# Institute for a Secure & Sustainable Environment

# 2021-2022 Annual Report to THEC

# ISSE Mission Statement

The University of Tennessee's Institute for a Secure and Sustainable Environment (ISSE) seeks to promote the development of policies, technologies, and educational programs that cut across multiple disciplines, engage the university's research faculty and staff, and grow in response to pressing environmental and security issues facing the state, the nation, and the globe.

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## Contact ISSE

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# Message from the Director

As recent challenges begin to subside, ISSE has continued to grow during 2021-2022. ISSE is conducting and funding research while furthering the university's mission of education and outreach through the products of our research, via community engagement, collaborations, publications, and presentations. This Annual Report will highlight a number of our accomplishments during this time.

ISSE has six areas of research: clean energy and energy efficiency, climate change, regional sustainability, water research, building environment, and sustainable food systems. Each ISSE program has conducted significant research: water resources through US Geological Survey projects; methane hydrates and global soil moisture datasets; adoption of electric vehicles in the state and across the nation; ways to reduce food loss and waste; monitoring indoor environment for health and energy conservation, and trends in Appalachian tourism and diversity.

A critical aspect of our research revolves around engaging students in the kind of educational research experiences that will further their careers. Eighteen ISSE research staff and affiliated faculty members guide 70 students–both graduate and undergraduate—in projects involving ISSE's research areas. In particular, Dr. Jon Hathaway (CEE) obtained NSF funding for The Green Infrastructure for Sustainable Urban Environments Research Experience for Undergraduates (REU). This 10-week summer program exposed 10 undergraduate students to Green Infrastructure research. Green Infrastructure is a unique way to restore and improve urban infrastructure. The first class of REU participants wrapped up in August 2022, and the next class will begin in May 2023.

Through the Appalachian Leadership Institute, the Appalachian Teaching Project, the Appalachian Community Technical Assistance and Training Program, NSF Sustainable Regional Systems grants, and others, ISSE outreach is growing with new and expanded programs that support local economic and environmental sustainability. Among our state, regional, and national collaborators are Tennessee Valley Authority (TVA), Tennessee Department of Environment and Conservation (TDEC), Appalachian Regional Commission (ARC), and the National Park Service (NPS).

ISSE's First Annual Research Conference was held on September 15, 2022. It was an auspicious start to an annual event that is sure to grow in scope and influence. Following an overview of ISSE's history and current work, researchers presented their latest projects, and state and community leaders in sustainability gave updates on their initiatives. In addition, there was a student poster competition.

While we are proud of the work we do, we recognize that such work can only be realized through the vision and steady efforts of our staff and those with whom we collaborate, particularly the Tickle College of Engineering. We are beholden to you all. I hope you enjoy reading about our past year!

*Dr. Mingzhou Jin, ISSE Director*

# Executive Summary

During 2021-2022, ISSE continued to expand its research and outreach, and this report describes the activities carried out by ISSE staff, students, and ISSE-affiliated faculty.

ISSE has a robust internal operation with 10 support staff, 11 research staff, and four research faculty members as well as several visiting scholars. Our 18 affiliated faculty members represent the departments of Ecology & Evolutionary Biology, Biosystems Engineering & Soil Science, Sociology, Economics, the Baker Center for Public Policy, Civil & Environmental Engineering, and Industrial & Systems Engineering; our advisory board members come from UTK, UTIA, ORNL, TVA, TDEC, and the City of Knoxville.

ISSE principal investigators are currently leading 22 active, sponsored projects for ISSE, and there are 17 individual agencies funding these projects. ISSE also has nine funded seed grant projects in progress. ISSE research projects have engaged more than 50 UT faculty members, two post-doctoral associates, and many graduate and undergraduate students.

ISSE awarded four new seed projects in FY21. These projects, which have been underway for four months, support research related to chemical levels in Tennessee surface water ecosystems, novel pathways for bacterial degradation, utilization of waste plastics, and micromobility vehicle second-life battery applications.

ISSE's external funding sponsors include US Geological Survey, US Department of Energy, UT-Battelle & Oak Ridge National Laboratory, National Science Foundation, Appalachian Regional Commission, Environmental Protection Agency, and several others.

Besides a healthy list of conference presentations and publications—most in peer-reviewed journals—ISSE's work has received extensive media coverage, transferred knowledge and information through a variety of programs and activities, created and shared large datasets, and fostered international exchanges. Many ISSE faculty have been recognized by their peers with honors and awards.

ISSE provides an important platform for interdisciplinary research to promote environmental sustainability. The Healthy Environment team led by Dr. Qiang He won the 2021 UTK Success in Multidisciplinary Research award. The team integrates expertise in environmental engineering, health, infrastructure, human factors, automation, systems engineering, and data science to attack complex health problems in a systematic way. Besides Dr. He, the team includes ISSE affiliates Shuai Li and Mingzhou Jin and five other researchers from the Tickle College of Engineering, College of Arts & Sciences, College of Nursing, and the UT Institute of Agriculture.

ISSE has increased its training and education programs with new courses and an expanding base of participants across the state. While ISSE's efforts in outreach and collaboration reached into many sectors within our state and region, East Tennessee Clean Fuels has built strong connections throughout the region with its development of the Southeastern Corridor Council, Drive Electric Tennessee, DRIVE Electric USA, the EMPOWER program, and the EPA Clean School Bus Program. Coalition staff from 10 states and 25 state DOTs are sharing ideas to address several different types of alt-fuel signage and filling in gaps in alt-fuel corridors.

# ISSE Centers & Programs

## FEWSUS International Research Coordination Network

FEWSUS stands for International Research Coordination Network to Create Transdisciplinary Nodes of Food-Energy-Water to Support Sustainable Urban Systems. FEWSUS is funded by the US National Science Foundation. The grant, awarded to faculty and scientists at the University of Tennessee and Oak Ridge National Laboratory, supports the development of an International Research Coordination Network, designed to facilitate transdisciplinary, multinational communications and accelerate the development and transfer of multisectoral data, standards, analysis tools, new technologies, and a trained workforce among differently urbanized countries.

## Tennessee Water Resources Research Center (TNWRRC)

TNWRRC is a federally designated state research institute supported in part by the US Geological Survey. The center was established following enactment of the Water Resources Research Act of 1964. TNWRRC partners with the state of Tennessee as a primary resource to develop and implement programs that can achieve sustainable quantities of quality water in Tennessee and the nation. Dr. John S. Schwartz directs TNWRRC and is a professor in Civil & Environmental Engineering.

## East Tennessee Clean Fuels (ETCF)

ETCF works to increase the use of cleaner American fuels and vehicles and energy saving transportation technologies to improve air quality and health, curb dependence on imported petroleum, and support Tennessee's economy. Its mission is to implement alternative fuel projects in East Tennessee and to make ETCF a sustainable coalition of involved participants from across East Tennessee. ETCF is a 501(c)3 under the umbrella of Transportation Energy Partners. Mr. Jonathan Overly is the Executive Director and Coordinator.

## Drive ElectricTN (DET)

DET promotes the adoption of electric vehicles for fleets and individuals across Tennessee with a goal of getting 200,000 EVs on TN's roads by 2028. An autonomous program of TNCleanFuels, DriveElectricTN is supported by 60+ stakeholders from across Tennessee and the United States, with focus areas such as EV Awareness, EV Policies & Program, and EV Infrastructure intended to achieve precise, targeted development goals for electric vehicles in our state.

## Methane Center

The Methane Center integrates science, engineering, and business models to create a broad conceptual understanding of CH4 (methane) as a driver of ecosystem processes and services. Center researchers use this understanding to create a lifecycle assessment framework for environmentally sustainable generation, management, and utilization of CH4. The center's mission is to provide fundamental and technological research advances and training in CH4 environmental science. The aim is to produce young engineers and scientists who are dedicated to effective communication of scientific findings to inform and stimulate the public and provide structured rationale for economic and environmental policy decisions and regulations. Dr. Terry Hazen directs the Methane Center.

## Appalachian Leadership Institute (ALI)

ISSE partnered with ARC to launch this program focused on the unique challenges and solutions around Appalachia's economic development. ALI trains community leaders who live and work in the region through skill-building seminars, best-practice reviews, and field visits across the 13 states that make up the Appalachian region. The goal is to create leaders who can help the region adapt to these changes and use opportunities to create thriving, equitable, and sustainable communities. Dr. Timothy Ezzell is the PI for this program and a Research Professor in Political Science.

## Climate Change Initiative

Climate change is one of the most critical challenges faced by humans and our planet. Researchers at ISSE, working closely with the Climate Change Science Institute at Oak Ridge National Lab, are advancing our understanding of climate change and its impacts on human and natural systems. We use Earth system modeling, integrated ground and remote sensing observations, and advanced data analytical tools to study climate change and its effects on water availability, soil moisture, wildfires, and vegetation. Team members are Drs. Yaoping Yao, Yulong Zhang, Jiafu Mao, Joshua Fu, Mingzhou Jin.

## Worker Health and Safety Training at Department of Energy Facilities

DOE Worker Training was developed to protect and inform DOE communities and their workers by delivering quality and flexible safety and health training to target populations of hazardous waste workers and emergency responders. Its mission is to prevent work-related harm by training workers to protect themselves and their communities from exposure during hazardous waste operations and transportation, environmental restoration at nuclear weapons facilities, or chemical emergency responses. Dr. Sheila Webster (retired) is the principal investigator.

# Sponsored Research

| Faculty/PI | Project Title | Sponsor | Co-PI | Duration |
|---|---|---|---|---|
| Khalid Ahmed Alshibli | 3D dynamic evolution of pore water-air interaction within saturated sheared sand | National Science Foundation | | 7/15/2020 - 6/30/2023 |
| Timothy Ezzell | Increasing Economic and Entrepreneurial Opportunities by Promoting Outdoor Recreation Among Underrepresented Visitor Groups | East Tennessee State University | | 08/15/2019 - 06/30/2023 |
| Timothy Ezzell | ASPIRE: Appalachian Students Promoting the Integration of Research in Education | National Science Foundation | | 9/5/2016 - 8/31/2023 |
| Timothy Ezzell | Appalachian Leadership Institute | US - ARC - Appalachian Regional Commission | Katie Cahill, Catherine Wilt | 2/6/2019 - 7/31/2023 |
| Jon Hathaway | Wetland Restoration with RSC's | US-EPA-US Environmental Protection Agency | John Schwartz | 10/1/19 - 6/30/2023 |
| Jon Hathaway | REU Site: Green Infrastructure for Sustainable Urban Environments | National Science Foundation | | 10/1/2021 - 9/30/2024 |
| Jon Hathaway | Collaborative Research: Reimagining Urban Watershed Management: A Systems Approach to Stormwater Control and Ecological Rehabilitation | National Science Foundation | Anahita Khojandi, Michael Blum | 8/1/2022 - 7/31/2025 |
| Qiang He | AOP for wastewater treatment from the oil/gas industry | Aramco | | 3/9/2022 - 3/8/2024 |
| Mingzhou Jin | Anyalysis for Regional and Global Land Ecosystem Modeling | DOE - ORNL - UT-Battelle - Oak Ridge National Laboratory | | 8/1/2020 - 12/31/2022 |
| Mingzhou Jin | Smart Manufacturing | DOE - ORNL - UT-Battelle - Oak Ridge National Laboratory | | 11/10/2020 - 11/9/2022 |
| Mingzhou Jin | US Food, Loss, and Waste and Its Relationship with Energy consumption and Carbon Emissions | DOE - ORNL - UT-Battelle - Oak Ridge National Laboratory | | 5/27/2022 - 5/31/2023 |
| Mingzhou Jin | East Tennessee Clean Fuels Initiative | East Tennessee Clean Fuels Coalition | | 7/1/2011 - 6/30/2023 |
| Mingzhou Jin | INFEWS: U.S.-China: Coupled FEWS Modeling for Sustainability of the Global Crop Supply Chain with a Focus on China - US Interactions | US - NSF - National Science Foundation | | 7/1/2019 - 6/30/2023 |
| Mingzhou Jin | SRS RN: People-Centric Integrated Assessment Model for Regional Sustainability (PIAMRS): Focusing on the Central Appalachian Region | National Science Foundation | Timothy Ezzell, Yulong Zhang, Lisa Zottarelli, Thankam Sunil, Wendy Tate, Paul Armsworth, Liem Tran | 1/1/2022 - 12/31/2022 |
| Jonathan Overly | TDOT I-40 Alternative Fuels Continuation | TDOT through CTR | Yulong Zhang | 7/1/2021 - 9/30/2022 |
| John Schwartz | Improving the GRSMs understanding of its natural resources and processes and thereby enhancing protection of the Park's resources | DOI - NPS - National Park Service - Great Smoky Mountains National Park | | 6/18/2014 - 6/29/2023 |
| John Schwartz | FY2021 and FY2022 Water Resources Program Year 1 | DOI - USGS - US Geological Survey | Jon Hathaway, Yaoping Wang, Timothy Gangaware | 9/1/2021 - 4/30/2023 |
| John Schwartz | FY2022 and FY2023 Water Resources Program Year 2 | DOI - USGS - US Geological Survey | Timothy Gangaware | 9/1/2021 - 8/31/2023 |
| John Schwartz | Increasing water treatment resiliency by using natural flood records to reduce the uncertainty of water hazard predictions under changing climate-University of Alabama | DOI - USGS - US Geological Survey | Timothy Gangaware | 12/15/2021 - 12/14/2023 |
| John Schwartz | TN Stream Quantification Tool Training | TDEC | | 5/1/2020 - 4/30/2023 |

| Faculty/PI | Project Title | Sponsor | Co-PI | Duration |
| --- | --- | --- | --- | --- |
| John Schwartz | Urban Waters Report Card | Metro Gov Nashville | Timothy Gangaware | 3/1/2021 - 12/31/2023 |
| John Schwartz | Urban Waters Report Card | City of Memphis | Timothy Gangaware | 3/7/2022 - 6/30/2023 |
| John Schwartz | Urban Waters Report Card | Hamilton County Government | Timothy Gangaware | 4/1/2022 - 11/30/2023 |
| John Schwartz | Appalachian Community Technical Assistance and Training (ACTAT) Program | West Virginia University (WVU) | | 10/1/2018 - 9/30/2023 |
| Sheila Webster | Worker Training at DOE facilities | National Partnership for Environmental Technology Education | | 9/1/2020 - 7/31/2023 |
| Hongyu, Zhou | Utilizing coal-derived solid carbon materials towards next-generation smart and multifunction pavements | DOE - NETL- National Energy Technology Lab | Baoshan Huang, Wei Hu | 1/5/2021 - 9/30/2023 |

