Tennessee Water Resources Research Center
University of Tennessee

Annual Technical Report
2019

TNWRRC FY 2019 Annual Report

General Information

Products/Publications

1. 2013TN102B – Larsen, D., and Waldron, B., 2020, Low-level soluble chloride extraction in soil: MethodsX, v. 7, 100967, https://doi.org/10.1016/j.mex.2020.100967

2. 2013TN102B – Larsen, D., Bursi, J., Waldron, B., Schoefernacker, S., and Eason, J., 2020, Recharge pathways and rates for a sand aquifer beneath a loess-mantled landscape in a humid region: Journal of Hydrology, Regional Studies, v. 28, 100667, https://doi.org/10.1016/j.ejrh.2020.100667

3. 2019TN245B – Aghilinasrollahabadi, K. 2020. Investigate the contaminant fate and transport within stormwater. Master Thesis, Department of Civil Engineering, University of Memphis, Memphis, TN. pp. 127.

4. 2019TN245B – Salehi, M., Aghilinasrollahabadi, K., Salehi Esfandarani, M. (2020). An Investigation of Stormwater Quality Variation within an Industry Sector Using the Self-Reported Data Collected under Stormwater Monitoring Program. *Water,* 12(11), 3185

5. 2019TN245B – Salehi, M., Salehi Esfandarani, M. Evaluate the Industrial Facilities Stormwater Pollution Prevention Plan Using the Self-Reported Stormwater Quality Data, A Case Study in West Tennessee, USA. *In Preparation Manuscript*

6. 2019TN249B – Horn, S., L.D. McKay, H. Cyr, S. Driese, P. Perilla-Castillo, M. Boehm, M. Kerr, L. Tran, A 1000-year paleoflood record from the Tennessee River near Decatur, TN, Geological Society of America Annual Meeting, Indianapolis, IN, Nov. 4-7, 2018.

7. 2019TN249B – Perilla-Castillo, P., H. Cyr, S. Horn, L.D. McKay, Flood history from paleoflood deposits in cut bank solid profiles in Chickamauga Reservoir, Tennessee River, U.S.A., Geological Society of America Annual Meeting, Indianapolis, IN, Nov.4-7, 2018.

TNWRRC FY 2019 Information Transfer Program

The major emphasis of the information transfer program during the FY 2019 grant period focused on technical publication support, conference planning/development, and improvement in the information transfer network. The primary purpose of the program was to support the objectives of the technical research performed under the FY 2019 Water Resources Research Institute Program.

During the FY 2019 grant period, a major focus of the information transfer activities was on the participation of the Center staff in the planning and implementation of several statewide conferences and training workshops.

As an on-going sponsor, the TNWRRC was involved in the planning and implementation of the 28th Tennessee Water Resources Symposium, which was held on April 10-12, 2019 at Montgomery Bell State Park in Burns, Tennessee. The goals of the symposium are: (1) to provide a forum for practitioners, regulators, educators and researchers in water resources to exchange ideas and provide technology transfer activities, and (2) to encourage cooperation among the diverse range of water professionals in the state. As with previous symposia, the 28th Symposium was very successful with over 327 attendees and approximately 68 papers and 28 student posters being presented in the two-day period.

TNWRRC was a co-sponsor of the 2019 Tennessee Stormwater Association Annual Conference, "*Bridging the Gap*", held on November 19-21, 2019 at Montgomery Bell State Park. Over 242 attendees including MS4 communities, state and federal government agencies and engineering consulting companies from across the State participated in the three-day event. The opening keynote speaker was John Guider award winning photographer and author of *The River Inside*. The conference included over 58 presentations, a special Stormwater Utilities workshop and several social networking sessions.

