacity for *R. subcapitata* from P to N. The results also demonstrate that standard growth assays may not indicate the full negative impact of P enrichment to a watershed due to N limitation of carrying capacity *in vitro*.

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ANTIBIOTIC RESISTANT BACTERIA IN URBAN KARST GROUNDWATER SYSTEMS IN BOWLING GREEN, KENTUCKY

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Keywords:
Antibiotic Resistance, Urban Karst Groundwater

Antibiotic resistance is a significant global concern to human, animal and environmental health. Many studies have identified wastewater treatment plants and stormwater runoff to be major reservoirs of antibiotic resistant bacteria (ARB) and associated genes. Yet their prevalence, dissemination and correlation with environmental parameters in urban karst groundwater systems remains largely unexplored. Considering the extent of karst landscape in Tennessee and Kentucky, and the growing urban areas in these regions, this is an urgent need to understand antibiotic resistance in karst systems to protect source water and public health. Therefore, this study evaluated the presence of ARB in ten urban karst features in Bowling Green, Kentucky. Water samples were collected weekly for 46 weeks and analyzed for environmental parameters that influence their prevalence. Specifically, this study focused on Tetracycline resistant *E.coli*, extended spectrum beta-lactamase (ESBL) resistant *E.coli*, 3rd Generation Cephalosporin resistant *E.coli*, Tetracycline resistant *Enterococcus*, and Erythromycin resistant *Enterococcus,* and assessed how water quality (cations, anions, biochemical and chemical oxygen demand, oil and grease, pH, dissolved oxygen, temperature, and conductivity), land-use and seasonality affected the prevalence of these emerging pathogens in urban karst system. In addition, the resistant isolates were confirmed with the targeted genes including tetA; tetB; tetM; ErmB; CMY-2, and CTXm. A consistent prevalence of ARB throughout the entire aquifer was observed, as indicated by resistant genes associated with clinical and agricultural practices.

SESSION 2C

WATER RESOURCES MANAGEMENT
(Moderator: Paul David, P.E.)
8:30 a.m. – 10:00 a.m.

How the Clean Water Movement is Shifting the Culture of Wastewater and Leading the Charge in Economic Growth and Workforce Stability
S. Ferrell

Is it Time to Finally Build a Water Planning Tool for the State of Tennessee?
Jeffrey S. Schaeffer

End the Guesswork: Determining Water Resource Knowledge, Opinions and Habits for Tailored Education Outreach
Sarah Woolley Houston

MICROBIAL COMMUNITIES
(Moderator: Qiang He, UT)
10:30 a.m. – 12:00 p.m.

Patterns of Microbial Assemblage in Wetland Ecosystems Across Habitat Type and Core Incubations
N. Reed Alexander, Danna Baxley, Taryn Bradley, Robert Brown, Shrijana Duwadi, Michael Flinn, Jeffrey Fore, Alfred Kalyanapu, Morgan Michael, Shelly Morris, Justin Murdock, Kristen Veum, Donald Walker, Lisa Webb, Spencer Womble, and Howard Whiteman

Evaluation of Next Generation Sequencing (NGS) for Microbial Source Tracking in Pathogen Impaired Streams
V. Logue

Evaluation of Nutrient and Escherichia coli Loading Dynamics in a Middle Tennessee River
Ryan Jackwood

FAUNAL STUDIES AND RULES
(Moderator: Tom Lawrence, TLE, PLLC)
1:30 p.m. – 3:00 p.m.

Asian Carp Egg Transport Modeling in the Tennessee River System
Colleen Montgomery

Assessing Efficacy of Translocation as a Conservation Strategy for Wild Eastern Hellbenders in Tennessee
Bradley D. Nissen, Emilly Nolan, Michael Freake, Rebecca Hardman, and William Sutton

Fish and Wildlife Coordination Act: Opportunities for States to Review Federal Water Development Projects
Jennifer Sheehan

AGRICULTURAL PRACTICES
(Moderator: John Schwartz, UT)
3:30 p.m. – 5:00 p.m.

Row Crop Agricultural Adaptation Under Uncertain Climate Conditions in the Upper and Lower Mississippi River Basin
Christos P. Giannopoulos, John Schwartz, Christopher G. Wilson, and Jonathan Hathaway

Groundwater Availability and Agricultural Use in West Tennessee
Mary A. Yaeger

Development of a GIS-Based Watershed Vulnerability Assessment Tool for the Loosahatchie Watershed in Tennessee
Vinay A. Dhanvada, Alfred J. Kalyanapu, Tania Datta, and Jenny Adkins

HOW THE CLEAN WATER MOVEMENT IS SHIFTING THE CULTURE OF WASTEWATER AND LEADING THE CHARGE IN ECONOMIC GROWTH AND WORKFORCE STABILITY

S. Ferrell

For decades, public perception of the water environment profession has (literally) been down the toilet. The sector is ready to clear up these negative perceptions. The Water Environment association of Kentucky & Tennessee has taken the first step in moving forward by changing our name to the Clean Water Professionals of Kentucky & Tennessee (CWP-KT), and that's only the beginning.

With the US EPA Clean Water Needs Survey showing a combined need of $9 billion for clean water projects in Kentucky and Tennessee, it's time to tell a new story. Those in the water environment field know that, above all else, we clean water. So why are we still calling ourselves wastewater professionals? We don't waste water – we clean water. The water environment field strives toward three principles – protecting the planet, protecting people and making play possible by being the stewards of the many lakes, rivers and streams throughout the nation. By recycling and reclaiming water, we're doing our part to preserve our beautiful states. Our work literally flows through our communities. Quality water means quality of life, so we make sure to leave water cleaner than we found it.

And in order to make these changes, we need new, diverse recruits in our sector, especially with one third of water utility workers retiring in the next decade and only 15% of the water workforce being women. Each job in Water Infrastructure construction adds 3.68 jobs to the economy. By bringing more interest to our sector, we'll continue to do our part to help our states and country thrive. The goal for the Clean Water Movement is to not only restore dignity, but put the sector at the forefront of environmental advancement, economic expansion and community development.

Learn how CWP-KT is recruiting Clean Water Partners to change the narrative about wastewater management to improve public perception, boost recruitment and create economic growth opportunities across the entire water sector. Find out about resources that will help partners encourage the clean water culture shift through monthly internal training, public education materials, partnership designation and participation in collaborative initiatives. All of this will leverage our work for the good of our communities, and through these partnerships, will remind us of our purpose and our passion to provide clean water for all.