## Completed

| Faculty/PI | Project Title | Sponsor | Co-PI | Duration (start/stop dates) |
| --- | --- | --- | --- | --- |
| Timothy Ezzell | Trends and Strategies for Tourism in Appalachia | US - ARC - Appalachian Regional Commission | Jui-Chi Chen, Catherine Wilt | 10/1/2017 - 8/31/2020 |
| Timothy Ezzell | PIPES: Possibilities in Postsecondary Education and Science among Rural Appalachian Youth | National Institute of Health | | 5/13/2015 - 8/4/2020 |
| Yaoping Wang | Data Analytics Support for Integrated Earth Model | DOE - ORNL - UT-Battelle - Oak Ridge National Laboratory | Mingzhou Jin | 3/6/2019 - 3/1/2022 |
| John Schwartz | FY2019 Water Resources Program Year 4 | DOI - USGS - US Geological Survey | Timothy Gangaware | 6/18/2019 - 12/31/2020 |
| John Schwartz | FY2020 and FY2021 Water Resources Program Year 5 | DOI - USGS - US Geological Survey | Timothy Gangaware | 3/1/2020 - 12/31/2021 |
| John Schwartz | Urban Waters Report Card | Shelby County | | 9/1/2021 - 6/30/2022 |
| Mingzhou Jin | Supporting the Land Freight Lifecycle | OnTrackNorthAmerica | David Clarke | 7/15/2021 - 4/15/2022 |
| Mingzhou Jin | EV Requirement Analysis | TVA through Curent | Yulong Zhang, Nawei Liu | 2/1/2021 - 9/30/2021 |
| Mingzhou Jin | Policy Study on the Adoption of Alternative Fuel Vehicles | DOE - ORNL - UT-Battelle - Oak Ridge National Laboratory | | 09/01/2019 - 02/28/2022 |
| Mingzhou Jin | Industrial Landfill Waste Management (Reduce, Recycle, and Reuse) Technology Assessment | DOE - ORNL - UT-Battelle - Oak Ridge National Laboratory | | 08/01/2019 - 07/31/2021 |

# Seed Grants

| Faculty/PI | Project Title | Co-PI | Duration |
|---|---|---|---|
| Khalid Alshibli Ahmed | Geochemical Interaction between CO2 and Caprock for Safe Carbon Sequestration | Nicholas Dygert | 1/1/2021-12/31/2022 |
| Qiang He | Toward Precision Environmental Health Risk Management | Cronley & Li | 1/1/2021-12/31/2022 |
| Kelsey Ellis | Beat the Heat: Builiding adaptive capacity of vulverable populations in Knox County to combined stressors from climate change and urban heat. | First & Kintziger | 7/1/2021 - 12/31/2022 |
| Frank Loeffler | Microbial transformation and degradation of sulfonated per- and polyfluoroalkyl substances. | Shawn Campagna | 7/1/2021 - 12/31/2022 |
| Jie Wu | Socioeconomic inequalities and drinking water quality: assessin arsenic concentrations in community water systems by novel field deployable biosensors. | Cronley & He | 7/1/2021 - 12/31/2022 |
| Jiangang Chen | Assessing the levels of forever chemicals (PFAS) in surface water in Tennessee aquatic ecosystems | Jie Wu, Qiang He | 7/1/2022 - 6/30/2023 |
| Alison Buchan | Identification of novel pathways for bacterial degradation of polycyclic aromatic hydrocarbons | Qiang He | 7/1/2022 - 6/30/2023 |
| Baoshan Huang | Utilization of Waste Plastics | Qiang He, Brian Long, Pawel Polaczyk | 7/1/2022 - 6/30/2023 |
| Chris Cherry | Micromobility Vehicle Second-Life Battery Applications: Market Inventory and End Use Feasibility Analysis | Daniel Costinett | 7/1/2022 - 6/30/2023 |

# Completed Seed Grants

| Faculty/PI | Project Title | Co-PI | Duration |
|---|---|---|---|
| Khalid Alshibli Ahmed | Gas Driven Fracture During Gas Production using 3D Synchrotron Computed Tomography (SMT) | Claudia Rawn | 7/1/2018 - 12/31/2020 |
| Chris Clark | Analyzing Strategies for Diverting and Managing Organic Waste Streams in Tennessee | | 7/1/2019 - 12/31/2020 |
| Anahita Khojandi | Multi-Sensor Data-Driven Inspection/Maintenance of Green Infrastructure | Jon Hathaway | 7/1/2019 - 6/30/2021 |
| Steven Ripp | Emerging synthetic biology for plant phytosensing and agricultural sustainability | Tingting Xu, Sarah Werner, Scott Lenaghan | 7/1/2019 - 12/31/2020 |
| Scott Lenaghan | Bioengineering of the Duckweed Plastid Genome | Barry Bruce | 1/1/2021 - 6/30/2022 |

# ISSE Advisory Board, Faculty & Staff

| ISSE Research Staff | |
|---|---|
| Mingzhou Jin | ISSE Director, Professor of Industrial & Systems Engineering and Civil & Environmental Engineering |
| Jason Brown | Research Associate II |
| Tim Ezzell | Director, Appalachian Leadership Institute, Assistant Research Professor |
| Tim Gangaware | Research Director, Tennessee Water Resources Research Center |
| Terry Hazen | Director, Methane Center, Governor's Chair, Professor of Civil & Environmental Engineering |
| Steven Hoagland | Research Associate II |
| Nawei Liu | Research Associate |
| Jonathan Overly | Director, East Tennessee Clean Fuels |
| John Schwartz | Director, Tennessee Water Resources Research Center; Professor, Civil & Environmental Engineering |
| Daniel Siksay | Chief of Staff, East Tennessee Clean Fuels |
| Ian Simpson | Research Associate III |
| Sheila Webster | Director, Technology Research and Development Program |
| Catherine Wilt | Research Associate |
| Yulong Zhang | Assistant Research Professor |
| Xu Zheng | Post-doctoral Research Associate |

| ISSE Support Staff | |
|---|---|
| Kellie Caughorn | Senior Administrative Services Assistant, Tennessee Water Resources Research Center |
| Madelyn Collins | Project Coordinator, East TN Clean Fuels |
| Leland Davidson | Project Coordinator, East TN Clean Fuels |
| Lissa Gay | ISSE Communications Director |
| Ainsley Kelso | Communications Coordinator, East TN Clean Fuels |
| Jennifer Kidd | Project Coordinator, East TN Clean Fuels |
| Bonnie Morris | Tennessee Water Resources Research Center |
| Dylida Ries | ISSE Accounting Specialist |
| Savannah Robertson | DriveElectricTN Coordinator, East TN Clean Fuels |
| Sherry Russell | ISSE Business Manager |

| ISSE Affiliated Faculty | |
|---|---|
| Paul Armsworth | Ecology & Evolutionary Biology |
| Walker Forbes | Biosystems Engr & Soil Science |
| Joshua Fu | Civil & Environmental Engr |
| Michael Galbreth | Haslam College of Business |
| Jon Hathaway | Civil & Environmental Engr |
| Qiang He | Civil & Environmental Engr |
| Robert Jones | Sociology |
| Anahita Khojandi | Industrial & Systems Engr |
| Shuai Li | Civil & Environmental Engr |
| Jiafu Mao | Industrial & Systems Engr |
| Sean Schaeffer | Biosystems Engr & Soil Science |
| Charles Sims | Baker Center for Public Policy, Department of Economics |
| Wendy Tate | Haslam College of Business |
| Jie Zhuang | Biosystems Engr & Soil Science |
| Nick Zhou | Civil & Environmental Engr |

| 2021-2022 ISSE Advisory Board | | | |
|---|---|---|---|
| Stan D. Wullschleger | Director of Environmental Sciences Division, ORNL | Rebecca Tolene | VP Environment-Chief Sustainability Officer, TVA |
| James Parks | Section Head, Energy and Transportation Division, ORNL | Chris Cox | Professor and Dept Head, Civil & Environmental Engineering, Tickle College of Engineering |
| Matthew K. Taylor | Deputy Director of Sustainability Office, TDEC | Tim Rials | Associate Dean at UT AgResearch, UT Institute of Agriculture |
| Jay Price | UTK Sustainability Manager | Brian Blackmon | Director, Office of Sustainability, Knoxville |
| Bill Dunne (as observer) | Assoc. Dean for Research & Facilities, Tickle College of Engineering | | |

# ISSE Welcomes New Staff

Jenni Kidd
East TN Clean Fuels
Project Coordinator

Steven Hoagland
TN Water Resources Research Center
Research Associate II

Leland Davidson
East TN Clean Fuels
Project Coordinator

Ian Simpson
TN Water Resources Research Center
Research Associate III

# ISSE Student Highlights

Sa'ad Abd Ar Rafie is a 5th year Ph.D. student in UTK's Department of Civil and Environmental Engineering. Sa'ad received his Bachelor of Science in Civil Engineering from the Bangladesh University of Engineering and Technology, Dhaka, Bangladesh, in 2016. His current research at the Methane Center focuses on assessing the feasibility of utilizing methane hydrates to efficiently desalinate flowback produce water from the oil and gas industry. Sa'ad is currently looking at ways to improve the kinetics of lab-scale hydrate formation and developing a method for synthesizing these hydrates using flowback and produce water. Mr. Rafie employs multiple omics and analytical techniques to study the fixation of methane in clathrate matrices, microbial community relationships, and the geochemistry of fire-affected soils. These techniques include X-Ray powder diffraction, Scanning electron microscopy, stable isotope geochemistry, 16S rDNA Sequencing, and Ion chromatography. Mr. Rafie's research interests include contaminant hydrology, microbial ecology, bioremediation, and image processing with machine learning. He has presented his research at six international conferences. His recent publications/presentations as a co-author and first author focus on contaminant hydrology, bioremediation, wastewater treatment, and microbial ecology of the subsurface.

Yawen He is a fourth-year Ph.D. student in UTK's Department of Civil and Environmental Engineering. Ms. He received her Bachelor of Engineering in the College of Civil Engineering from Southeast University, Nanjing, China, in 2014. Her current research focuses on design, construction, and control of responsive building envelopes (RBEs), to study the mechanisms governing the dynamic thermal properties and synthesis rules of multiple technologies/functional modules for building energy efficiency. Ms. He conducts experimental analysis and formulates a computational framework to investigate the behavior of RBEs as well as control strategies (rule-based control and model-free reinforcement learning control) for autonomous performance regulation and self-adaptation. Ms. He's research interests include building simulation, building control, machine learning, bioinspired structures, and structural engineering. Ms. He's recent publications as a co-author and first author focus on modeling and control of RBEs with active thermal insulations.

Crispin Martin is a second-year undergraduate student in UTK's department of Civil and Environmental Engineering. He is currently exploring concentrations within the department, but hopes to work with water resources, environmental work, and structures. In the future, he would like to research the effects of climate change on coastal infrastructure, specifically as they apply to flooding. A member of the Cook Grand Challenge Honors Program at the university, he is due to finish his undergraduate degree in May of 2025.