TNWRRC FY 2019 Student Support

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	7				7
Masters	5				5
Ph.D.	2				2
Post-Doc.	0				0
Total	14				14

TNWRRC FY 2019: Notable Awards and Achievements

Dr. Jon Hathaway, Associate Professor, Department of Civil and Environmental Engineering, University of Tennessee, Knoxville was awarded Best Case Study, by the *Journal of Sustainable Water in the Built Environment.* Dr. Hathaway's paper, "Establishing a Framework for the Spatial Identification of Effective Impervious Areas in Gauged Basins: Review and Case Study, was co-authored with UT alumnus Thom Epps (PhD '18). The research was funded in part through **2014TN104B.**

Christos Giannopoulos, a Civil & Environmental Engineering doctoral candidate received the Excellent Scientists Award (ESA) for Best Paper as part of the Protection and Restoration of the Environment XV conference in Patras, Greece. His award-winning paper, "Hillslope geomorphologic and hyrdrodynamic dispersion: Implications for propagation and filtering of runoff signals" looks at soil erosion and sediment transport processes at the catchment scale, with a focus on catchment geomorphology and watershed dynamics in Intensively Managed Landscapes, such as those in the US Midwest and Southeast. His research is support in part through **2019TN248B.**

Understanding Effluent Movement In Clayey Soils When Using Subsurface Drip Dispersal To Apply Domestic Wastewater

Project Type: Annual Base Grant
Project ID: 2019TN244B

Project Impact:

Primary Findings/Impacts

Task 1 was installed at the Holston Unit of the East Tennessee Research and Education Center. Instead of installing three replications, a single system has been divided into five subplots. As described in the original work plan, drip tubing was placed in four sets of three laterals. Set #1 has tubing on a 2-foot spacing, #2 on a 3-foot spacing, #3 on a 4-foot spacing, and #4 on a 5-foot spacing. Each drip lateral is 50 feet long. Within each set, two soil moisture sensors (one at 8" and the other at 16") have been placed between the laterals. Two additional soil moisture sensors were placed outside of the experimental plot to monitor the background soil moisture content. Rainfall depth and intensity was measured with a tipping bucket rain gauge. The experimental drip field was dosed at 0.2 gallon per day per square foot (gpd/ft2) using potable water.

Preliminary results indicate that placing the drip laterals on two- and three-foot spacing will provide a uniform water application between the drip laterals. The four- and five-foot lateral spacing resulted in measurable soil moisture differences between the laterals. These results are still preliminary because the data collection was interrupted by the COVID-19 pandemic. The experimental infrastructure is still in place and the data collection will be continued during the spring 2021 using other funds.

Impact. The impact of this task is that regulators in the state of Tennessee can have greater comfort for allowing drip laterals to be placed on a three-foot center, instead of the proposed two-foot centers. On a per acre basis, the three-foot spacing accomplished the same treatment goals as the two-foot spacing, and requires 7,260 less feet of tubing resulting in a saving of more than $20,000 per acre.

Task 2. Task 2 was installed in Wilson County, Tennessee. Our cooperator, Wilson County Water and Wastewater Authority requested a delay the installation until the COVID-19 spread had slowed. The installation took place during September 2020. The experimental configuration was modified from the original work plan. A tight grid of drip emitters was constructed to uniformly apply water to a 36 ft2 surface area. This grid is 6-foot long, by 6-foot wide. It contains 6 drip laterals with a 12-inch emitter spacing. Soil moisture sensors were placed between the laterals (at depths of 4, 8, and 12 inches below the surface) to determine when the soil has become saturated – thus indicating that the water is being applied at a rate greater than percolation. The initial hydraulic loading rate was set at 2 gpd/ft2. Water application was operated by a microcontroller that dosed the system for five minutes, two times per hour. The microcontroller also collected the data from the soil moisture sensors and from a tipping bucket rain gage. A 275-gallon tote served as the water supply.

Data collection proceeded until the first frost and will begin again after the frost-free date in spring 2021. Preliminary results indicate that this soil can accept a hydraulic loading rate of 2 gpd/ft2 without causing ponding on the soil surface.

Impact. There are two impacts from this work. First, it demonstrates that a soil series that was thought to not have the hydraulic properties needed for secondary-treated wastewater application can indeed be utilized. For land with this soil type, the land value increased from poor pasture to land that can be developed into residential housing. The second impact is the development of a device that will improve the hydraulic evaluation of a soil for the land application of a secondary-treated wastewater. This device applies water over 36 square feet, which is much more indicative of hydraulic properties than a eight-inch diameter hole as prescribed in a standard percolation test.