IS IT TIME TO FINALLY BUILD A WATER PLANNING TOOL FOR THE STATE OF TENNESSEE?

Jeffrey S. Schaeffer[1]

TNH2O, the master water planning document for Tennessee, calls for a statewide hydrologic model that could be used for science-based water governance- a need first recognized in 1957. The historic impediment is that traditional hydrologic models always needed spatially-broad, long-term flow data acquired by gauges. Those data exist for navigable rivers and urban areas, but often not for rural landscapes. But, new approaches might make it possible to fulfill that decades-overdue need. For most river reaches, the USGS StreamStats tool now provides summary data, while NOAA's National Water model estimates real-time flows. Both agencies are collaborating to improve predictions, predictions are ratified by gauge data, and NOAA predictions can be backcast to examine past flows during historic extreme weather events. But, both tools were developed with emphasis on local, sub-watershed applications. That was an avowed need, but what is also needed are large-scale visualizations that can be used to plan future water use in a more variable climate. This is actually being considered through the lenses of navigation and power generation, but again, no statewide approach exists. Since we now have flow information on almost every river reach, would it would be possible to assemble those predictions in a web-based tool that would allow users a Statewide view of water availability under different weather patterns, and examine impacts of flooding, diversions, and withdrawals under multiple future scenarios? This is a daunting task that would require multiple agencies, universities, and stakeholders, but it could be a way to implement TNH20's vision.

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END THE GUESSWORK: DETERMINING WATER RESOURCE KNOWLEDGE, OPINIONS AND HABITS FOR TAILORED EDUCATION OUTREACH IN SHELBY COUNTY, TENNESSEE

Sarah Woolley Houston

The Center for Applied Earth Science and Engineering Research (CAESER) in partnership with the Center for Community Research and Evaluation (CCRE) at the University of Memphis developed and distributed a survey tool to understand the public's current knowledge, attitudes and behaviors surrounding water resources in Shelby County, Tennessee. The survey instrument contains quantitative and qualitative questions to measure the knowledge of water resources and environmental terminology, perceived attitudes, threats and concerns about water, current behaviors that impact water resources, and places where people receive messaging and consume information to determine future targeting strategies. This survey also helps achieve the goals of Tennessee's first state water plan, TN H_2O, which includes emphasis on educating the public about the importance of this invaluable natural resource. This survey will aid CAESER in understanding the public's perception of water resources to direct its education and outreach efforts. These initial efforts will serve as a baseline study to help compare future surveys by measuring progress as well as messaging effectiveness to ensure efficient use of funds. The project will result in a series of reports distributed to utilities and governing bodies within Shelby County. The presentation contains the project details including survey development, distribution methodologies, analysis and preliminary report findings.

Source:

Tennessee Department of Environment and Conservation. (2018). *TN H_2O: Tennessee's Roadmap to Securing the Future of Our Water Resources.* https://www.tn.gov/environment/program-areas/wr-water-resources/tnh20.html

Keywords:

1. Management Issues
2. Water Supply
3. Regulation
4. Public Forum
5. Education

PATTERNS OF MICROBIAL ASSEMBLAGE IN WETLAND ECOSYSTEMS ACROSS HABITAT TYPE AND CORE INCUBATIONS

N. Reed Alexander[1], Danna Baxley[2], Taryn Bradley[3], Robert Brown[4], Shrijana Duwadi[4], Michael Flinn[5], Jeffrey Fore[2], Alfred Kalyanapu[6], Morgan Michael[4], Shelly Morris[2], Justin Murdock[4], Kristen Veum[7], Donald Walker[1], Lisa Webb[8], Spencer Womble[4], and Howard Whiteman[3]

Recent work has suggested that microbial assemblages within wetland ecosystems may serve as bioindicators for the restoration of wetland functions, as microbes make direct contributions to nutrient loading and cycling, and establishment of redox potential within soils (Urakawa and Bernhard 2017). Studies of spatial ecology are both defined and constrained by two parameters, grain, and extent. Patterns of ecological significance inferred from spatial studies have been shown to be scale-dependent, requiring analysis across multiple scales to generate confidence in results (Wiens 1989). Our lab has developed a novel methodology for collecting soil cores for microbial community analysis, allowing for a fine-scale spatial analysis within the organic layer of wetland soil. The purpose of this study is to elucidate patterns of microbial biogeography within and among wetlands by developing diversity profiles from high-throughput sequencing data, phospholipid fatty acid profiles, and soil geochemistry, to investigating the forces driving spatial variation of community structure across habitat types among wetlands. Comparisons will be made between microbial assemblages contained in the top and bottom of the organic layer, as well as between remnant forest, tree planting, and shallow water habitats across two wetlands. The response of community assemblage to core incubation will also be assessed.

Literature Cited:

Urakawa, Hidetoshi, and Anne E. Bernhard. "Wetland management using microbial indicators." *Ecological engineering* 108 (2017): 456-476.

Wiens, John A. "Spatial scaling in ecology." *Functional ecology* 3.4 (1989): 385-397.

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EVALUATION OF NEXT GENERATION SEQUENCING (NGS) FOR MICROBIAL SOURCE TRACKING (MST) IN PATHOGEN IMPAIRED STREAMS

V. Logue

Elevated in-stream bacterial levels are often attributed to multiple sources. Microbial source tracking (MST) can be used to profile and compare the microbial communities between fecal sources (human or animal) and environmental samples (e.g. water, soil and sediment). In recent years, MST has utilized Next Generation Sequencing (NGS) to build a library of Operational Taxonomic Units (OTUs) from sources of known fecal contamination. In this project, we collected both fecal samples from suspected contributors (e.g. dog, squirrel, deer, opossum) and in-stream samples from streams with prolonged elevated E. coli levels to investigate microbial communities using NGS based MST. We evaluated the intragroup variability to explore differences among fecal sources.

Statistical analyses (PCA and PCoA) were used to attempt to predict the most substantial fecal sources contributing to each watershed. Although we did not obtain significant results for this question, analyses revealed significant clustering among water samples as well as clustering within animal species. The information gained from this project will provide direction for future source tracking projects.