Zoe Crihfield is a second year Master of Public Policy and Administration Student from Wise, Virginia. She received her bachelor's in History and Philosophy from the University of Virginia's College at Wise. Zoe is a student fellow for the Appalachian Leadership Institute with Dr. Tim Ezzell. She is passionate about the Appalachian Region and enjoys learning about ways to better the region economically while still upholding the rich culture she grew up around. Zoe hopes to remain in the region and pursue a career in local government. In doing so, Zoe plans to use the unique combination of skills acquired through her time in both the MPPA program and as part of the Appalachian Leadership Institute to serve Appalachia.

Kepler Barnhart is a first-year Master's Student and graduate research assistant in UTK's Department of Civil and Environmental Engineering. Kepler received his Bachelor of Science in Business Administration as a Supply Chain Management major from Haslam College of Business in 2017. For five years, Kepler worked in supply chain management roles in the electric bike industry, experiencing the electrification of the transportation industry firsthand. Kepler's current research focuses on second-life battery inventory within the micromobility sector and applications for energy storage. Other research interests include scooter/two-wheel vehicle safety and intelligent transportation system technologies for vulnerable road users. At ISSE's first annual research conference, Kepler was awarded second place in the student poster competition.

Ceara Parks Oliver is a first-year Ph.D. student in UTK's Department of Civil and Environmental Engineering, with a concentration in Water Resources Engineering. Ceara received her Bachelor of Science in Civil Engineering from the University of Oklahoma in May 2013. After graduation, she pursued consulting work at Burns & McDonnell in Dallas, Texas for the next nine years. As a civil engineer in the transportation industry, Ceara eventually focused solely on stormwater. Her responsibilities included assessing and designing linear and cross culvert stormwater infrastructure for highways. Ceara also has experience with MS4 regulations, stormwater control measures, and Waters of the US. Now, as a Ph.D. student, she plans to continue her passion in stormwater.

Ella Hunter is a junior at the University of Tennessee, Knoxville, majoring in data science and geography with a minor in math. Her research with Dr. Kelsey Ellis includes analyzing the urban heat island effect on the city of Knoxville. She works as a student trainee under the Pathways Program at the National Oceanic and Atmospheric Administration Atmospheric Turbulence and Diffusion Division in Oak Ridge, TN. Ella has also worked at the National Weather Center through the NSF REU program, where she conducted research on snow events with a sudden drop in visibility. After graduation, she plans to work towards a Master's and Ph.D. in meteorology.
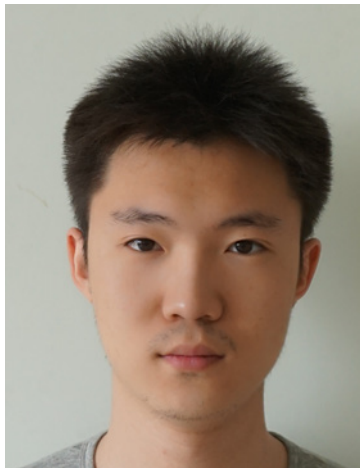
Diana Ramirez is a third-year Ph.D. candidate in UTK's Department of Microbiology. Diana received her Bachelor of Science in Microbiology from Arizona State University in 2020. Her current research focuses on studying how bacteria can transform, degrade, and interact with per- and polyfluoroalkyl substances (PFAS). Ramirez developed a high-throughput testing system to explore microbial PFAS transformation and uses genomics, microscopy, and mass spectrometry to elucidate the potential fate and transport of PFAS in environmental systems. Diana recently presented her work at the 2022 Chlorinated Conference in Palm Springs, California and at the Annual University Consortium for Field-Focused Groundwater Research at the University of Guelph in Canada.

Sarita Rattanakunuprakarn is a second-year Ph.D. student in UTK's Department of Industrial and System Engineering. Sarita received her Bachelor of Science in the Industrial Engineering from Kasetsart University, Nakhon Pathom, Thailand, in 2017 and master's degree in Industrial Engineering and Management Systems from University of Central Florida in 2020. Her current research focuses on comparative evaluation of highways and railways construction projects using life-cycle benefit cost analysis. The scope of the methodology not only captures typical financial investment and operating costs, but we consider overall impacts over the lifecycle of the infrastructure and transportation equipment, including monetized values of the projects' environmental and social impacts. Miss Sarita's research interests include operations research and reliability and maintenance of the system, especially in transportation field.

Caitlyn Smugor is a first-year Ph.D. student in UTK's Department of Civil and Environmental Engineering. She received her Associate of Science in Mathematics from Pellissippi State Community College in 2017 and went on to receive a Bachelor of Science in Chemical and Biomolecular Engineering from the University of Tennessee, Knoxville in 2021. Her current research focuses on water disinfection using electrochemical processes as an alternative to conventional chlorination. Her research involves testing various operating conditions such as electrode material, chloride concentration, and voltage to determine the feasibility and effectiveness of electrochemical disinfection. She presented her research about electrochemical processes for disinfection at the Tennessee Water Resources Symposium.

Jian Song is a second-year Ph.D. student in UTK's Department of Civil and Environmental Engineering. Jian received his Bachelor of Engineering in 2017 and Master of Engineering in 2020 in the College of Water Resource and Civil Engineering from China Agricultural University, Beijing, China. Jian's research interests include developing, improving, and utilizing agricultural and hydrological models. His current research focuses on how the hydrological process responses to the adaptation measures to the climate change. He uses the SWAT model to simulate and assess the rotational grazing in Oostanaula Creek Watershed.

Matthew Tolson is a first-year graduate student in UTK's Department of Civil & Environmental Engineering pursuing a master's degree in Environmental Engineering with a concentration in water resources. Matthew received his bachelor's degree in Civil & Environmental Engineering from the University of Tennessee, Knoxville in 2022. His current research focuses on prioritizing urban stream restoration and rehabilitation projects based on watershed models. Mr. Tolson utilizes SWMM modeling, incorporating rainfall data, geomorphic characteristics, and obstruction locations along waterways. Mr. Tolson's research interests include stream/wetland restoration and stormwater management with a focus on properly pairing the two fields in practice.

## List of Advisors & Students

**Anahita Khojandi**
Kalina Scarbrough, U, Civil
Rachel Wood, G, Industrial

**Barry Bruce**
Abigail Wells, U, Biochem/Cell & Molecular Biology

**Chris Cherry**
Kepler Barnhart, G, Civil

**Frank Loeffler**
Alexander Walls, G, Chemistry
Blessing Ayokunle Abiodum, G, Chemistry
Diana Ramirez, G, Microbiology
Qudus Olamilekan Sarumi, G, Chemistry

**Jie Wu**
Cortney Myers, U, Ctr for Behavioral Health
Jessie Baer, U, Center for Behavioral Health
Jiamei Huang, G, EECS
Yu Jiang, G, EECS

**Joe Zhuang**
Zhibo Cheng, G, Biosystem Engineering & Soil Science

**John Schwartz**
Ceara Parks Oliver, G, Civil
Cole Emmett, G, Civil
Crispin Tucker Martin, U, Civil
Cydney Kirby, U, Civil
Gillian Palino, G, Civil
Grace Long, G, Civil
Jian Song, G, Civil
Karen Abercrombie, G, Civil
Matthew Montgomery, G, Civil
Matthew Tolson, G, Civil

McKenna Hoag, U, Civil
Probal Saha, G, Civil
Samantha Jurek, U, Civil

**Jon Hathaway**
Arden Lady, U, Civil
Claudia Bible, U, Civil
Devina Langarica, G, Civil
Ghada Diab, G, Civil
Gillian Palino, G, Civil
Isidora Fletcher, G, Civil
Padmini Persaud, G, Civil
Probal Saha, G, Civil

**Joshua Fu**
Kuo, Cheng-Pin, G, Civil

**Kelsey Ellis**
Caroline Parker, U, Public Health
Ella Hunter, U, ISSE
Emily Norris, U, Social Work
Mel Haruto Yoshimoto, U, Public Health
Priscilla Pineda, G, Public Health
Victoria Haynes, G, Geography

**Khalid Alshibli**
Amirsalar Moslehy, G, Civil
Md Murfat Uzzaman, G, Civil
Mohammad Safi, G, Civil
Mohammed Elbushra Elsheikh Elnur, G, Civil

**Mingzhou Jin**
David Vance, G, Bredensen Center
Rongyun Tang, G, Industrial
Rui Zhou, G, ISSE
Sarita Rattanakunuprakarn, G, Industrial

**Nick Zhou**
Adam Brooks, G, Civil
Emily Stanton, U, Civil
Griffin Bedell, U, Civil
Hsun Jui Chang, U, Civil
Reese Sorgenfrei, U, Civil
Rui Xiao, G, Civil
Yanhai Wang, G, Civil
Yawen He, G, Civil
Yucen Li, G, Civil
Yuetan Ma, G, Civil

**Qiang He**
Caitlyn Smugor, G, Civil
Clifford Swanson, G, Civil
Hope Newberry, G, Civil
Jeffery Emmett Jr, G, Civil
Xinghan Zhao, G, Civil

**Scott Lenaghan**
John Beatty, G, Biochem/Cell & Molecular Biology

**Sheila Webster**
Blayne Chance, U, ISSE

**Terry Hazen**
Saad Abd Ar Rafie, G, Civil
Zabrenna Griffiths, G, Genomic Science & Technology

**Timothy Ezzell**
Alexis Webster, G, ISSE
Zoey Crihfield, G, ISSE

*G - graduate student*
*U - undergraduate student*

# ISSE Research

## ISSE Holds First Annual Research Conference

ISSE's First Annual Research Conference was held on September 15, 2022. It was an auspicious start to an annual event that is sure to grow in scope and influence. Following opening remarks by Dr. Brad Day, UTK Associate Vice Chancellor for Research, Dr. Jin gave an overview of ISSE's history and current work. Researchers then presented their latest projects:

- Water-related Research, Dr. John Schwartz, Director, Tennessee Water Resource Research Center
- Alternative-Fuel and Electric Vehicle Adoption: Local, State, and Nation, Johnathan Overly, Director, East TN Clean Fuels Coalitions
- Sustainability and Leadership in the Appalachian Region, Dr. Tim Ezzell, Director, Appalachian Leadership Institute
- Climate Change Research, Dr. Yulong Zhang, Assistant Research Professor, ISSE

Next, state and community leaders in sustainability gave updates on initiatives in each of their areas:

- Sustainability in Knoxville, Brian Blackmon, Sustainability Director, Knoxville
- UTK Global Energy Ecosystem (GEE) Initiative, Dr. Mingzhou Jin, ISSE Director
- ORNL Environmental Research and Future Directions, Dr. Erin Webb, Senior R&D Engineer and group leader, ORNL
- TDEC Sustainability Programs, Matthew K. Taylor, Deputy Director of Sustainability Office, TDE
- TVA Sustainability Effort, Dr. Rebecca Tolene, VP Environment-Chief Sustainability Officer, TVA
- International Collaboration on Sustainability Research and Engagement, Dr. Tom Gill, Director of Smith International Center

An important part of the program was the student poster competition. Student researchers submitted 30 posters for judging, and these are the winners:

- First prize: Clifford Swanson, Microbiome of the Drinking Water Distribution System
- Second prize: Kepler Barnhart, Micromobility Vehicle Second-Life Battery Applications: Market Inventory and End Use Feasibility Analysis
- Third prize: Rongyun Tang, Interannual Variability of Global Wildfires

Wrapping up the program, Dr. Bill Dunne presented Jonathan Overly with the 2022 Outstanding ISSE Staff Award. Jonathan is a visionary leader in efforts toward national clean fuels use.



*Drs. Bill Dunne (left) and Mingzhou Jin (right) present the 2022 ISSE Outstanding Staff Award to Jonathan Overly*

# Sponsored Research

Since the last reporting period, each ISSE program has conducted significant research: water resources through four US Geological Survey projects; methane hydrates and global soil moisture datasets; a US-China transdisciplinary research network at the nexus of food-energy-water systems; and trends in Appalachian tourism and diversity. ISSE's six main areas of research are

- Clean Energy & Energy Efficiency
- Climate Change
- Building Environment
- Regional Sustainability
- Water Research
- Sustainable Food Systems

## Clean Energy & Energy Efficiency

### TDOT I-40 Alternative Fuels Continuation, PI Jonathan Overly

Thanks to a 2019 federal grant, TDOT received funding to build a partnership across Arkansas, Tennessee, and North Carolina to fill the gaps in compressed natural gas (CNG) and electric vehicle direct current fast charging (DCFC) refueling infrastructure along I-40. The project was completed in 2020, and the results led to a TDOT-UTK contract involving East Tennessee Clean Fuels and ISSE researchers who will develop a "How-To" including prioritization criteria, a site selection formula, and sustainable funding strategies. Work will conclude in fall 2022.

### Utilizing coal-derived solid carbon materials towards next-generation smart and multifunction pavements, PI Hongyu Zhou

Assistant Professor Nick Zhou and Edwin G. Burdette Professor Baoshan Huang have been awarded a Phase I cooperative agreement of $430,000 from the US Department of Energy's (DoE) Office of Fossil Energy and Carbon Management (FECM), and an additional $107,500 from non-DoE funding for a total of $537,500 over 18 months. One of the goals of FECM's Carbon Ore Processing Program is to support research and development for projects utilizing coal or coal wastes that are outside of traditional thermal and metallurgical markets, like this sustainable pavement concept.