Task 3. Task 3 was dropped from this project due to the COVID-19 pandemic. This task required travel and close-contact with our cooperators. Based on guidance from the U.S. CDC, it was decided to proceed with this task at a future data using an alternative funding source.

Investigate Industrial Facilities Storm Water Quality And SWPPP Performance

Project Type: Annual Base Grant
Project ID: 2019TN245B

Project Impact:

Storm runoff pollutants are among the major sources of surface water impairments in the U.S. Despite several monitoring programs and guidance on stormwater management practices, there are many streams still impaired by urban runoff. In West Tennessee, numerous streams and surface waters have been assessed as impaired by storm runoff. For instance, only in Shelby County, more than 90 streams with more than 700 miles of length are listed in the Tennessee 2018 final list of impaired water. Stormwater pollutants could originate from various sources in the urban environment, including residential and commercial landscapes, construction sites, roads and highways, parking lots, and industrial sites. The proportion of pollutants in urban stormwater that originated from industrial activities have been reported to be significant compared to the other sources. Despite a large number of stream impairments in West Tennessee, the industrial facilities' runoff constitutes, pollutants loading, and effectiveness of their management practices are poorly understood.

This study evaluated an industry sector's pollutant discharge characteristics using the self-reported data collected under Tennessee Multi Sector Permit program. As a part of the National Pollutant Discharge Elimination System (NPDES), TN Multi-Sector Stormwater Permit (TMSP), each industrial facility is required to collect the stormwater runoff samples, conduct the laboratory analysis to quantify the certain constituents in stormwater, and report the analytical results to the Tennessee Department of Environment and Conservation (TDEC), annually. Thus, the stormwater pollutant discharge characteristics were analyzed from 2014 to 2018 for an industry sector involving twelve facilities in West Tennessee, USA. The Principal Component Analysis (PCA) was applied to better understand the correlation between water quality parameters, their origins, and seasonal variations. The water quality indexes (WQI's) were calculated to evaluate the stormwater quality variations among studied facilities and seasons. Furthermore, the long-term stormwater quality variation in select two facilities was utilized as an indicator to assess the effectiveness of the implemented control measures over the five-year period.

The data analysis revealed organic and inorganic contaminant presence in stormwater samples collected at all twelve industrial facilities, with the most common metals being Magnesium, Copper, and Aluminum. The results demonstrated slight variations in stormwater WQI's among the studied facilities ranging from "Bad" to "Medium" quality The lowest seasonal average WQI was found for Spring compared to the other seasons. The control measures described in Stormwater Pollution Prevention Plans (SWPPPs) of two select facilities were mostly the employees' procedures or operational practices. They did not involve the structural best management practices (BMPs) or pollution control devices. At both studied facilities, total suspended solids (TSS), Magnesium, Copper, and Aluminum concentrations frequently exceeded the state regulatory agency benchmark levels. These pollutants were mostly originated from the fill materials storage area, where the silt, sand, and gravel were released to the drainage area. Evaluating the temporal variation of TSS concentration revealed a descending order starting from 2015 at both facilities. This could imply more effective stormwater management practices such as more frequent housekeeping to prevent the silt or sand release to the drainage area. Certain limitations associated with the self-reported data were identified to inform the decision makers regarding the required future changes. Using the self-reported stormwater quality data could introduce some uncertainties such as poor sampling or analysis practices. Although in this study, 9,363 data points were analyzed, there was a significant number of missing data (33.75%) that made the identification of specific trends difficult. Limited information regarding the type of industrial activities was reported in the Notice of Intent documents, which made significant challenges to identify the pollution sources.