EVALUATION OF NUTRIENT AND *ESCHERICHIA COLI* LOADING DYNAMICS IN A MIDDLE TENNESSEE RIVER

Ryan Jackwood

Excessive nutrient and microbial contamination of surface waters contribute to poor water quality that threatens environmental and human health. Nutrients drive increased occurrence and severity of harmful algal blooms whereas microbial contamination (indicated by the presence of *Escherichia coli*) can lead to swim advisories at local beaches or rivers frequented by swimmers. The Harpeth River was evaluated as a model system to better understand loading dynamics of bacteria and nutrients in middle Tennessee rivers. Water quality data (total phosphorus, total nitrogen, *E. coli*, and discharge) were collected in the Harpeth River between 2012 and 2020. These data were used to identify temporal trends in loadings within the Harpeth River for total nitrogen, total phosphorus, and *E. coli*. Nutrient (total phosphorus and total nitrogen) loading trends are utilized to identify water management priorities within the Harpeth River watershed that will help reduce the occurrence of harmful algal blooms. Loading trends of *E. coli* are evaluated to predict when densities of *E. coli* are above the Tennessee Department of Environment and Conservation's Recreational Criteria (geometric mean of 126 colony forming units [CFUs]/100 mL or individual sample threshold of 941 CFUs/100 mL). Predicted *E. coli* densities can serve as an "early warning" system to advise members of the public when microbial contamination is unsafe for swimming in surface waters due to the threat on human health.

ASIAN CARP EGG TRANSPORT MODELING IN THE TENNESSEE RIVER SYSTEM

Colleen Montgomery

There are four types of “Asian carp” that are a threat to US waterways. These include bighead-, silver-, black- and grass carp. All of them were intentionally introduced to aquaculture facilities in the US in the 1960’s and 1970’s to perform clean-up and pest control services in confined ponds. Unfortunately, due to floods or accidental releases, these fish escaped confinement and have been reproducing and spreading rapidly in US waters ever since, most notably in the Mississippi River Basin and its tributaries. The USGS is at the forefront of the battle against the fish and is working diligently to keep the fish out of the Great Lakes. TVA has partnered with the USGS to learn more about the fish, model egg growth and transport in the TVA system, and benefit from the USGS expertise in fish barrier technology.

The carp are a nuisance because they eat aggressively, consuming up to 40% of their weight in food every day, depleting their ecosystem of food for other inhabitants, and increasing the potential for erosion by stripping vegetation from banks. Additionally, a female carp can lay a million eggs in a spawning season! Silver carp pose an additional threat to unsuspecting boaters and water skiers, as they spontaneously leap from the water when they feel threatened or hear loud noises such as a boat motor. Although videos of the fish jumping out of the water and hitting water skiers are amusing, in reality, being hit by a 20+ pound carp while traveling at high speed in or behind a boat can lead to serious injuries in some cases. The main focus of this evaluation is on silver carp.

The silver carp are currently enough of a problem in Kentucky and Barkley Lakes that free ice is provided to commercial fishermen who wish to catch these fish, and numerous carp fishing tournaments are scheduled every year to help keep the fish population under control. Although all year classes of the fish are found in Kentucky Lake, the fish are generally not reproducing in the Tennessee River, but they are migrating to Kentucky Lake very abundantly. Surveys only found carp eggs on one occasion in 2015 on the Duck River, a Tennessee River tributary in Kentucky Lake. Carp eggs have not been found anywhere in the Tennessee River system since 2015. This may be due to the way TVA schedules the dam releases throughout the system with high flow during times of peak power demand on a daily basis, compared to more steady Corps of Engineers dam operations. Nonetheless, TVA reservoirs offer a lot of excellent potential habitat to the fish, should they migrate upstream beyond Kentucky Lake.

TVA is working with the USGS to learn from their experiences with the fish over the last 20 years and is using an egg transport model celled FLUEGG (FLUvial EGG transport model), developed by the USGS Water Science Center in Urbana, IL to evaluate the Tennessee River System for suitability for the carp eggs and hatchlings. Presently, the model requires output from the USACE HEC-RAS model as one of its inputs. TVA used the HEC-RAS and FLUEGG models to evaluate 16 reaches in the Tennessee River Basin for survival potential of the eggs under summer flow conditions when spawning would occur.

In this summary, results from the HEC-RAS 1-D modeling and FLUEGG transport modeling are presented for the 16 modeled Tennessee River reaches and the reaches were ranked for carp egg hatching suitability and potential habitat availability for carp hatchlings.

ASSESSING EFFICACY OF TRANSLOCATION AS A CONSERVATION STRATEGY FOR WILD EASTERN HELLBENDERS IN TENNESSEE

Bradley D. Nissan*, bradnissen915@gmail.com, Emilly Nolan, Tennessee State University, Dr. Michael Freake, Lee University, Rebecca Hardman, University of Tennessee Knoxville, and Dr. William Sutton, Tennessee State University

The fully aquatic Eastern Hellbender salamander (*Cryptobranchus alleganiensis alleganiensis)* is sensitive to disturbances to aquatic environments and often considered a bioindicator. Due to population declines and habitat fragmentation throughout its range, the hellbender is a strong candidate for translocation in Tennessee. We evaluated the short-term success of translocation on wild hellbenders by comparing the spatial ecology of individuals pre- and post-translocation using radio-telemetry. We studied the home range sizes, movements and multi-scale habitat use of individuals (N = 27) in two sustainable populations (SS1 & SS2) for one year and then subsequently collected similar data from a portion of these individuals (N = 17) that were translocated (May-July 2019) into two nearby streams (TS1 & TS2) with declining populations. We collected 1,571 location data points (869 pre-translocation and 715 post-translocation) from our four study sites. Survival rates of translocated individuals increased when moved from SS1 to TS1 (80% to 100%), while they decreased when moved from SS2 to TS2 (76% to 33%). Home range sizes increased from pre-translocation rates at both sites, but responses depended heavily upon physical characteristics of the release sites. An observed increase in importance of boulder densities on hellbender resource selection *after* translocation implies that large boulder clusters could serve as important cues for "suitable habitat" as hellbenders are assessing new environments. We found that translocations of wild hellbenders could be beneficial for regions where suitable habitat exists without healthy hellbender populations. This study informs managers about the potential for translocation as a hellbender conservation strategy.