The objective of the research project is to develop and demonstrate a novel, multifunctional, smart pavement system that incorporates coal-derived solid carbon materials. The product would integrate de-icing, self-sensing, and microwave-induced self-healing that would provide a cost-effective, efficient, and reliable solution to safety, mobility, and resilience challenges on bridges and roadways in winter weather.

"We aim to create a pavement product that serves multiple functions at once: providing advanced safety and reliability, while also contributing to the national goal of reaching net-zero emissions by 2050," said Zhou. "The DoE's Office of Fossil Energy and Carbon Management support is helping to make this a reality."

The main ingredient in the aggregate is a low-cost domestic coal-derived solid carbon, which can be used to build and

improve asphalt pavements while utilizing coal resources. With the increasing adoption of renewable energy resources, some coal-burning power plants will be phasing out.

This project will provide a promising pathway to rethink the use of the US domestic coal resources by utilizing the low-cost, electrically conductive, and mechanically strong coal-derived solid carbon materials to produce infrastructural components. It does not require any change to existing paving equipment and process and makes it possible to produce multifunctional smart pavements at costs comparable to those of regular pavements.

A smart pavement system will especially benefit and improve bridge deck paving, where freezing issues are eminent, and resolve the negative effects of corrosion and pollution from deicing salts. Potential performance benefits include enabling multi-functionalities to reduce maintenance costs, enable a longer service life, and reduce travel delays and costs. The technology is also readily transferrable to other sectors including roadway and airport construction.
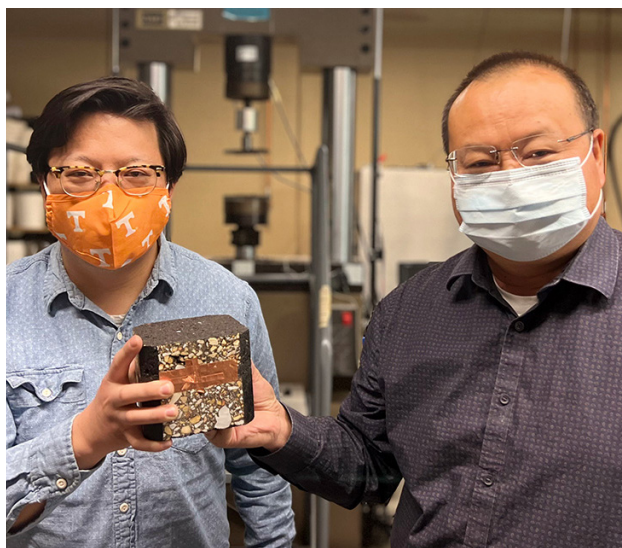


## Manufacturing Engineering Efficiency, PI Mingzhou Jin

Working with the Manufacturing Energy Efficiency Research & Analysis group at Oak Ridge National Lab, the research team led by Dr. Mingzhou Jin is investigating the adoption of smart manufacturing (SM) for energy efficiency and decarbonization. The team has evaluated all SM maturity models and discuss their applicability [6]. The study defined ten categories of dimensions to characterize the maturity of SM adoption at a manufacturer, including IT & operations, strategy, supply chain, products, culture, technology, customer, cybersecurity, leadership, and governance. This research result will guide ETISE's evaluation of the current SM maturity at companies that will be assisted and help identify opportunities for more applications to realize better energy management and productivity improvement. For the second effort, the team started to work with the Volkswagen plant in Chattanooga, TN to develop a digital twin for monitoring, modeling, visualizing, and improving the energy consumption and carbon emissions of the whole plant with bus-level data. Recently funded by the U.S. Department of Energy (DOE), the team will launch the East Tennessee Initiative for Smart Energy Management (ETISE) in October 2022. ETISE will create a regional model for technical assistance and workforce training to effectively integrate SM in energy management systems into energy-related business practices. The resulting regional model could be applied by DOE to other regions to improve the national goals of reducing manufacturing energy consumption and carbon emissions. Using East Tennessee as a test bed, ETISE will pursue three objectives over the next two years: 1) Understand how to implement SM for energy management by industries and sizes in the region, 2) Develop a technical assistance and workforce training model at the regional level through

*left: Nick Zhou & Baoshan Huang*



ground service to manufacturers in East Tennessee, and 3) make strategic suggestions to DOE and AMO that will promote the adoption of SM for energy management. ETISE is a collaborative program between ISSE, UT Center of Industrial Services, and Oak Ridge National Lab.
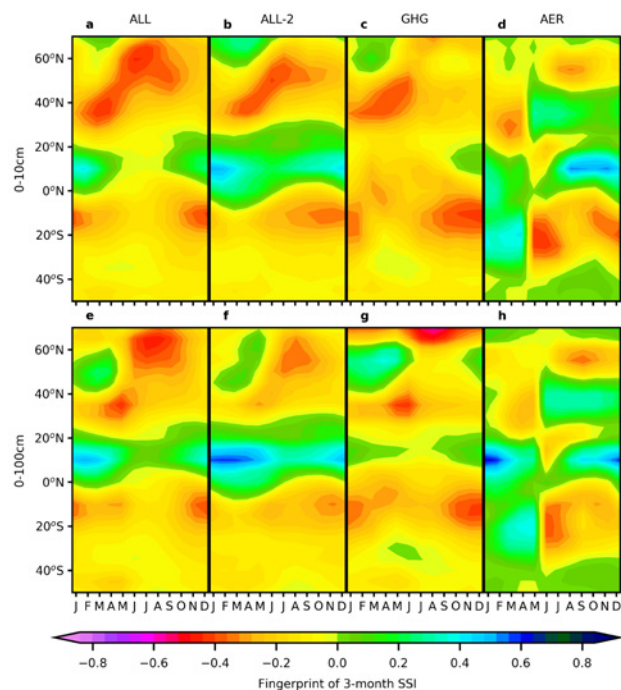
## Climate Change

**ISSE researchers and graduate students studied a variety of climate change issues—soil moisture, wildfires, vegetation, and droughts. PI Mingzhou Jin**

Despite growing evidence of human influence on terrestrial aridity, there is considerable uncertainty on the spatial, vertical, and seasonal patterns of recent and future changes in soil moisture-based terrestrial aridity and associated environmental drivers. The team formed by researchers at ISSE and Oak Ridge National Lab calculated a Standardized Soil Moisture Index (SSI) for two soil layers (0–10 and 0–100 cm) from newly merged soil moisture data sets, conducted pattern-based detection and attribution analysis to quantify the impacts of natural and anthropogenic forcings on the monthly trends in the zonally averaged SSI, and developed an emergent constraint–based approach to use the historical signal-to-noise ratios of the detection and attribution

to constrain future evolution in the zonally averaged SSI. The team found that widespread drying occurred in the midlatitudes of both hemispheres from 1971 to 2016, and wetting occurred in the northern subtropics and in the spring between 45°N and 65°N. Human forcings, mainly greenhouse gas emissions, exerted significant influences on the surface SSI from August to November and on the root-zone SSI from September to April; anthropogenic aerosol emissions might have played a role in some months and soil layers. Observation-constrained future SSI changes under the Shared Socioeconomic Pathway 5–8.5 scenario showed the continued presence of human impacts and more rapid drying of the surface soil than the root-zone soil. The findings highlight the predominant human contribution to terrestrial aridification and reveal the spatiotemporal heterogeneity therein, providing a basis for drought and flood risk reduction strategies and activities. The paper summarizing the findings and led by Dr. Yaoping Wang, ISSE assistant research professor, has been accepted by Nature



*left: Fingerprints of the CMIP6 simulations under different forcings for the 3-month SSI. The ALL fingerprint were calculated on zonally averaged 3-month SSI over the 1971–2100 period, and the other fingerprints over the 1971–2020 period. The SSIs were calculated based on the GMM distribution.*

Communications. In addition, the team developed seven global, gap-free, long-term (1970–2016), multilayer (0–10, 10–30, 30–50, and 50–100 cm) SM products at monthly 0.5 resolution and published at Earth System Science Data. The merged products outperformed their source datasets when evaluated with in situ observations regarding bias and errors.

Observation-constrained future SSI changes under the Shared Socioeconomic Pathway 5–8.5 scenario showed the continued presence of human impacts and more rapid drying of the surface soil than the root-zone soil. The findings highlight the predominant human contribution to terrestrial aridification and reveal the spatiotemporal heterogeneity therein, providing a basis for drought and flood risk reduction strategies and activities. The paper summarizing the findings and led by Dr. Yaopoing Wang, the assistant research professor at ISSE, has been accepted by Nature Communications. In addition, Drs. Yulong Zhang, Mingzhou Jin, and Jiafu Mao and graduate students at ISSE and researchers at ORNL Climate Change Science Institute are studying global fire controls related to climate, vegetation, and anthropogenic activity. They leveraged an ensemble of five state-of-the-art machine learning (ML) models and multiple satellite-based observations to conduct global fire modeling for three fire metrics (i.e., burned area, fire number and fire size and), and further quantified fire controls from climate, vegetation, and human in a spatially resolved manner through ML-based scenario simulations. Overall, the optimized ensemble ML well reproduced annual dynamics of global burned area, total fire numbers and averaged fire size. Spatially, the ensemble ML further

captured key patterns of multi-year mean magnitudes, yearly variabilities, yearly anomalies, and long-term trends for three fire metrics. The ML-based fire attribution highlighted the dominant role of enhanced anthropogenic activity in reducing global burned area, followed by climate control, and vegetation control. Spatially, climate control dominated a much larger burned area (53.7%) than that for human control (23.4%) and vegetation control (22.9%). However, the counteracting effect from regional wetting and drying trends weakened climate control on global burned area.

Fire number and fire size generally showed similar spatial control patterns with burned area. However, globally, fire number tended to be more controlled by climate while fire size more controlled from human. Overall, the study confirmed the feasibility and efficiency of the ensemble ML in global fire modeling and subsequent control attribution. The heterogeneous fire controls revealed by this study could enhance our understanding of contemporary fire regime at multiple dimensions, and further contribute to the robust fire projection in a changing climate. The team also Fires are becoming a severe danger to the sustainability of the peatland ecosystem and the balancing of the global carbon budget. Multiple factors (e.g., drought, drainage) are associated with peatland fires, but the natural and anthropogenic driving mechanisms underlying the changes of peat fires remain to be explored. This paper investigates the primary affecting factors and predictability of peatland fires from 1997 to 2016 using a two-step correcting machine learning (ML) framework, which combines multiple ML classifiers, regression models, and an error correcting technique.

Results show that (1) the applied oversampling algorithm effectively addresses the unbalanced data by improving the recall rate by 26.88% to 48.62% for multiple data sets, and the error correcting technique can tackle the overestimation of fire sizes during fire season, (2) non-parametric models

outperform parametric models in simulating fire occurrence and fire counts, and the Random Forest performs best with the area under the receiver operating characteristic curve ranging from 0.83 to 0.93 across multiple fire data sets, and (3) four sets of factor-control simulations for multiple data sets consistently indicate that temperature, air dryness, and frost dominate the boreal peat fires, overriding the effects of precipitation, wind speed, and human activities. These findings disentangle the primary factors regulating boreal peatland fire and demonstrate the efficiency and accuracy of ML techniques in peat fire prediction, facilitating the projection of boreal peatland fires and protective management of boreal peatlands. The climate change research team ISSE also investigated peatland fires, which are a severe danger to the sustainability of the peatland ecosystem and the balancing of the global carbon budget.