The results of this study suggest that the efficiency of current industrial stormwater monitoring programs could be improved by providing more detailed stormwater sampling guidelines and more strict requirements for the water quality reports to generate a more accurate database for future decision makings and policy development. This research also highlights the importance of understanding stormwater quality data to encourage industry stakeholders to take serious steps toward the protection of their stormwater quality. Industrial facilities' operators are encouraged to understand their stormwater quality data, detect the pollutants of concerns and potential problems in contaminating the storm runoff, and implement the efficient BMPs. In addition, our findings will assist the state, and federal regulatory decision makers recognize the impacts of industrial activities on local creek and streams. It will allow the regulators to assess their progress toward managing the stormwater quality at industrial sites and protecting the watersheds to lower the pollutant discharge. The data could serve as the representative of industrial stormwater quality resulted from different types of activities to assist the regional, state, and local decision makers in protecting receiving waters effectively. Lack of information about the pollutants' types and their concentrations released to the stormwater by the specific type of industry makes it difficult for the regulatory agencies to identify the specific pollutants that should be monitored. So, this research will provide background data about the type and concentrations of the pollutants we expect from a specific type of industry. In addition, the research outcomes could be used in issuing future industrial stormwater permits. To verify that the control measures described in the SWPPPs are actually implemented, frequent site inspections are required. Implementation of nonstructural BMPs in industrial sites involves a high degree of uncertainty regarding their performance in reducing the pollutants loading. Very limited information is available to the industry stakeholders in respect to the effectiveness of nonstructural BMPs, thus many of them implement those without sufficient information on their effectiveness. A greater level of practical training should be provided by the regulatory agencies to stormwater managers on how to evaluate and monitor their nonstructural BMPs. The onsite operators at each facility should be informed regarding the applied stormwater management changes. The local regulatory agency can conduct annual surveys to evaluate the changes in the people's knowledge, attitude, and behavior toward the protection of stormwater quality. This survey in combination with the assessment of self-reported stormwater quality data, could be utilized as a valuable tool by the regulatory agency to assess the effectiveness of their enforcement and monitoring practices.

Harmful Algal Blooms In Critical Amphibian Habitats At Mammoth Cave National Park, Kentucky

Project Type: Annual Base Grant
Project ID: 2019TN246B

Project Impact:

Harmful algal blooms are a growing concern at Mammoth Cave (MACA) National Park, Kentucky, because of the danger they pose to the tourists and sensitive ecosystems. MACA has ~650,000 annual visitors and was designated a Biosphere Reserve in 1990 because of the outstanding ecosystems on the surface and subsurface. It is home to over 70 threatened, endangered or State listed species (MACA NPS, 2014, 2017) and has declining amphibian populations. There is concern that cyanotoxins may be exacerbating pathogens such as chytrid fungus and renavirus. In December 2017, January and April of 2018, the USGS, in partnership with MACA and Tennessee State University, ran preliminary tests for the cyanotoxins microcystin and saxitoxin, and genetic tests for cyanobacterial presence in surface and cave waters. Microcystins were detected in surface waters and cave lampenflora at concentrations greater than 0.3 µg/L, the EPA advisory level for microcystin, and, established that cyanobacteria capable of producing cyanotoxin are present in cave and surface waters. These preliminary results validate concerns that harmful algal blooms are a danger to MACA's ecosystems and tourists.

The goal of this proposed research is to better understand the distribution and occurrence of cyanobacteria and toxins in critical amphibian habitats, such as the vernal ponds and illuminated cave passages of Mammoth Cave National Park. A census of the amphibians that use the ponds for breeding will be conducted to establish a connection between water chemistry and amphibian use. This information will help resource managers better predict, manage, and mitigate the occurrence of harmful algal blooms. A total of 100 environmental samples will be collected at four amphibian ponds, two Green River sites and six cave locations with lampenflora. Those samples will be analyzed for field parameters, nutrients, cyanotoxins, community structure, and cyanobacteria by molecular methods (Rinta-Kanto et al, 2005; Graham et al, 2008). Depending on the molecular assay, either TaqMan Universal PCR Master Mix or SYBR Green PCR Master Mix (Applied Biosystems, Foster City, Calif.) will be used as described in Stelzer et al, (2013). In addition to distribution and occurrence, this research will provide data on the timing and conditions that lead to bloom development, the production of microcystin toxin, and the effects on amphibians.