FISH AND WILDLIFE COORDINATION ACT: OPPORTUNITIES FOR STATES TO REVIEW FEDERAL WATER DEVELOPMENT PROJECTS

Jennifer Sheehan, Arkansas Game and Fish Commission

The Fish & Wildlife Coordination Act (FWCA) amendments of 1946 require consultation with the Fish and Wildlife Service and the fish and wildlife agencies of States where the "waters of any stream or other body of water are proposed or authorized, permitted or licensed to be impounded, diverted . . . or otherwise controlled or modified" by any agency under a Federal permit or license. Consultation is to be undertaken for the purpose of "preventing loss of and damage to wildlife resources." The FWCA provides an opportunity for states to be on equal footing with the federal government when it comes to reviewing and providing recommendations on all federal water development projects across the country.

A survey conducted by the Arizona Game & Fish Department in September of 2019 found that state participation in FWCA consultations varies wildly: some states have good working relationships with their federal partners (primarily the U.S. Army Corps of Engineers and the Federal Energy Regulatory Commission), some states have poor and even adversarial relationships with federal agencies, and there are a few states that are not even aware of the FWCA and the project review abilities it affords them. As a result the Association of Fish & Wildlife Agencies, Subcommittee on Water, has created an ad hoc committee to determine what steps need to be taken to 1) make sure that state wildlife agencies are aware of their rights under the FWCA and 2) what tools, guidebooks, and/or training sessions need to be created for states.

ROW CROP AGRICULTURAL ADAPTATION UNDER UNCERTAIN CLIMATE CONDITIONS IN THE UPPER AND LOWER MISSISSIPPI RIVER BASIN

Christos P. Giannopoulos, John Schwartz, Christopher G. Wilson, and Jonathan Hathaway

Climate uncertainty with warmer summers, extreme storm events, shifts in rainfall patterns, and higher temperature and CO_2 concentrations, in conjunction with increasing water demands will intensify agroecosystem stresses through lower water availability and changes in growing season dynamics, leading to reduction in crop yields. Successful adaptation will require an understanding of how the ensemble of climatic and adaptation factors might drive changes in agroecosystem resiliency and the extent to which adaptation practices could be effective, which are considerations missing from existing agroecosystem studies. In this study, the Agricultural Production Systems sIMulator (APSIM) model is employed to quantify projected corn and soybean crop yields, water and nitrogen use efficiency, and irrigation demands in the Upper and Lower Mississippi River Basin. Two key adaptation scenarios are considered, namely Business as Usual (BAU) scenario representing current practices and Acclimation-Technological-Management Adaptation (ATMA) scenario representing crop acclimation (structural, ecophysiological, biochemical), technological adaptation (cultivars), and management adaptation (planting, irrigation, fertilization) conditions. The model is calibrated and verified using past county-level yields from the USDA National Agricultural Statistics Service. Projections are based on four global circulation models (GCMs) and the RCP8.5 extreme representative concentration pathway. Findings suggest that corn yields are susceptible to water and nitrogen stress, with a projected decline under BAU conditions, while soybean yields are less affected because of acclimation. Under the ATMA scenario, there is a decrease in inter-year variability, and increase in crop yields over time. Results also suggest that annual irrigation demand is expected to increase by 200-300 mm by 2100.

GROUNDWATER AVAILABILITY AND AGRICULTURAL USE IN WEST TENNESSEE

Mary A. Yaeger

Increasing population growth in West Tennessee (TN) means an increasing demand for groundwater and the need to plan ahead to ensure a sustainable supply for future generations. To do this, knowledge about current groundwater availability, accurate water use estimates, and recharge avenues and rates are required. Currently, there is a lack of data to understand these three things, particularly as it relates to agricultural use. While groundwater usage is highest in West TN compared to the rest of the State, and agriculture is a major part of the economy there, it may not be the largest groundwater user. To get a more accurate estimate of agricultural groundwater usage, the University of Memphis CAESER in collaboration with the TN Department of Agriculture are reaching out to farmers and landowners in West TN to be partners in gathering and collecting groundwater levels and water withdrawals. In 2020, CAESER began a 3-year project in Gibson and Carroll Counties to address agricultural groundwater use and its impact in support of TN H2O recommendations. Three observation wells will be drilled to observe irrigation well impacts on groundwater and groundwater-surface water interaction as well as background conditions. Water level sensors will be installed in each well, plus one in a nearby stream. Scheduled pumping tests will provide for aquifer characterization and a portable flow meter will allow for a more accurate estimate of discharge from irrigation wells. In addition, a weather station was installed to capture rainfall amounts and estimate evapotranspiration in the area.

DEVELOPMENT OF A GIS-BASED WATERSHED VULNERABILITY ASSESSMENT TOOL FOR THE LOOSAHATCHIE WATERSHED IN TENNESSEE

Vinay A. Dhanvada[1], Alfred J. Kalyanapu[2], Tania Datta[3], and Jenny Adkins[4]

Watershed vulnerability is the extent to which a watershed is susceptible to the adverse effects of hydrological changes, alterations to its current condition, and its ability to adapt. It is often used as a measure to assess how land-use practices and climate conditions within a watershed will affect its health, downstream water quality, aquatic biodiversity, and the economy. Our study aims to develop an easy-to-use watershed-scale vulnerability assessment tool using Multi-Criteria Decision Making (MCDM) approach and geographic information system (GIS) based algorithm to assess the contributions of agricultural practices to vulnerability. This tool uses readily available GIS datasets and can guide local governments and resource managers (such as Natural Resources Conservation Service, soil conservation districts) in prioritizing watershed areas for the implementation of agricultural conservation measures required for watershed health and water quality protection. Designed within the ArcGIS environment, we developed the tool for the Loosahatchie watershed, which is located in western Tennessee. It considers factors such as soil erodibility (K-factor), hydrologic soil group, land-use, land capability class, percent slope, drainage density and proximity to an impaired stream to assess watershed vulnerability. The tool ultimately results in a vulnerability map categorized into five classes ranging from No/Least Vulnerability to Extreme Vulnerability, and can be applied to other regions where datasets for the listed factors are available.

Keywords: Watershed Vulnerability, Multi-Criteria Decision Making, Geographic Information System

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SESSION 3A

WATERSHED MODELING
(Moderator: Alfred Kalyanapu, TTU)
8:30 a.m. – 10:00 a.m.