The project investigates the primary affecting factors and predictability of peatland fires from 1997 to 2016 using a two-step correcting machine learning (ML) framework, which combines multiple ML classifiers, regression models, and an error correcting technique. Results show that (1) the applied oversampling algorithm effectively addresses the unbalanced data by improving the recall rate by 26.88% to 48.62% for multiple data sets, and the error correcting technique can tackle the overestimation of fire sizes during fire season, (2) non-parametric models outperform parametric models in simulating fire occurrence and fire counts, and the Random Forest performed best with the area under the receiver operating characteristic curve ranging from 0.83 to 0.93 across multiple fire data sets, and (3) four sets of factor-control simulations for multiple data sets consistently indicate that temperature, air dryness, and frost dominate the boreal peat fires, overriding the effects of precipitation, wind speed, and human activities. These findings disentangled the primary factors regulating boreal peatland fire and demonstrate the efficiency and accuracy of ML techniques in peat fire prediction, facilitating the
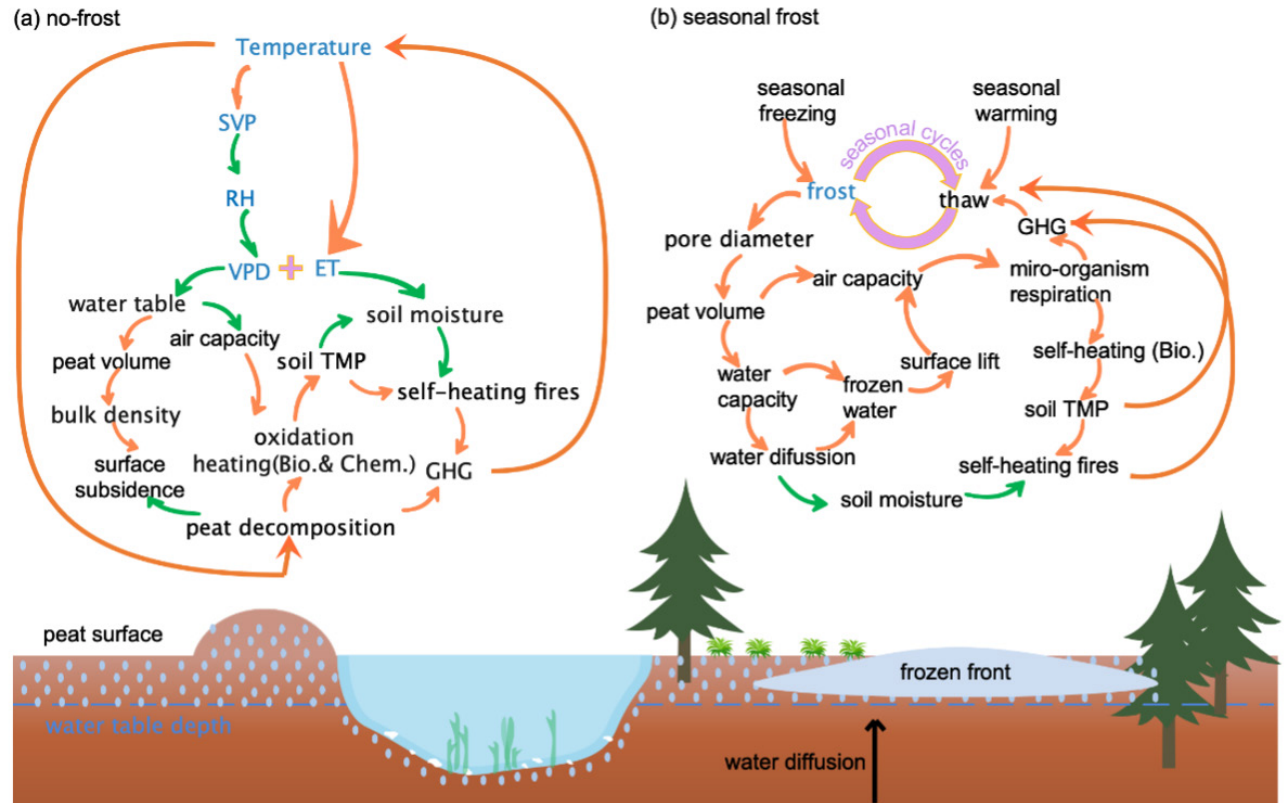


*Processes environmental factors participate in for self-heating peatland fires.*
*ML-identified primary factors are marked in blue; green arrows indicate negative correlation between the connected two factors,*
*and orange arrows indicate positive correlation between the connected two factors.*

projection of boreal peatland fires and protective management of boreal peatlands.

## Regional Sustainability

### SRS RN: People-Centric Integrated Assessment Model for Regional Sustainability (PIAMRS): Focusing on the Central Appalachian Region, PI Mingzhou Jin

With funding from National Science Foundation, ISSE is developing is a research network to co-produce a

People-Centric Integrated Assessment Model for Regional Sustainability (PIAMRS) with stakeholders for the Central Appalachian region through convergent research involving multiple institutes and disciplines in the region. Applications of PIAMRS will help transform the region from a traditional resource-based economy into a modern sustainable system and generate a new understanding of the co-benefits and trade-offs among multiple outcomes and new theories of changes. The consortium will develop PIAMRS to capture the major concerns of people living in a region along with its natural resources and ecosystems and create a forward-looking tool to understand the consequences of different policies and interventions through

the many linked subsystems. A co-production process with intensive stakeholder engagement will guarantee the local relevance of PIAMRS. Through its development and application, we expect to gain new understanding of the complex interactions among various policies and create new and holistic theories of changes for regional sustainability. Although the research network focuses on Central Appalachia, the research results will be compared against other similar regions with a resource-based economy to assess the scalability of the proposed PIAMRS.

## Urban Floodplain Reconnection through Regenerative Stormwater Conveyances, PI Jon Hathaway

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 flow paths are short circuited by storm drains and pipes that bypass these ecosystem services. This causes increased peak flows in receiving waters with subsequent 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. Studies that help identify linkages between RSCs and local groundwater systems, and studies that provide scientifically informed design guidance are limited, representing a need in scientific literature. The objectives of this project are to: (1) site, design, and create a floodplain wetland using RSC-style natural system design, (2) through surface and groundwater measurements, establish the quality and abundance of wetlands created by the Enhanced RSC installation, (3)

develop much needed design guidance for Enhanced RSCs being used to reconnect urban watersheds to floodplains / recreated wetlands, and a wetland functional tool to assess restoration outcomes, and (4) use a series of workshops and webinars to educate regulators, designers, and other academics about the use of Enhanced RSCs for wetland restoration.

During this period, pre-construction monitoring continued at the site while the RSC design was finalized. The design was thoroughly reviewed by the project PIs and spearheaded by graduate student Gillian Palino. Due to the high velocity of flows entering the site, advanced design techniques such as 1-D and 2-D modeling were employed to ensure safe conveyance of flows. These models allowed a more enhanced understanding of how flows would be routed through the system, where high velocities may be experienced, and what size materials are needed to resist erosion. These advanced design techniques are unique in stormwater control design, in particular for RSCs. We plan to produce guidance for using these techniques for RSCs in an attempt to advance the practice of their design (one of our project goals). Examples of 1D and 2D modeling are shown in figures 1a and 1b, respectively.
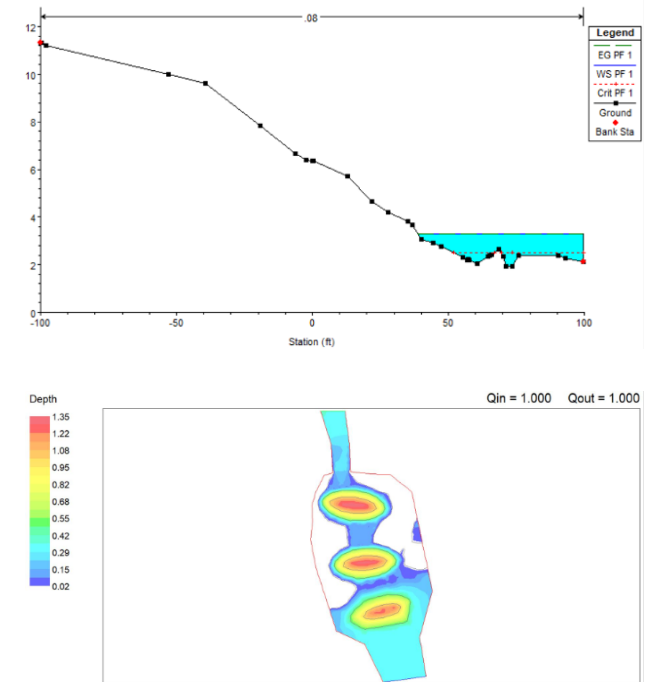


*Figure 1: (a) HEC-RAS output for 100 year storm event at final cross section. Water depth satisfies design criteria to support safe conveyance, (b) River-2D depth (m) output for 100 yr storm event. Water across the site is shown to be safely conveyed with current design. This verifies the findings of the HEC-RAS model.*
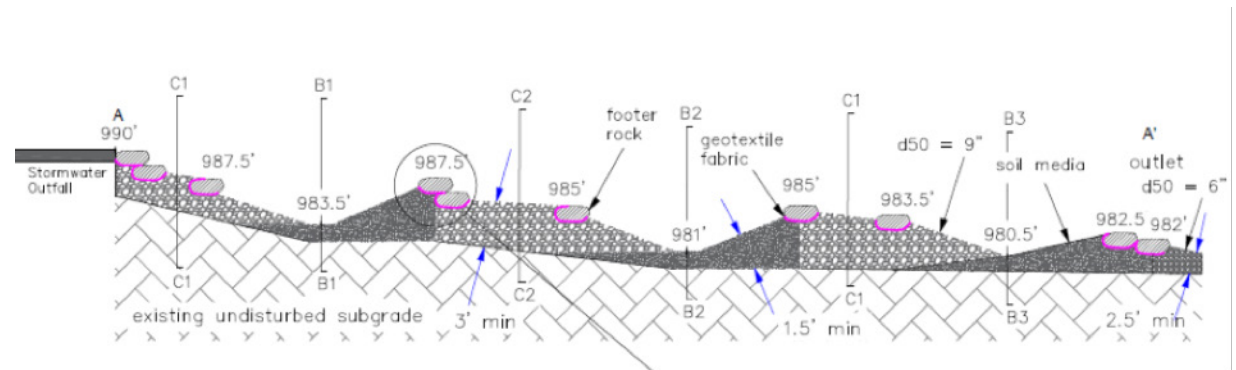


*Figure 2: RSC cross section*

Data collection is underway at the site. These efforts will be critical to understanding the benefits of RSC installation at the site by first establishing the current hydrologic regime. We anticipate positive environmental outcomes from the RSC installation, i.e., reduced erosion and increased infiltration to the groundwater system, but this monitoring will allow quantification of these outcomes.

### REU Site: Green Infrastructure for Sustainable Urban Environments, PI Jon Hathaway

Green Infrastructure for Sustainable Urban Environments (GI4SUrE) Research Experience for Undergraduates (REU) is a 10-week summer program designed to expose and immerse 10 undergraduate students to unique green infrastructure (GI) research. Green infrastructure is a way to build better infrastructure, as a part of the National Academy of Engineering's Grand Challenge, to restore and improve urban infrastructure. This program lets students perform field, laboratory, or modeling studies to explore how GI can mitigate the effects of urban runoff on surface water quality and hydrology. This research will affect not only eastern Tennessee, but any area that deals with urban stormwater runoff. Summer 2022 was the first year for GI4SUrE, and students dove into a professional and social atmosphere that developed their fundamental research methodologies and critical thinking skills. The GI4SUrE program is an intense, 10-week opportunity where undergraduate students perform field, laboratory, or modeling studies to explore how GI can mitigate the effects of urban runoff on surface water quality and hydrology. Participant work closely with other undergraduates from around the U.S., graduate students and faculty, and staff mentors on projects related to Green Infrastructure for sustainable urban environments. They learn about proper experimental design, the ethics of science, and how to present scientific information. This REU is a unique chance to make contacts in the field of sustainable urban environments.

**Improving the GRSMs understanding of its natural resources and processes and thereby enhancing protection of the Park's resources, PI John Schwartz**

Long-term research continues on the effects of acid deposition from atmospheric pollution on stream water quality in the Great Smoky Mountains National Park (GRSM) by advancing our understanding of the soil biogeochemical processes associated with nitrogen, sulfur, and carbon dynamics. Jason Brown completed his MS thesis on characterizing dissolved organic carbon in the GRSM's stream park wide. This research provides critical information on the potential for organic acids to contribute to continued stream acidity. Dr. John Schwartz published a paper titled: Throughfall Deposition Chemistry in the Great Smoky Mountains National Park: Landscape and Seasonal Effects in the journal Water, Air, and Soil Pollution. This paper demonstrated that continued stream acidity in the GRSM appears to be due to base cation deletion in the soils, and the potential contribution of organic acids.

Jason Brown was hired as a Research Associate at the TNWRRC in January 2022 and manages the bimonthly stream sampling and water sample analysis and maintains the high-elevation monitoring station at Noland Divide near Clingman's Dome collecting data on weather, rainfall, throughfall, soil water, and stream flows and water quality.

### Urban Waters Report Card, PI John Schwartz

The TNWRRC is working with a group with members from Nashville Metro, cities of Chattanooga and Memphis, counties of Shelby, Hamilton, and Knox, the Tennessee Stormwater Association and Tennessee Department of Environment and Conservation to develop an Urban Waters Report Card (UWRC) to "grade" the quality of streams in communities that maintain a stormwater management program. Jason Brown and Ian Simpson, Research Associates at the TNWRRC are aiding in the production of the UWRC. Funding has been received from each of the municipalities listed above.

The goal for use of the UWRC is to provide MS4s a means to track improvements in streams from their stormwater management and stream rehabilitation efforts. Even though with considerable effort by the MS4s, in many cases streams will continue to fail to meet their designated uses remaining on the impaired waters list. A grading scale for the UWRC will span from A to F providing an assessment scheme that demonstrates the incremental enhancement of a stream's condition. Such a scheme is more informative to the local stakeholders including the MS4 professional and administrative staff, political leaders, and the public. The planned framework of the UWRC is simple and intuitive. Number of categories are to be graded including water quality, watershed hydrology and connectivity, and stream corridor characteristics such as habitat, channel stability, and riparian vegetation. A composite grade will be reported for each stream assessed, and available on a web site, currently under development. A beta-version of the UWRC will be completed fall 2022/spring 2023.