Why this Study is Important: The Green River flows through the park and is considered the fourth most biologically diverse river system in the United States (Kentucky Waterways Alliance, 2018). The surface ponds and river of MACA also support much of the Park's fauna, including 11 endangered mussel species, many amphibians listed as threatened or endangered by States, and rare, threatened or endangered troglobites in cave waters. The surface and subsurface karst waters of MACA have been designated critical habitat for these sensitive species. Previous studies have attributed declining amphibian populations to single problems, such as chytrid fungus, renavirus, or hydrologic modifications. Recent studies at other locations found that aquatic ecosystems are complex and that

HABs are one of multiple stressors that make a species more susceptible to parasites or pathogens (Budria, 2017; Tellenbach et al., 2016).

In addition to the biologically diverse Green River, there are 33 woodland ponds that provide critical habitats for amphibians, insects for bats and scenic hiking trails for tourists. Sensitive amphibian species that are listed as rare, threatened or endangered in several States use these ponds for breeding and larval development (MACA NPS 2017). Renavirus and chytrid fungus (Batrachochytrium dendrobatidis) have been confirmed in several park ponds and are thought to contribute to the declining amphibian population. However, focusing on a single causal agent for the declining amphibian population does not address the complexity of ecological communities or the additional stress added by HABs. The causes for amphibian population declines are complex and may differ among species, populations, and life stages within a population; and are context dependent with multiple stressors interacting to drive declines (Blaustein et al., 2011; Oberemm et al., 1999; Milotic et al., 2017). A review of 15years of satellite imagery provided evidence of algal blooms in one of the main amphibian habitats (Sloan's Pond) during prime reproduction season in April and May. The role of HABs in the amphibian population decline has not been addressed.

Significance to TN Water Resources: While the Green River is not in Tennessee, the proximity to TSU, the temperate climate, geohydrology and karst landscape are similar to middle Tennessee, and similar biological diversity (including threatened and endangered species) make it an ideal research site. Also, the ongoing research collaboration between TSU, USGS and MACA National Park Service adds depth and is mutually beneficial to each other's projects. TSU will be generating much of their own data, but also leveraging the data provided by the USGS-NPS Water Quality Program, to make this project more meaningful. Likewise, this TSU project will provide added benefits and insight to the USGS-NPS project, making it a mutually beneficial project for all. The USGS-NPS will be generating data on the hydrology and chemistry of the water. TSU's activities will increase the sampling through time and geospatial area. This research will provide information about the biological and ecological repercussions of the hydrology and chemistry. The results and techniques developed for this project are transferable to Tennessee waterways.

Real-time Adaptive Detention Control Network: An Application In The Conner Creek Catchment

Project Type: Annual Base Grant
Project ID: 2019TN247B

Project Impact:

Objective: The objective of this research is twofold; (1) to implement a real-time network of sensors and smart adaptive control systems (ACS) on detention ponds to optimize their urban stormwater mitigation function, and (2) to monitor the hydrologic and geomorphic implications for the receiving waterbody, Conner Creek. A network of adaptive detention controls in a watershed presents a novel approach for stormwater management and streambank erosional control by controlling and mitigating for extreme flow or channel forming events. Each ACS will accomplish this by receiving external rainfall prediction data from the National Weather Service, processing these data to determine what, if any action, should be taken, and control the outlet of the system though an externally controlled valve. For instance, it may be desirable to draw down the water level in a pond to make room for runoff that is anticipated from an incoming storm event. The ACS will be informed by a detailed SWMM model of the system allowing extensive testing and scenario building.

Introduction: Current stormwater detention practices lack the ability to adapt to changing conditions. This presents a significant performance challenge for these practices, as many watersheds are rapidly urbanizing or are subjected to a higher frequency of extreme storm events. By outfitting the outlet structures of detention ponds with relatively low-cost sensors and controls, this once static practice is redesigned as an adaptive system (Kerkez et al., 2016). This essentially moves static urban stormwater infrastructure toward a more managed system more common to entities such as the Tennessee Valley Authority. To truly understand the benefits of this technology, there is a significant need to quantify the effects of a real-time network ACS's in terms of runoff reduction and streambank erosion and protection.