Integrated Watershed Process and Empirical Modeling for Mercury Transport: An Application to an Industrially Contaminate
Sujithkumar Surendran Nair, Christopher DeRolph, Mark J. Peterson, Ryan McManamay, and Teresa Mathew

Hydrological Parameter Sensitivity Analysis of HSPF Model on South Chickamauga Watershed
Preyanka Dey and Jejal Bathi

Modelling of Sediment Transport in Oostanaula Creek, Athens, Tennessee
Miroslav Bauer, Josef Krasa, Tomas Dostal, Barbora Jachymova, John Schwartz, and Karina Bynum

INTEGRATED WATERSHED PROCESS AND EMPIRICAL MODELING FOR MERCURY TRANSPORT: AN APPLICATION TO AN INDUSTRIALLY CONTAMINATE

Sujithkumar Surendran Nair[1], Christopher DeRolph[1], Mark J. Peterson[1], Ryan McManamay[1,2], Teresa Mathews[1]

We used the Soil Water Assessment Tool (SWAT) as a framework to model Hg flux in Upper East Fork Poplar Creek (UEFPC), a Hg-contaminated watershed in Oak Ridge, TN. By integrating long term Hg monitoring data with simulated flow and suspended solid loads in a site-specific empirical Hg transport model we were able to: 1) quantify the spatial, temporal, and flow regime controls on daily Hg flux (adjusted R^2=0.82), and 2) make predictions about Hg flux under future climate, land use, and management scenarios. We found that 62.79% of the average daily Hg flux in the UEFPC watershed is currently driven by base flow, while variability in Hg flux is driven by storm and extreme flow. We estimate an average annual Hg flux of 28.82 g day^{-1} leaving the watershed under baseline precipitation, with an estimated 43.73% reduction and 296% increase in daily Hg flux under drought and extreme precipitation scenarios respectively. We estimated that a new mercury treatment facility would result in a 24.7 and 33.4% reduction in Hg flux under baseline and extreme precipitation regimes, respectively. While our model is site-specific, the framework can be adapted to any site at which information on flow, suspended solids and Hg concentrations are available.

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HYDROLOGICAL PARAMETER SENSITIVITY ANALYSIS OF HSPF MODEL ON SOUTH CHICKAMAUGA WATERSHED

Preyanka Dey, Graduate Student (M.S.), Civil and Chemical Engineering, University of Tennessee at Chattanooga, and Jejal Bathi, Ph.D., P.E., Faculty Advisor, Civil and Chemical Engineering, University of Tennessee at Chattanooga

Sensitivity Analysis in hydrological models is usually performed to understand watershed parameters' influence on its hydrology. While such analysis has several approaches, the simplest one is to use One Factor at a Time (OFAT) where one watershed parameter is being changed keeping the others at their baseline values. Thus any difference in the watershed model output from its baseline can be attributed to the change in the single input factor. In this study, we developed a detailed Hydrological Simulation Program - Fortran (HSPF) model for South Chickamauga Creek watershed and applied OFAT method to test sensitivity of parameters to the watershed hydrology. Among tens of parameters analyzed, LZETP (lower zone evapotranspiration), INFILT (Index to Infiltration Capacity) and INTFW (interflow inflow) and AGWRC (Base Groundwater Recession), DEEPFR (Fraction of Groundwater Inflow to Deep Losses) were found to be more influential for the different flow regimes. Overall, in addition to demonstrating model set-up and sensitivity analysis, our calibrated model provides a tool for watershed management and sets references for developing such models for other southeastern Tennessee watersheds.

MODELING OF SEDIMENT TRANSPORT IN OOSTANAULA CREEK, ATHENS, TENNESSEE

Miroslav Bauer[1], Josef Krasa[1], Tomas Dostal[1], Barbora Jachymova[1], John Schwartz[2], and Karina Bynum[3]

The soil loss and sediment transport including its spatial pattern was studied in Oostanaula Creek catchment in Southeast Tennessee (tributary to the Hiwassee River).

The area of 70.3 mi^2 (182.1 km^2) of Oostanaula Creek watershed (HUC 06020021101 and 060200021102) was modeled by WaTEM/SEDEM soil erosion and sediment transport model, based on long term average RUSLE approach and transport capacity estimation. Modelling has been based on utilization of the most recent available DEM, LU and soil data in raster resolution 10x10 m.

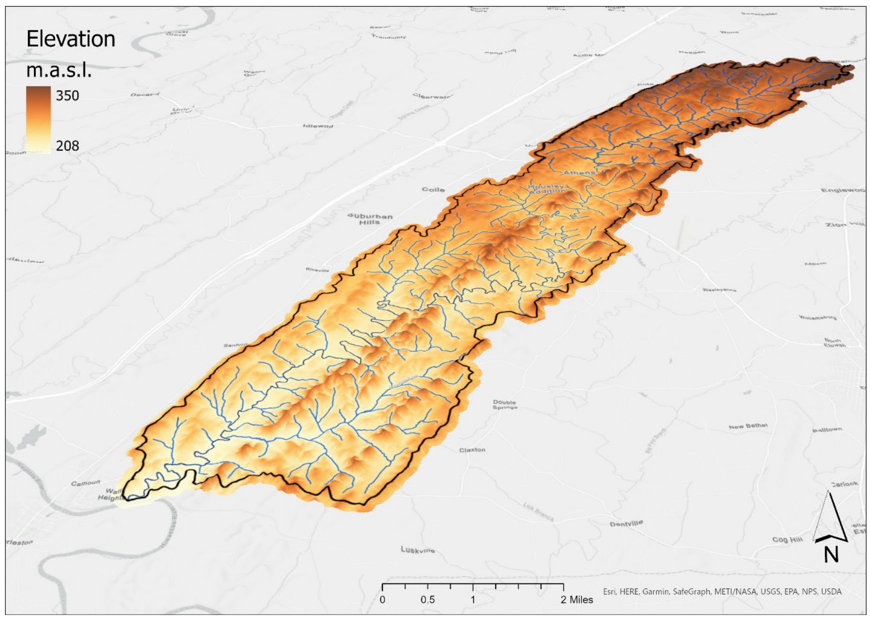

Figure 1: DEM of Oostanaula Creek watershed

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The aim of this simulation effort has been to derive map of spatial distribution of soil loss, sediment transport and deposition for the entire catchment. Furthermore, sediment reaching the streams and transported downstream is estimated for each segment of river network, therefore complex dynamic of sediment transport through the catchment can be described by the model in long term annual average values.