## Sustainable Food Systems

Responding to the second UN Sustainable Development goal of ending hungers and achieving food security, ISSE studies food sustainability in the United States and world, using analytic models and pursuing systematic solutions. We assess the sustainability and resiliency of the global food systems by carefully considering socioeconomic, policy, and climate scenarios.

### Food and Energy Nexus, PI Mingzhou Jin

Supported by the DOE's Advanced Manufacturing Office, researchers from ISSE and ORNL further studied the energy consumption and GHG emissions along the U.S. food supply chain (FSC) and identifying the high impact areas are the first steps to transforming the U.S. food sector to net-zero emissions. This work provides a database of the energy consumption and GHG emissions from the U.S. food system at national and state level by FSC stage, fuel type, and food commodity. We estimate that the U.S. food system consumed a total 4,787 TBTU of site energy, 7,258 TBTU of primary energy, and generated 984.1 MMT of GHG emissions in 2016. Among all the FSC stages, on-farm production is the largest energy consumer (35% primary) and, by far, the largest source of GHG emissions (71%). Raising animals (for dairy; meat, poultry, eggs; or seafood products) requires a large portion of the on-farm energy consumption and creates the largest portion GHG emissions and making this a key target of any efforts of energy use and GHG reduction.

In addition, optimizing the U.S. food distribution system can directly reduce the distribution stage energy consumption and GHG emissions and increase products' shelf-life, reducing food loss and waste generation and the energy consumption and GHG emissions to produce them. Reducing food loss and waste generation is one of the best options for reducing the impact of the FSC, as it also reduces the amount of food that is necessary to grow, and thus impacts the overall FSC. With the developed database, future work by the authors or others can aid in creating detailed analyses for understanding the benefits and impacts of each proposed strategy. Stage- and regional-specific strategies and goals, as well as other more substantial ways to change the environment impact of the food system can be identified using the database.
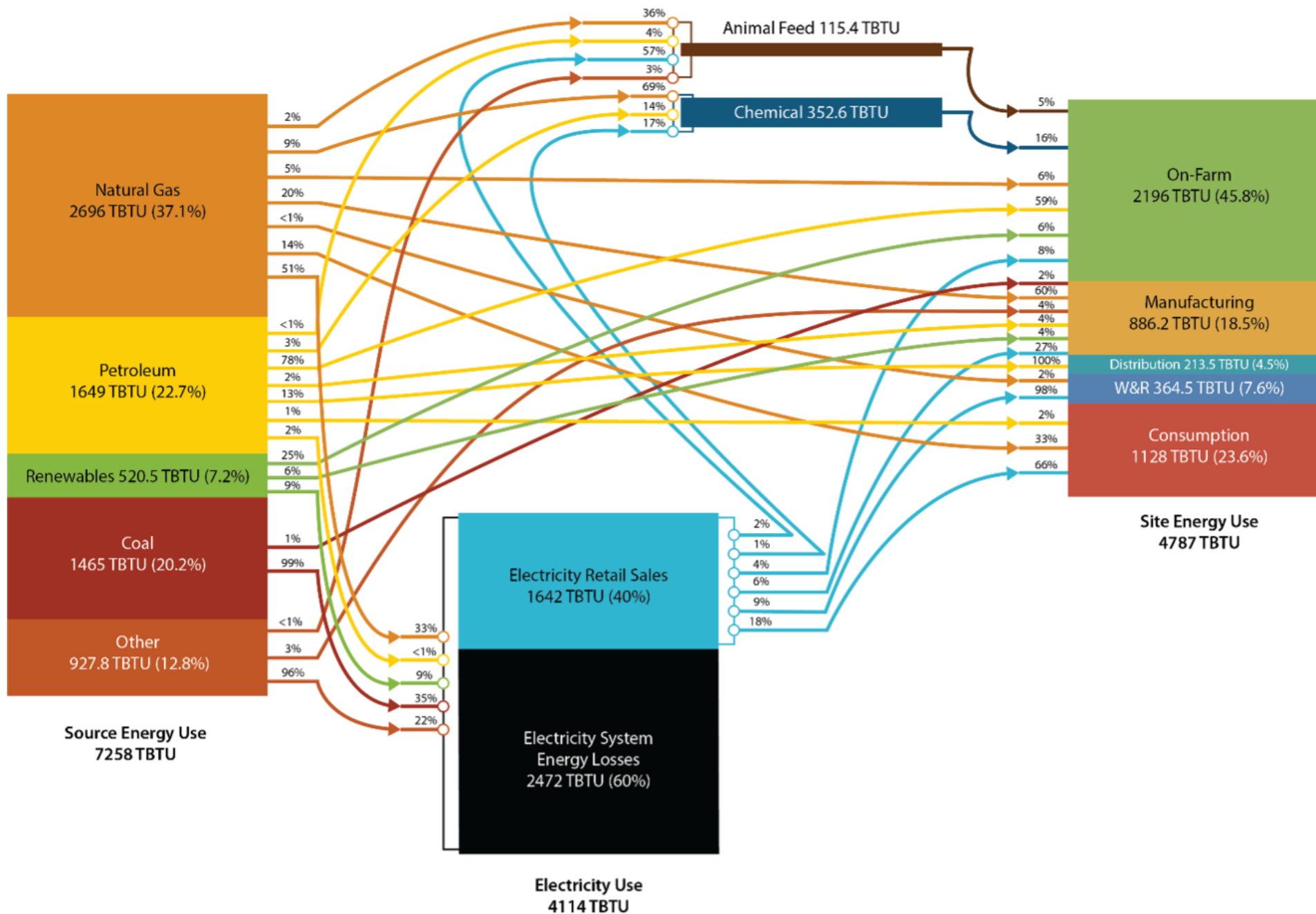
above: Overview of energy flows along the 2016 U.S. food supply chain illustrating the energy flows into power generation, animal feed manufacturing, and agricultural chemicals manufacturing.

## Water Research

The Tennessee Water Resources Research Center (TNWRRC) is a federally designated state research institute supported in part by the U.S. Geological Survey and the Environmental Protection Agency. It serves as a primary link among water-resource experts in academia, government, and the private sector, and the diversity of its staff in terms of background and expertise enhances flexibility and positions the Center to establish productive partnerships.

### 3D dynamic evolution of pore water-air interaction within saturated sheared sand, NSF sponsor, PI Khalid Ahmed Alshibli

Soils behavior is highly influenced by its degree of saturation (S), and the constitutive relationships for partially saturated soils (a three-phase system) is fundamentally different than fully saturated or dry soils (a two-phase system). The presence of both air and water in the pore space introduces capillary forces as an influential component of inter-particle interactions. A small change in the degree of saturation alters suction, which influences soil stiffness and shear strength. Based on the PI's preliminary experiments, it appears that current ASTM standard procedures to saturate axisymmetric triaxial compression (ATC) specimens may suffer from a major shortcoming despite decades of use and wide acceptance by the geotechnical community. It appears that it is difficult to eliminate all air bubbles from sand pore space, even when the utmost care is taken to use de-aired water. The assumption of a fully saturated state for a sand specimen with no change in degree of saturation is not correct based on preliminary experiments. The objective of this research is to monitor solid-water-air interaction within sheared sand under drained condition, to examine the accuracy of the current specimen saturation procedure in yielding fully saturated ATC specimens, and to monitor the change in degree of saturation of sheared sand. This

project will use dynamic in situ 4D imaging (3D plus time) in a world-class facility (Advanced Photon Source, APS) to probe specimens and to monitor water-air phases and the change of degree of saturation in relation to back pressure, specimen density, grain size distribution, and particle morphology.

The objective of this research is monitor solid-water-air interaction within sheared sand under drained condition, to examine the accuracy of the current specimen saturation procedure in yielding fully saturated ATC specimens, and to monitor the change in degree of saturation of sheared sand. It appears that it is difficult to eliminate all air bubbles from soil pore space even when the utmost care is taken to use de-aired water, slow water percolation, etc.

## TN Stream Quantification Tool Training, PI John Schwartz

Dr. John Schwartz and Tim Gangaware, with the assistance of Jason Brown are developing a training workshop for stream restoration professionals engaged in projects to receive compensatory migration credits. Compensatory mitigation is required for aquatic resource losses from development activities near waterways as stipulated in the federal Clean Water Act and state law. Before the training could be developed, the existing stream quantification toll (SQT) was requested to be improved from its original version. A working group was formed with 18 members from the regulatory community and consultants. A review was completed and a revised SQT developed. This project supports the Tennessee Department of Environment and Conservation and the US Army Corps of Engineers to implement their compensatory mitigation programs. Trainings will begin fall 2022/spring 2023.

*left: Dr. Alshibli setting up the triaxial cell on the stage of Beamline 13D at the advanced Photon Source*

## TNWRRC USGS Awards: US Geological Survey 104B Program

**FY2021 and FY2022 Water Resources Program Year 1: Improving peak discharge estimates for low annual exceedance probability floods in the French Broad, Clinch, and Nolichucky rivers using paleoflood hydrology.**

The USGS 104g is a nationally competitive program. For FY2021-2022, TNWRRC was awarded a grant with the Dr. Lisa Davis at University of Alabama, Miles Yaw at the Tennessee Valley Authority, and Tessa Harden at the USGS Arizona.

### FY2022 and FY2023 Water Resources Program Year 2

FY2022-2023 funding from the USGS was used to support three projects and a newly created TNWRRC Graduate Student Scholarship. Matthew Tolson was awarded the first scholarship. He is a master's student in the Department of Civil & Environmental Engineering. His research will explore watershed modeling and planning to better coordinate implementation of stormwater control measures and stream restoration projects.

## Sourcing Runoff and Chemical Origins in Urban Stormwater Runoff: An Application in Knoxville, Tennessee, Jon Hathaway, Department of Civil & Environmental Engineering, University of Tennessee, Knoxville

Hydrologic regimes in urban streams are altered by increased runoff from impervious surfaces. Runoff also delivers pollutants that have collected on impervious surfaces during dry periods antecedent to storm events. Determining the source of stormwater runoff (and thus the associated source of pollutants) is a critical need in urban hydrology to optimize siting of stormwater controls and improve water quality modeling. This project uses stable isotope analysis of nitrogen ($\partial 15N$) and oxygen ($\partial 18O$) for dissolved nitrate, and sulfur ($\partial 34S$) and oxygen for sulfate as environmental tracers for stormwater source partitioning in the unique urban watershed of Baker Creek in the City of Knoxville, TN.

Three monitoring sites were established: (1) at the forested headwaters (BCP), (2) at a node entirely fed by urban runoff (MJP), and (3) at a node downstream of where points 1 and 2 combine (LEN). Stream and runoff samples were taken during different seasons and hydrological conditions (e.g., rain, baseflow). Preliminary isotope results suggest that atmospheric deposition and soil processes are the main contributors of nitrate/nitrite into the Baker Creek. In contrast, sulfate is mainly sourced from surface water and groundwater interaction with the bedrock (e.g., evaporite dissolution, sulfide weathering). During the study period, contributions of nitrate/nitrite and sulfate from the local sewer systems were minor, if any. Generally, the $\partial 15N$, $\partial 18O$, and $\partial 34S$ appear to be useful tracers in studying source partitioning in urban runoff and stream water, which are sensitive to changes in hydrological conditions.

**Development of a Low-cost Real-time Water Quality Monitoring Network for Rural Watershed, Alfred J. Kalyanapu, Associate Professor, Tania Datta, Associate Professor, Department of Civil and Environmental Engineering, Tennessee Tech University**

The project team built a low-cost real-time water quality probe. The prototype water quality sensor was deployed along Little Creek, near Tennessee Tech University. The components of the sensor include a Particle Electron LTE Micro-controller (Particle, 2021), 1800 mAh Li-Po battery, water quality probes (pH, Dissolved Oxygen, Electrical Conductivity and Temperature), 3.5V solar panel, printable circuit board and an IP-67 waterproof enclosure. The project team has developed a general bill of materials with cost details. The four probes that are used in this project are manufactured by Atlas Scientific Environmental Robotics (Atlas Scientific, 2021).