Methods: This study will utilize currently constructed detention ponds and outlet structures within the Conner Creek catchment, specifically those which detain runoff from Hardin Valley High School and Middle School along the reach of Conner Creek between Brooke Willow Blvd and Steele Rd. Four detention ponds exist between these two sites and each will be outfitted with custom ACS's. Each ACS will be equipped with a cellular IoT (Internet-of-Things) control board to manage the system and transmit data, an electric butterfly valve to control the outlet of the detention pond, an ultrasonic sensor to collect water level readings, and a battery/solar panel combination to provide power to the system.

Our team will develop stage-volume relationships for each detention pond in addition to SWMM models to understand precipitation-runoff relationships. This will allow algorithms to be developed for each individual ACS to allow them to estimate how much drawdown must occur in the detention pond to detain a given projected storm event. When this drawdown occurs, each ACS will communicate with others on the network to determine if the combined discharge from each detention pond will be excessive enough to cause streambank erosion along Conner Creek and will adjust itself to stay below these combined discharge values. At the onset of the study, extensive geomorphic surveys of Connor Creek will be performed to understand erosion potential and establish flow thresholds.

To determine the influence the ACS's have on the hydrologic regime and erosion within the reach, the inlet and outlet of the reach will be outfitted with monitoring equipment. This equipment will consist of a cellular IoT control board using an ultrasonic sensor to monitor stage and discharge via a stage-discharge relationship that will be developed for each monitored location. The monitoring equipment at the inlet and outlet will be allowed to collect data for two 3 months before the ACS's are installed to develop a hydrologic baseline which post-ACS flow regimes in the stream can be compared. Significance to Tennessee Water Resources: Urbanized watersheds more quickly transmit runoff at higher volumes and with higher peaks than natural systems. In addition, extreme rainfall events are occurring at an increased rate, resulting in a higher frequency of flash flooding and high flow events within stream channels. These high flow events increase the stress induced on the streambank channel, and in most cases, begin to erode the streambank. If the runoff from these urbanized watersheds is reduced or completely detained the likelihood that extreme rainfall events will result in streambank erosion significantly decreases. Real-time adaptive control systems would allow detention ponds to be modified such that mitigation of runoff from the urbanized landscape of the watershed can be optimized.

This research is highly significant for Tennessee. With adaptive control systems detaining all or the majority of runoff generated in a watershed, transported sediment is intercepted before it can reach the receiving waterbody. This is a major ecological benefit to receiving waterbodies as sedimentation is the second highest cause of degradation in rivers and streams in Tennessee with over 6,000 miles threatened or impaired (USEPA, 2016). This study will set the stage for other adaptive controls to be implemented within Tennessee watersheds, and allow a building block towards subsequent studies that will improve on the design and implementation of these systems.

From The Plot To The Catchment Scale: Towards The Next Generation Of Hydrodynamics - Sediment Transport Models

Project Type: Annual Base Grant
Project ID: 2019TN248B

Project Impact:

The overarching goal of my research is to assess the movement of mobilized soil from where it is eroded in agricultural fields through the drainage network of the watershed under a non- stationary climate and different management regimes. This information is needed to understand better the short- and long-term resilience of intensively managed agroecosystems under such variable conditions. Intensively managed agroecosystems have constantly changing land cover that varies in space and time due to extensive anthropogenic activities and weather dynamics.

This goal is met with the development of a state-of-the-art physically-based modeling tool for simulating transport of water and sediment from the plot to the catchment scale, and applicable to event temporal scales. The tool is necessary for accurate design, monitoring, and assessment of edge-of-the-field Best Management Practices (BMPs) to mitigate on-site and off-site impacts of anthropogenic activities.One of the biggest concerns of existing models is that they do not represent well the underlying processes at the floodplain-gully domain, which is the interface between the uplands and the stream and is responsible for amplification or suppression of upland-stream connectivity (Bennett and Wells, 2018). This domain is complex and characterized by topographic discontinuities due to abrupt changes in slope gradient. The shortcoming of existing models is attributed to three key factors: (a) the main focus of past research has been on interrill and rill erosion, though field evidence suggests that interrill and rill erosion alone are not reliable indicators of catchment scale erosion (Poesen et al., 2003); (b) high-resolution, spatially- distributed topographic data have previously been difficult and laborious to obtain, particularly for the floodplain-gully domain (Belmont, 2011; Stout and Belmont, 2014); (c) a framework for delineating the floodplain-gully domain and dynamically resolving the governing processes is lacking.