The main reasons for using WaTEM/SEDEM model are: fully distributed methods, based on well known RUSLE; provides sufficiently accurate estimation and finally model was well tested worldwide (Krasa et al., 2019).

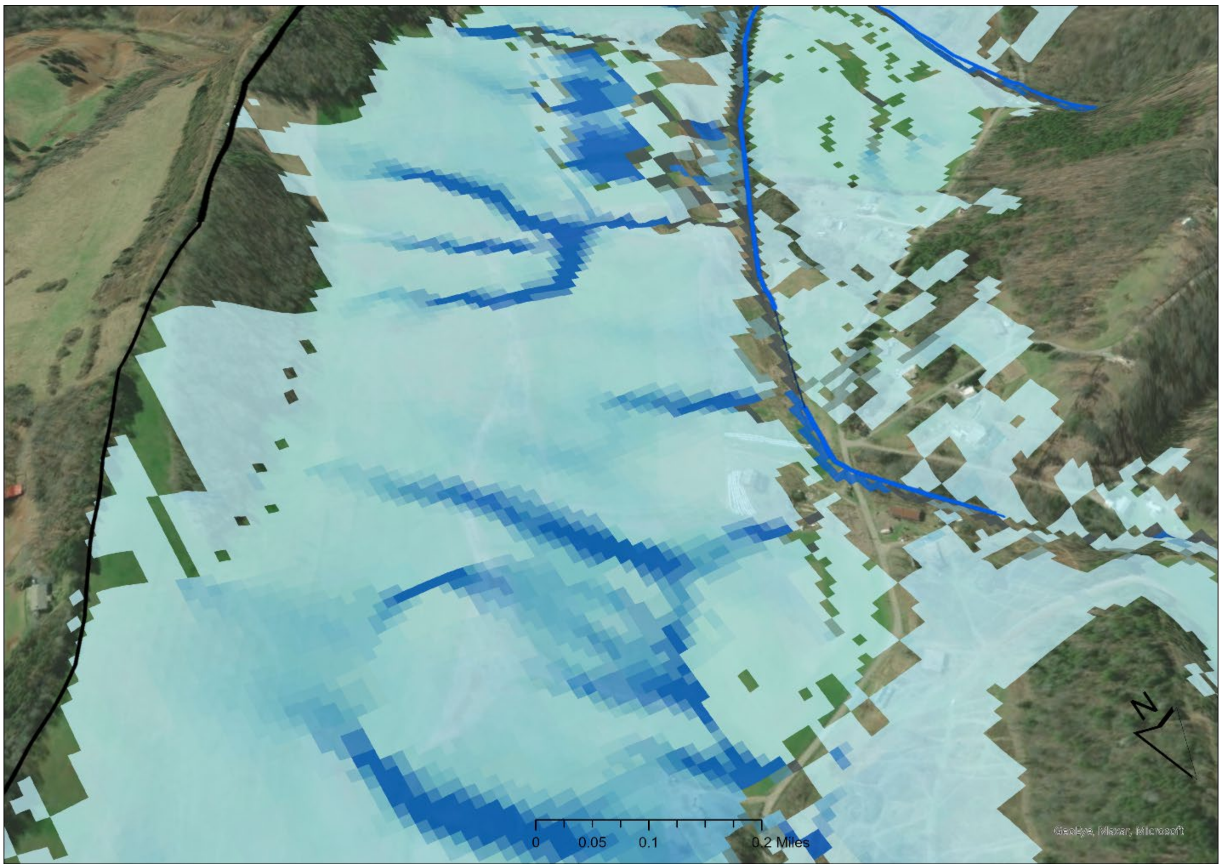

Figure 2: Sediment transport pathways connected to the stream

A total of 323 km of streams (280 km natural and 43 km artificially stabilized) was included in the model, in the land area covered by the following land use: Forest (46.0%), Shrub/Herbaceous/Pasture (38.4%), Urban and Developed areas (11.5%), Cultivated crops (3.8%), Wetlands and open waters (0.3%). Upper part of the catchment above the city of Athens is dominated by agricultural use (cultivated crops/pasture) compared with lower part of the catchment, which is covered mostly by forest.