Figure 2 depicts the process flow of how the probes read the information, transmit to the data hosting service and how that data is then published for usage. Each sensor
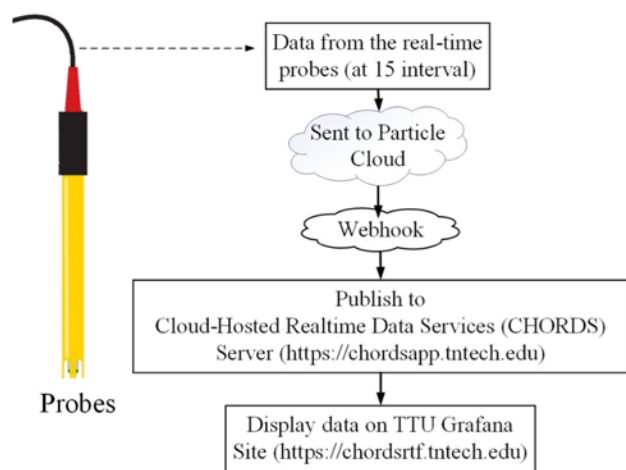


*above: Figure 2. Real-time Water Quality Monitoring Approach*

node is configured to collect the pH, DO, Electrical conductivity, and temperature every 15 minutes and they publish the data on a Cloud-Hosted Realtime Data Services (CHORDS) Server at Tennessee Tech University.

## Graduate Student Supplemental Research Grant Final Reports

**Assessing Water Quality of Rivers Feeding Riparian Wetlands in Agroecosystems: Research Supporting the Evaluation of the USDA Wetlands Reserve Program, Robert Brown and Justin Murdock, Department of Biology, Tennessee Tech University**

This report highlights the major findings of four field campaigns undertaken in 2021 to assess water quality at 15-16 sites on major rivers in west Tennessee and Kentucky (Fig. 1) feeding USDA Wetlands Reserve Program (WRP) easements. This research supplements our ongoing work at Tennessee Tech to understand the capacity of WRP easements to retain nutrients during floods. Our ongoing WRP assessment requires the collection of 30 soil cores from each of 40 easements across west Tennessee and Kentucky in the summers of 2019-2022. Soil cores are incubated for 48 hours in a continuous flow-through system under chemical and physical conditions that are kept constant between all easements so that differences in nutrient cycling rates can be attributed to soil characteristics. Water quality parameters for core incubations were set according to long term historical data collected by the USGS from the Obion River in Tennessee and Bayou de Chien in Kentucky. However, the majority of these data were collected during baseflow, and flood stage water quality would be expected to be slightly different. All nutrients were added as salts dissolved in deionized water to achieve target concentrations for synthetic lab water. The main objectives of this work were to determine the water chemistry of flood water
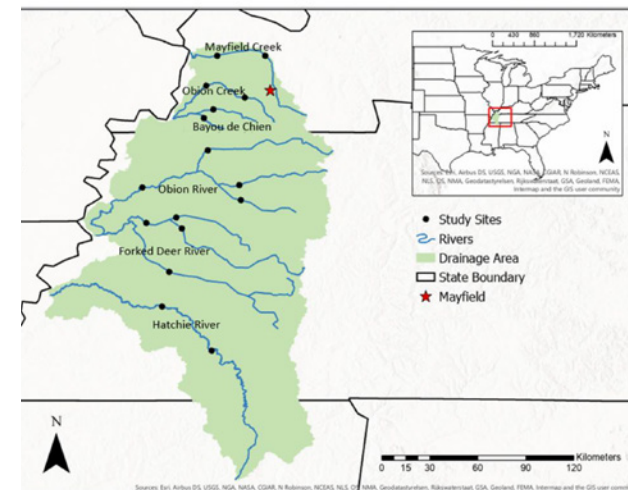


*above: Fig. 1 Study area in west Tennessee and Kentucky.*

entering easements during reconnection with the river and assess how closely our incubation water matches flood water chemistry.

**Composition of Epilithic Diatom and Soft-Algal Assemblages in Tennessee Reservoirs, Correlations of Algal Composition to Trophic State, and Development of Biotic Indices using Correlations to Monitor Trophic State, Jefferson G. Lebkuecher, Jenna L. Atma, and Hailey Conn, Department of Biology, Austin Peay State University**

Ten upper sublittoral sites in ten reservoirs in Middle and East Tennessee were sampled to assess the trophic state of the sites, correlate percent composition of epilithic algal taxa to trophic state and develop indices using the correlations to monitor trophic state. We tested the null hypotheses that the trophic state of sublittoral sites with differing morphological and chemical characteristics is not indicated by the concentration of epilithic chlorophyll a or by the composition of epilithic diatom and soft-algal assemblages. Concentration of epilithic chlorophyll a is a

more accurate gauge of the trophic state of the sites relative to the concentration of chlorophyll a of water as indicated by Pearson's correlation coefficients to the concentration of total phosphorus of water. The relationships of trophic state to percent composition of epilithic diatom and soft-algal taxa are expressed as abundance-weighted averages for epilithic concentration of chlorophyll a normalized between 0 and 100. The normalized abundance-weighted averages serve well as trophic-state indicator values. Numerous taxa with high normalized abundance-weighted averages are also documented as indicators of eutrophic streams and rivers by previous studies. Indices designed to denote trophic state of the sublittoral sites are calculated using percent composition of algal taxa at a site and their normalized abundance-weighted averages as a trophic-state indicator values. The trophic-state index using diatoms is significantly correlated with concentrations of epilithic chlorophyll a and concentrations of chlorophyll a of water. The trophic-state index using soft algae is significantly correlated with concentrations of epilithic chlorophyll a, concentrations total phosphorus of water, and the trophic-state index using diatoms. Values for the trophic-state indices accurately designate the trophic state of the sites, are easy to compute and apply and provide novel tools to help evaluate and monitor the trophic state of sublittoral sites in Tennessee reservoirs.

# ISSE-Funded Research: Seed Grants

### Geochemical Interaction between CO2 and Caprock for Safe Carbon Sequestration, PI Khalid Alshibli Ahmed

The overall aim of the proposed research is to characterize $CO_2$-caprock geochemical interaction at micro and nano scales by characterizing and monitoring the geochemical and fracture behavior of rock cores exposed $CO_2$-brine for a long duration using x-ray computed tomography (CT), scanning electron microscopy (SEM), and high-speed coupled micro-beam x-ray fluorescence (μXRF) and micro-beam x-ray diffraction (μXRD).

Cores were extracted from large limestone rock sample that was acquired from East Tennessee, and two sets of samples were obtained from the cores, the first set is a 1 inch in diameter by 1 inch in height cylindrical cores that were used for the super-critical $CO_2$ (SCCO_2) flow experiment. The second set is a thin 30μ in thickness slices that were used for the high-speed coupled micro- x-ray fluorescence (μXRF) and micro x-ray diffraction (μXRD) to characterize the mineralogical composition of the limestone rock sample.

The 1" x 1" cores were initially scanned using CT at the University of Texas at Dallas (UTD) and ZEISS Industrial CT Scanning Services to attain a baseline of the cores' structure and porosity, the result scans indicated variation in mineral composition and very low porosity as expected of limestone caprock sample.
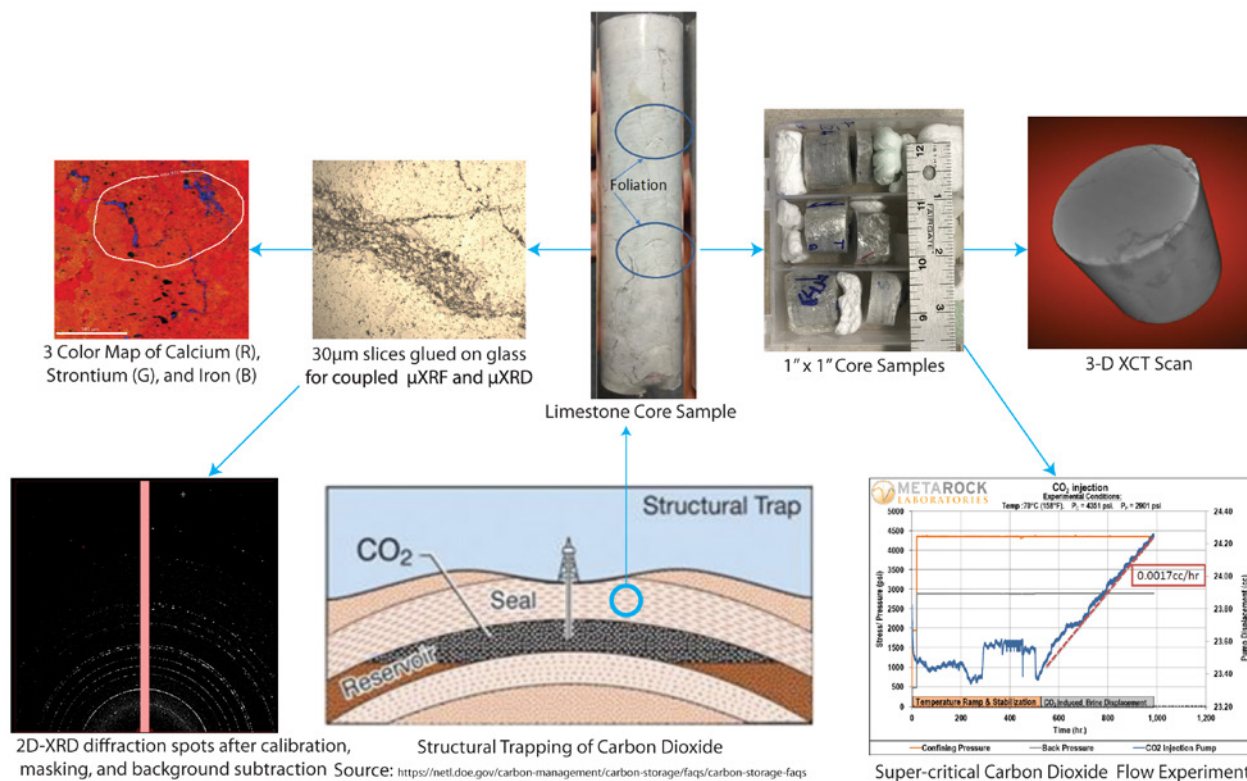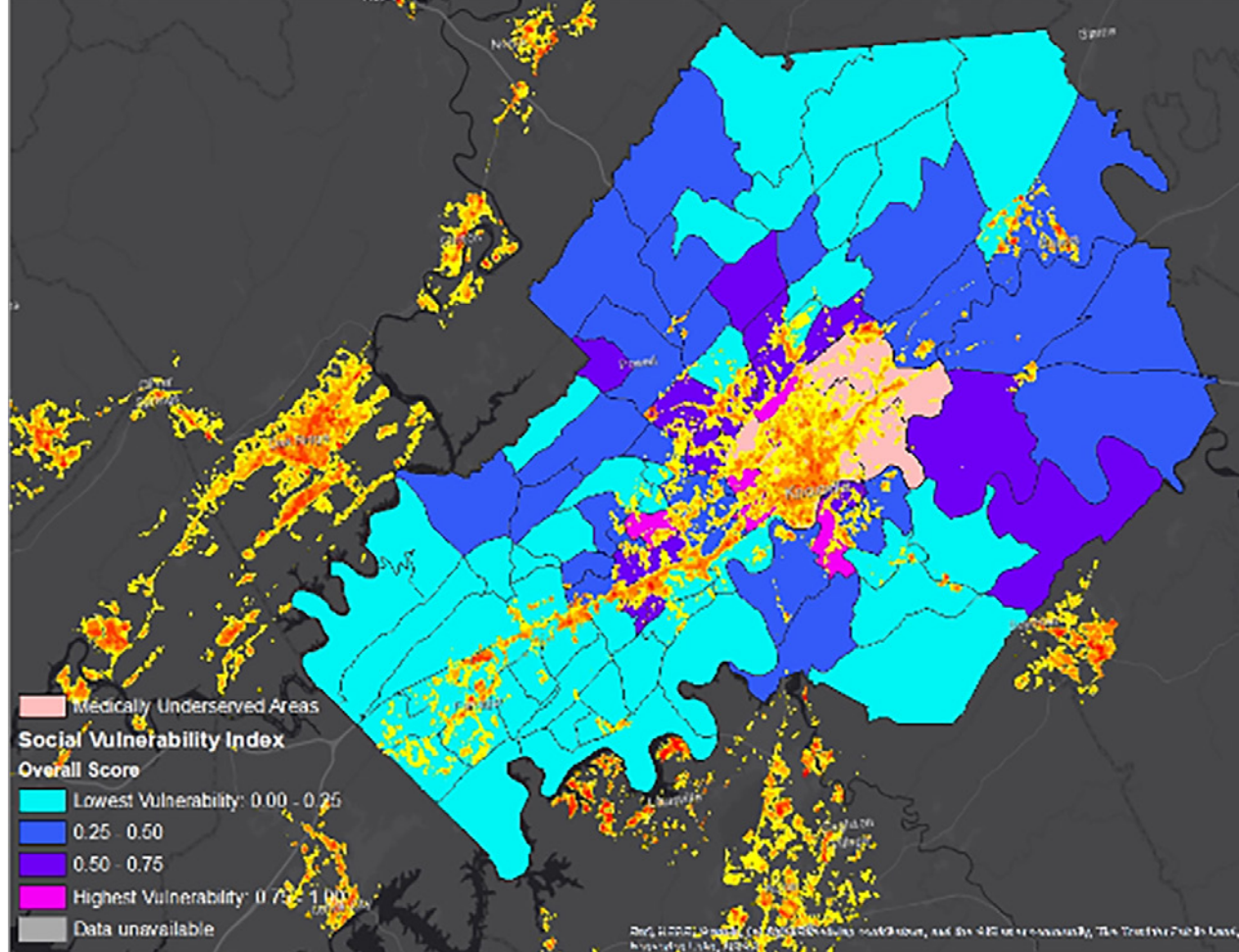
The high-speed coupled μXRF and μXRD experiments were performed at the Advanced Photon Source (APS) GSECARS beamline 13-ID-E where each of the slices was scanned with a 5 x 5 μm spot-focused beam covering an area of 4 x 6 mm. Analyzing the XRF spectrum generated from the μXRF data, several elements were successfully identified including (Ca, Sr, Fe, Si, Mn, Cu, Hg, Zn). Other elements such as Magnesium (Mg) were not detected even though they are typically present in limestone formations, this is due to the μXRF setup and range does not allow for the detection of all present elements. Additionally, some elements with weak presence on the μXRF spectrum were not successfully identified. The use of Electron Microprobe Analysis (EMA) is planned to tackle these issues.