A next-generation transport model that can resolve the hydrodynamics and sediment transport moving from the plot to the catchment scale. My approach includes the use of an enhanced version of the Water Erosion Prediction Project (WEPP), (Papanicolaou et al., 2018) to resolve interrill/rill erosion processes. Gully erosion processes will be resolved by first determining the gully initiation location and then resolving the advective and diffusive headcut retreat (Bressan et al., 2014), gully bank failure due to fluvial and mass failure (Papanicolaou et al., 2017), as well as bed incision due to excess bed shear stress (Papanicolaou et al., 2010). Finally, the hydrodynamics and sediment transport within the stream are resolved with the 3ST1D model, developed by Papanicolaou et al. (2004).

Validation of the model is needed at each spatial scale, where th erosional/depositional processes change, i.e., new sources/sinks are introduced. In the Clear Creek Watershed, IA, which is an intensively managed landscape where my research has been focused, I have so far obtained runoff, sediment, and enrichment ratio data at the plot scale for interrill/rill erosion by conducting rainfall simulator experiments, as well as flow discharge and sediment transport data in the stream domain using dye tracing techniques, sediment autosamplers and turbidity sensors. However, measurements that remain outstanding are high-resolution topography data and water/sediment measurements at the floodplain-gully domain.

Agriculture is very important for the state of Tennessee, as nearly 44% of its area is covered by farmlands. The anticipated high demands in the state for clean water combined with heavy storm events arising from climate non-stationarity can lead to excessive erosion rates, as well as soil and water quality degradation (Ghaneeizad et al., 2018). To keep sediment out of local stream and limit the development of gullies, edge-of-field BMPs are commonly used. Currently, the most common practice is the establishment of grassed waterways at the flow concentration and erosion-prone zones of a field, in order to increase the soil's erosional resistance and retard runoff. Additionally, check dams with drop structures are often utilized to dissipate flow energy and inhibit gully incision and widening. No-till management practices and topsoil compaction have been also shown to promote topsoil resistance to incision.

The research can provide the tools to assess the relative effectiveness of BMPs regarding on-site and off-site impacts of anthropogenic activities. The hydrodynamics and sediment transport model can be utilized as a decision-making tool to inform water management, by replacing current models with limited reliability and applicability (e.g., empirically-based models). The advantage of the model is that it is physically-based, with very few empirical parameters, thus it can be readily applied to any agroecosystem. It will also help advance the US Geological Survey's national mission for increasing knowledge of water quality and quantity.

Flood History From Paleoflood Deposits In Cut Bank Soil Profiles In Chickamaugua Reservoir, Tennessee River

Project Type: Annual Base Grant
Project ID: 2019TN249B

Project Impact:

This project studies floodplain deposits that are composed of paleoflood (PF) sediments interbedded with buried soil horizons in the Chickamauga Reservoir (CR). The CR is located on the Tennessee River, north of Chattanooga. Each flood layer represents an extreme flood that was recorded and preserved in the geological archive of the floodplains of the river and each buried soil represents a period of stability in between floods. Relevant information about past environmental conditions can be investigated from the buried soils [10]. Flood layers are repositories for information on PFs from extreme events. The research sites are six cut banks along the CR where soil profiles were selected, studied, and sampled during Summer 2018. Using a multi-proxy approach, the main goal of the project is to evaluate the presence and preservation of PF deposits and gather information on extreme floods that can fill in the gaps of existing knowledge of flood frequency and magnitude information for the Tennessee River.

The objectives of the portion of the study described in this proposal are to evaluate the presence, preservation and frequency of PF deposits in floodplains of the Tennessee River in the upper portion of the CR. My goal with this funding request is to obtain funds for radiocarbon dating that will allow me to fill the gap of knowledge of extreme flood events over the past several thousand years in the Tennessee River, and thus help improve hydrologic engineering, dam safety risk, and nuclear infrastructure safety. I hypothesize that the major flood events preserved at the six soil profiles can be distinguished and correlated between profiles. Correlation will allow for a better understanding of the flood history of the Tennessee River in different locations as well as flood frequency knowledge.