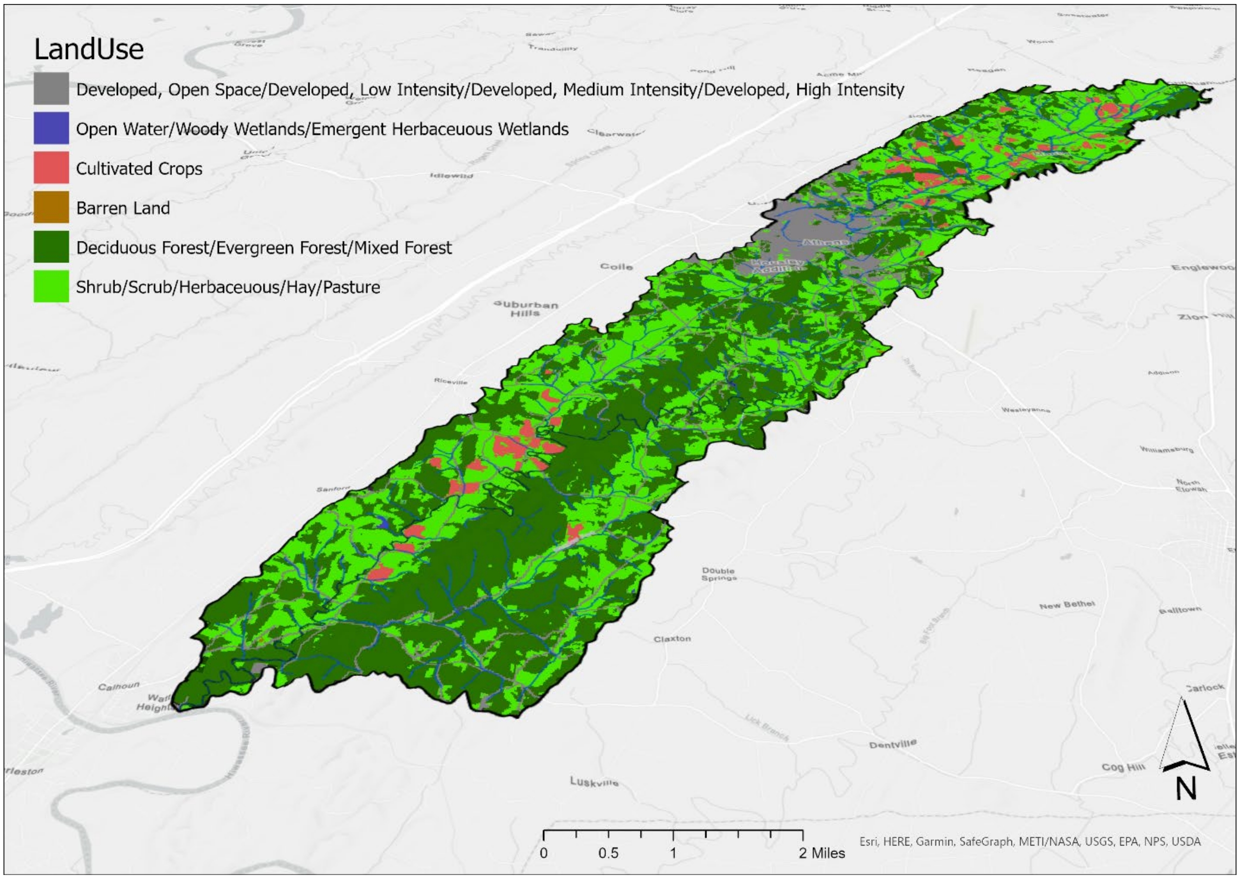

Figure 3: LandUse map of Oostanaula Creek watershed

Detailed results of the analysis and discussion of modelled data with records from monitoring data will be presented in in oral presentation.

Research has been supported by project LTA-USA 19019.

REFERENCES

Mueller, D.K., and Helsel, D.R., 1996, Nutrients in the nation's waters--too much of a good thing?: U.S. Geological Survey Circular 1136, 24 p.
Krasa J., Dostal T., Jachymova B., Bauer M., Devaty J., 2019, Soil erosion as a source of sediment and phosphorus in rivers and reservoirs – Watershed analyses using WaTEM/SEDEM, Environmental Research, Volume 171, Pages 470-483, ISSN 0013-9351, https://doi.org/10.1016/j.envres.2019.01.044.

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SESSION 3B

GROUND AND SURFACE WATER INTERACTIONS
(Moderator: Scott Schoefernacker, CAESER)
8:30 a.m. – 10:00 a.m.

A Multi-Scale Investigation of Surface Water-Groundwater Interactions Along the Loosahatchie River and Nonconnah Creek Using a Variety of Methodologies to Identify Aquitard Windows
Benjamin Ledesma

Determination of In-Situ Streambed Properties: Hydraulic Conductivity and Streambed Thickness, for the Loosahatchie River, Wolf River, and Nonconnah Creek
Paulina Reyes-Garcia

Unconfined Aquifer Modeling Practices in Shelby County, TN, Aquifer System
Joel Pierce

A MULTI-SCALE INVESTIGATION OF SURFACE WATER-GROUNDWATER INTERACTIONS ALONG THE LOOSAHATCHIE RIVER AND NONCONNAH CREEK USING A VARIETY OF METHODOLOGIES TO IDENTIFY AQUITARD WINDOWS

Benjamin Ledesma, Department of Civil Engineering, University of Memphis

Since the 1960s, more than 50 publications have pointed out the presence of hydrological windows in the upper confining unit to the Memphis aquifer, where water of lesser quality can migrate into the aquifer that supplies more than 95% of the water used in the Memphis area. Most of the previous works focused their efforts on age-dating analyses, groundwater modeling, developing water-table maps, and well-log analyses. In addition to these approaches, a few of them implemented surface water-groundwater (SW-GW) interaction techniques directly on streams. However, the main goals of these works were to estimate the SW-GW interactions in limited places to validate model results.

In this project, we aim to investigate the SW-GW interactions between the shallow alluvial aquifer and Nonconnah Creek and Loosahatchie River by applying various field-based methodologies at different spatial and temporal scales to identify new aquitard windows. Before attempting to find new windows proximal to these two river systems, an effort to ascertain a likely suite of methodologies and techniques to measure SW-GW interactions is being conducted first. Preliminary results indicate point-scale methods are valuable tools in determining SW-GW interactions; however, there is variability in instrumentation stabilization by method. Upcoming research will consider regional scale techniques like thermal imaging radar (TIR), discharge, and distributed temperature sensing with fiber-optic (FO-DTS).

DETERMINATION OF IN-SITU STREAMBED PROPERTIES: HYDRAULIC CONDUCTIVITY AND STREAMBED THICKNESS, FOR THE LOOSAHATCHIE RIVER, WOLF RIVER, AND NONCONNAH CREEK

Paulina Reyes-Garcia, Master's Degree Candidate, Department of Civil Engineering, University of Memphis

Two critical parameters in determining the water exchange between streams and their connected aquifer are the streambed hydraulic conductivity and thickness. Although most groundwater models consider a systematic relationship between groundwater and surface water, an inherent global lack of known measured values exists for streambed properties when modeling water resources in a specific region. Various numerical groundwater models have been developed for the Mid-South region; however, uniformly across these models there is the issue of there not being any *in situ* riverbed measures to provide good control on simulated groundwater-surface water interaction.

Several *in situ* slug tests in various locations were performed along the three major streams in Shelby County including the Loosahatchie River, Wolf River, and Nonconnah Creek. The goal was to determine the range of hydraulic conductivity values for the streambeds. Scour monitors were also installed to estimate the dimensions of the streambed dynamics; core samples were obtained to describe the sediment. Preliminary results for the Wolf River show a hydraulic conductivity range and mean of 210 m/d and 111 m/d, respectively. A maximum scouring depth of 39 cm is observed along the Loosahatchie River, whereas little scouring is evident within the Wolf River and Nonconnah Creek. Core samples indicate streambed heterogeniety and a possible depth at which the influence of the surface water becomes minimal.