Soil profiles were developed for about a dozen cut bank locations along the river in summer and early fall of 2018. Six of the sites showed clear evidence of the presence of PF sediments, mainly as alternating layers of granular sediments overlying gray paleosols that developed between flood events. Description of the soil profiles was done in the field, describing for each layer of the profile characteristics such as consistency, grain size, soil color, structure, and contacts between layers. Samples for each horizon were collected in Ziploc bags for laboratory analyses that include charcoal sampling, particle size analysis (PSA), X-ray fluorescence (XRF), organic matter content (OMC), and magnetic susceptibility (MS). Oriented soil samples were collected from major horizons or unclear contacts between units for micromorphological analysis of thin-sections prepared by a commercial laboratory. Dating of the sediments has been done by picking out pieces of wood charcoal from the sediment and performing Accelerator Mass Spectrometry (AMS) 14C dating. PSA distribution is an important proxy for identifying and determining deposits [1]. As well, important correlations have been observed between particle-size of suspended sediment and flood discharge [2]. PSA is being done in the Archeological Research Laboratory using the Malvern Particle Size Analyzer Mastersizer 3000. XRF will be done using the portable Thermo Scientific XRF (pXRF) Niton XL5 Analyzer. Geochemical characterization of the sediments using pXRF will potentially identify geochemical signatures that could help correlate extreme flood events. OMC will be determined by loss on ignition [11]. Loss on ignition provides an estimate of the amount of organic matter present in the horizons and is an additional way to correlate events in the studied profiles. MS can be used to reconstruct the paleoenvironmental evolution and erosional history of floodplain profiles [12]. Magnetic susceptibility will be measured using Bartington MS3 meter interfaced with an MS2E or MS2G sensor.

Floods can cause major economic losses and greatly impact our society [1]. In recent years, floods have done great damage, causing billion-dollar losses and affecting millions of people. Paleoflood studies are important for understanding floods and river changes [5]. The study of paleofloods can help in predicting future flooding events and their frequency [2]. Detailed historical records documented in the US go back to the past 150 years, and before that age the history of floods in many rivers is unclear. Flood-derived sediment layers offer tangible data on the occurrence and magnitude of large and infrequent floods over time periods from the present to thousands of years ago [2] [13]. In many cases, extreme floods destroy the monitoring equipment, so floods are determined by the extent of flood deposits [7].

The Tennessee River has 164 gauging stations located along the main stem and its tributaries, most of which have operated for less than 100 years. The gauging stations record surface water data such as stream flow (discharge) and gage height (stage). Paleoflood studies in southeastern United States have the potential to extend the flood record for many rivers. However, most research on paleofloods has focused on rivers in the arid western US, so there is need for testing these methods in the southeast.

Hydrologic engineering projects, dam safety risk analyses, modification of critical infrastructure, and even nuclear power plants rely on flood studies to estimate potential extreme floods and AEPs [4]. Determining flood risk for nuclear power plants is especially important because they are always situated near bodies of water and have high consequences of failure [14] [15]. Flooding is one of the major threats to nuclear plants. Along the course of the Tennessee River, three nuclear plants operate, the Browns Ferry Plant near Athens (AL), Sequoyah Plant near Soddy-Daisy, and Watts Bar Plant near Spring City (TN). These plants power about 4.5 million homes and businesses in the Tennessee Valley [14]. Water management in dams is very important in Tennessee as well. According to Tennessee Valley Authority (TVA), the city of Chattanooga had one of the most serious problems of flooding in the nation, until TVA built the Chickamauga dam and other dams upstream [9].

Paleoflood hydrology can provide important information that can be used in risk assessment in engineering projects. Most importantly, paleoflood data can provide upper limits of largest floods that have occurred in the Tennessee River basin over long time spans [16]. Using soil profiles from floodplains with paleoflood and paleosoil deposits, we can help in filling in the history of floods from thousands of years ago for the Tennessee River. It can also allow to foresee what could be the impacts if the nuclear plants were to be affected by a flood event of large magnitude.wered b