UNCONFINED AQUIFER MODELING PRACTICES IN THE SHELBY COUNTY, TN AQUIFER SYSTEM

Joel Pierce

Numerical groundwater modelers often encounter challenges in the construction and optimization of regional unconfined aquifers in matching real-world water table saturated thicknesses and that address localized areas of drying/rewetting. A common conservative assumption in numerical modeling states that adding greater real-world detail does not correlate to more substantive model results. The proposed work, however, tests the hypothesis that by incorporating specific areas of greater hydrogeologic complexity into modeling regional sized unconfined aquifers, simulated heads will better match observed local conditions, especially in areas of water loss through aquitard windows and where dry cells are a natural condition of the system. To determine the level of benefit from increases of complexity in specific hydrologic and hydrogeologic processes, we use a series of conceptual models where each model focuses on different additives of complexity such as recharge, stream network bifurcation, and evapotranspiration. Model outcomes are compared against each other, against observed conditions of the shallow aquifer beneath Memphis, TN, and against a fully calibrated groundwater model of the aquifer systems beneath Shelby County, TN. Preliminary results indicate that an increase in stream detail better mimics observed water table undulations and that gradients toward aquitard windows minimize cell drying while allowing for appropriate gradients and flows toward the windows. These kinds of results in modeling the shallow aquifer vastly improve models such as that of Shelby County, TN, by conveying appropriate quantities of water through windows and by affording better contaminant transport modeling from the shallow aquifer to the deeper, semi-confined Memphis aquifer.

SESSION 3C

EDUCATION AND OUTREACH
(Moderator: Regan McGahen, TDEC, DWR)
8:30 a.m. – 10:00 a.m.

TN-GA 4-H Water Camp 2019
Lena Beth Reynolds

Gaining Ground for Healthy Waterways with Sustainable Residential Landscapes
Andrea Ludwig, Natalie Bumgarner, and Julie Berbiglia

Public Outreach for Water Resources
Thomas B. Lawrence

TN-GA 4-H WATER CAMP 2019

Lena Beth Reynolds

TN-GA 4-H Water Camp occurred in July 2019, based at Camp McCroy, in Polk County TN. This rustic camp in the Cherokee National Forest, alongside a mountain stream was a great site for a 3 day-2 night adventure.

A presentation at the National County Agents meeting put a group together, that made it happen. The power of Conferences and networking is real! In addition, a mention of the upcoming camp during a TN AWRA presentation in 2019 introduced another major player.

University Extension agents from 2 Tennessee counties and 2 Georgia counties, specialists and program assistants planned and conducted the camp, with educational workshops and tours. Plenty of time was planned for camp activities such as recreation, Water Wars, crafts, campfires, and making friends. 4-H members from Whitfield and Murray Counties in Georgia, as well as Polk and McMinn Counties in Tennessee enjoyed the event. The group toured the Ocoee Whitewater Center where the Olympics were held, Copper Basin Mine Museum, a municipal pool, and overlooks to view the watershed of Lake Ocoee. Researchers with the Southeastern Hellbender Initiative allowed a visit to their study site with snorkeling. The 4-H'ers were allowed to see a hellbender up close and gently touch it, then snorkeled to its home under a big rock as the researchers released it back to its habitat. Evaluations evidenced that 4-H members and adults loved the event & plan for camp in 2021!

GAINING GROUND FOR HEALTHY WATERWAYS WITH SUSTAINABLE RESIDENTIAL LANDSCAPES

Andrea Ludwig[1], Natalie Bumgarner[2], and Julie Berbiglia[3]

Thousands of miles of Tennessee streams are impaired by pollutants carried by runoff from the over three million acres of developed land in Tennessee. This challenge must be met with a solution as diffuse as the sources of pollution causing it. This means practices and actions across the landscape that collectively generate the needed protection of water resources. Residential land is a significant portion of these developed watersheds, so private property owners are a key stakeholder group in watershed management. Unmanaged runoff, disturbance in riparian areas, and the excess use of chemicals are just a few of the common threats to water quality and aquatic ecosystems posed by activities on residential lands. Modeled after successful programs in other southeastern states, the University of Tennessee Extension along with its partners are empowering residents with information to help them achieve and maintain a more ecologically-sound landscape. In the Tennessee Smart Yards program, residents learn from experts and choose a set of stewardship activities that makes sense for their circumstances. After reaching a level of adoption, then they certify their yard as a Tennessee Smart Yard. This program has a decade-long history in some Tennessee communities, but recently efforts have been taken to create a pathway to certification for any Tennessean from the comfort and safety of their own home and at their own pace. This presentation will provide an overview of the program and provide some metrics for success for communities interested in participating as a Smart Yard Community.

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PUBLIC OUTREACH FOR WATER RESOURCES

Thomas B. Lawrence[1]

The presentation will discuss how to get the best results for public outreach on water resources issues, particularly storm water pollution prevention. A variety of outreach methods will be discussed, including how to determine what sorts of public education materials are needed.

ABOUT THE SPEAKER

Thomas B. Lawrence, PE has been active in the field of environmental engineering for over 25 years, including work as a regulator, as a manager for a regulated entity complying with water quality permits, and as a consultant helping to protect and restore water quality. As a registered Professional Engineer in Tennessee, California and Illinois, he has led the investigation of water pollution issues and developed solutions to address the water quality concerns that are specifically tailored to the situation, ranging from public education to the design and implementation of mechanical remediation systems. He has worked with regulators throughout the country to negotiate permit conditions to ensure that water quality remediation and water pollution efforts can proceed in the most efficient and cost-effective manner. Mr. Lawrence is an excellent speaker and has spoken on water quality issues and project management at conferences throughout the country, including the California Stormwater Quality Association (CASQA) Annual Conference, the International Erosion Control (IECA) Annual Conference and the Tennessee Engineers' Conference. Additionally, he is particularly adept at explaining complex water quality issues to the general public, neighborhood groups and school children.

During his career, Mr. Lawrence has been the President of Tennessee Section of the American Society of Civil Engineers (ASCE), the Chair of the Tennessee Chapter of the Environmental and Water Resources Institute (EWRI), President of the Engineers' Club of Memphis, a member of the Tennessee Stormwater Association (TNSA) board, a member of the Memphis Area Geographic Information Council (MAGIC) board, and the President of the Memphis Chapter of the Tennessee Society of Professional Engineers. In 2013, Mr. Lawrence won the prestigious ASCE "Daniel B. Barge, Jr. Distinguished Service Award" for his contributions to ASCE and the engineering field.

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