The μXRD data was used to isolate XRD patterns, Calcite and Quartz are two of the phases that were identified using the patterns. Some Identified elements were not successfully matched to expected minerals (Phases) such as Arsenic minerals and Metacinnabar (HgS), due to their small fraction based on the low count of their forming elements, the use of EMA is expected to help in addressing this issue.

The super-critical $CO_2$ flow experiment was performed at MetaRock Laboratories, the results from the flow experiment showed that the super-critical $CO_2$ injected did not displace the brine and did not penetrate the sample due to the low porosity and permeability of the limestone caprock, with the preliminary results from Microscope Photography of the injection face showing no variation before and after the test. After the SCCO_2 flow experiment one of the cores was scanned again at UTD to characterize the change in pore structure due to the interaction with SCCO_2, the results of the scans are yet to be analyzed.



3 Color Map of Calcium (R), Strontium (G), and Iron (B)

30μm slices glued on glass for coupled μXRF and μXRD

Foliation

Limestone Core Sample

1"x 1" Core Samples

3-D XCT Scan

2D-XRD diffraction spots after calibration, masking, and background subtraction Source: https://netl.doe.gov/carbon-management/carbon-storage/faqs/carbon-storage-faqs

Structural Trapping of Carbon Dioxide

Super-critical Carbon Dioxide Flow Experiment

*left: Structural trapping*

**Legend:**
Medically Underserved Areas
**Social Vulnerability Index
Overall Score**
Lowest Vulnerability: 0.00 - 0.25
0.25 - 0.50
0.50 - 0.75
Highest Vulnerability: 0.75 - 1.00
Data unavailable

**Beat the Heat: Building adaptive capacity of vulnerable populations in Knox County to combined stressors from climate change and urban heat, PI Kelsey Ellis**

Objective 1: To identify the scope of UHI effects on human-environment systems in Knox County, with a focus on modeling the DTR and experienced temperatures of vulnerable populations. This connects to the BRACE framework by anticipating climate impacts.

We have done some analysis of the iButton data but needed more information to add context to the temperature data collected inside homes. Thus, we received IRB approval and sent out a survey to the volunteers to understand their cooling resources and how heat affects them. These data will be integrated into the temperature data.

Objective 2: To assess social and medical vulnerabilities to the impacts of climate change and urbanization, with a specific focus on the impacts of the UHI, in Knox County. This connects to the BRACE framework by assessing vulnerabilities to climate change.

We have pulled together a number of data sources to examine the vulnerabilities to the effects of urban heat island, including data from the Centers for Disease Control and Prevention, the US Census Bureau, the Tennessee Department of Health, and others. This includes data sources examining heat-related, socioeconomic, and health-related vulnerabilities. Using these data, we have identified a number of neighborhoods in Knox County that are at greatest risk for harmful effects and negative outcomes for heat and climate impacts. We are developing a public-facing dashboard and story map of these data sources. The map identifies the areas and neighborhoods in downtown Knoxville with high social vulnerability that are also considered medical underserved areas and experience higher temperatures than surrounding areas due to the urban heat island.

Objective 3: To further our understanding of the associations between heat and other types of vulnerabilities, we conducted descriptive and correlation analyses. These findings were submitted as an abstract to the 103rd American Meteorological Society Annual Meeting. Next steps include using principal component analysis or other statistical method to create a heat vulnerability index for Knox County and provide this on the dashboard.

Objective 4: To develop an 8–12 member Heat Task Force of local stakeholders to identify community-based strategies to address heat exposure and impacts on vulnerable populations in Knox County. This connects to the BRACE framework of prioritizing climate-sensitive health outcomes and developing adaptation plans in consultation with community stakeholders such as local public health agencies, community members, local government, academics, and social service organizations.

We developed a community stakeholder task group, the Knoxville Heat Equity Coalition (KHEC), that is working together to develop solutions and build a critical social infrastructure to advance heat equity and environmental justice issues in Knoxville. Stakeholder meetings occurred November 2021-April, 2022.

### Microbial transformation and degradation of sulfonated per- and polyfluoroalkyl substances, PI Frank Loeffler

This project's overarching objective is to challenge the paradigm of "forever chemicals" and demonstrate that sulfonated PFAS are susceptible for biotransformation by specialized bacteria. Per- and polyfluoroalkyl substances (PFAS) are global contaminants linked to a variety of humans diseases. The proposed research will use the soil isolate Pseudomonas sp. strain 273, which harbors an unusually high number of 22 alkanesulfonate monooxygenase (ssuD) genes, to demonstrate that naturally occurring bacteria can transform and defluorinate perfluorosulfonic acids, including perfluorooctanesulfonic acid (PFOS). The research will generate evidence for the existence of a natural attenuation process for a major class of PFAS, which would have far-reaching implications for fate and transport modelling, sensible regulatory frameworks, and possibly enhanced remedies.

PFAS comprise thousands of synthetic chemicals produced since the 1950s for use in various industrial applications, diverse consumer products, and as components of aqueous film forming foam (AFFF) formulations for fire suppression. PFAS have emerged as global contaminants that can be detected in every person on the planet Earth and are linked to metabolic disruption, obesity, diabetes, immune suppression, and cancer in humans. Deemed "forever chemicals", some evidence is now emerging suggesting that naturally occurring microbes can transform PFAS 7. A major group of PFAS in AFFF are perfluorosulfonic acids with the general structure $CnF2n+1-SO3H$ and various precursors with the general structure $CnF2n+1-SO2R$. Sulfonated PFAS and its precursors are pervasive groundwater contaminants originating from AFFF applications, landfill leachate, and wastewater treatment plants 10, but also from non-point sources, predominantly urban stormwater runoff.

### Socioeconomic Inequalities and Drinking Water Quality: Assessing Arsenic Concentrations in Community Water Systems by Novel Field Deployable Biosensors, PI Jie Wu

Dr. Cronley developed a sampling strategy based on a stratified quota method. The method is based on: 1) census tracts classified as IRS-designated Qualified Opportunity Zones (QOZ), 2) non-census tract QOZs at median state income; and 3) non-QOZ census tracts above the median state income. The goal is to over-sample in QOZs and achieve a sample of 100 households.

The IRB application for data collection has been approved, which includes household demographic surveys and tap water samples. We have completed preliminary sampling of tap water samples from 100 households in 10 zip codes. These households are of various socioeconomic status. Households were asked to complete household-level demographic survey including six items about perceived household water quality. Water samples were tested for chlorine and pH levels in field. Tests for contaminants including arsenic, lead, etc. have been done for 3 zip codes, which shows potential correlation between contaminant levels and socioeconomic status. Ongoing efforts are focused on the selection and testing of sampling regions with greater potential of demonstrating the correlation with socioeconomic disparity.

The microcontroller-based ACEK capacitive sensing module was designed, simulated, and tested on a breadboard, which provides a foundation for realizing a portable sensor platform.
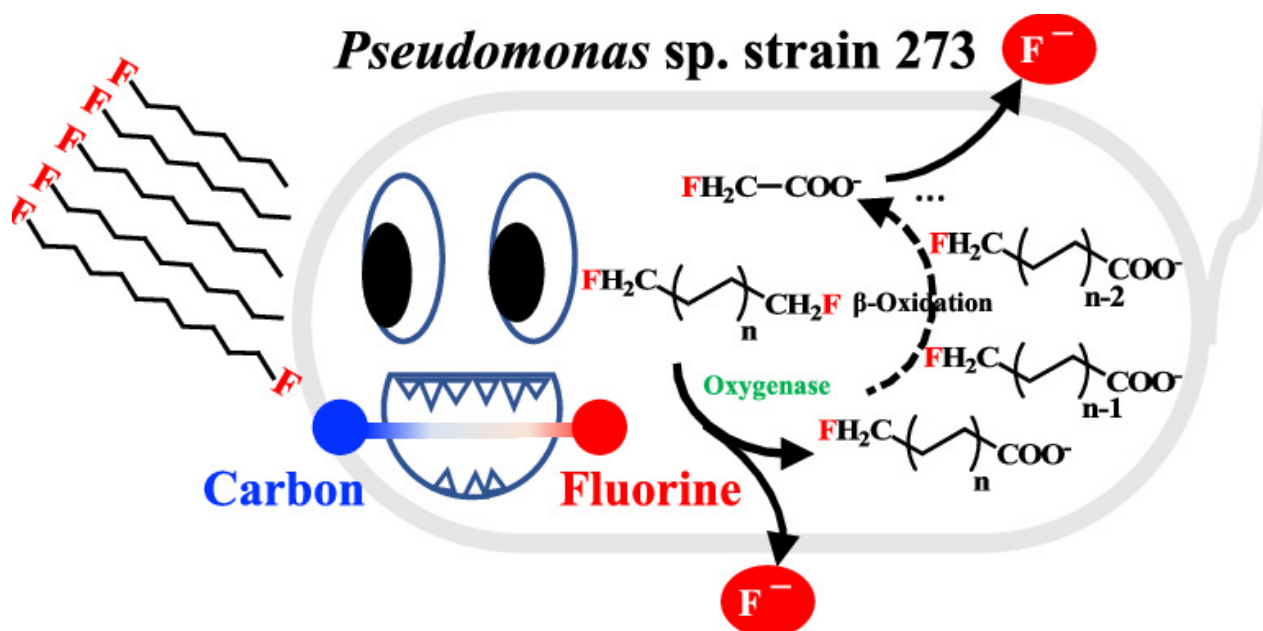
# Newly Awarded Seed Grants

ISSE makes annual funding available for multi-disciplinary, multi-investigator research and support. Each year, ISSE awards three or four seed grants to support research projects that are related to environmental sustainability. The aim is to support project teams as they develop interdisciplinary collaboration and build the capability to secure external funding. ISSE expects the funded teams to submit at least one external grant proposal and one article to a peer-reviewed publication acknowledging ISSE's support. Among the topics of interest are

- Modeling sustainability and resilience, especially for regional systems, under climate changes and other social and environmental stressors
- Systems or engineering solutions to reduce nutrients and pollution (e.g., microplastics) in water
- Technologies and analyses for carbon sequestration
- Solutions or modeling to enhance environmental health

For FY2023, a panel of independent reviewers scored all submissions and selected the following projects. Work on these projects began July 1, 2022 and will conclude on June 30, 2023.



**Jiangang Chen**
Assessing the levels of forever chemicals (PFAS) in surface water in Tennessee aquatic ecosystems



**Baoshan Huang**
Utilization of Waste Plastics



**Alison Buchan**
Identification of novel pathways for bacterial degradation of polycyclic aromatic hydrocarbons



**Chris Cherry**
Micromobility Vehicle Second-Life Battery Applications: Market Inventory and End Use Feasibility Analysis

# Training & Education

### Appalachian Community Technical Assistance and Training (ACTAT) Program, John Schwartz

The ACTAT Program is funded by the USDA Water and Environmental Programs and awarded to water centers at West Virginia University, University of Kentucky. and the University of Tennessee, Knoxville. The ACTAT Program helps small rural communities throughout Central Appalachian subregions improve drinking water and wastewater infrastructure operations and become eligible for financial resources to improve their vulnerable water infrastructure, a first step towards community economic growth. ACTAT supports the USDA's Rural Utilities Services objective to help improve quality of life and increase economic opportunities for rural people. Lessons learned from our program will be shared with other similar areas across Appalachia online through the group's website, and in-person via a Regional Symposium. This past year, Steven Hoagland gave a training with communites near Greenville and met with the communities of Norris, Cumberland Gap, and Luttrell. We were assisted by Rob Ramsey with TDEC's Knoxville Field Office.

### Tennessee Water Resources Research Center Training, Tim Gangaware

Since October 1, 2021, TNWRRC has offered eight different courses: Levels 1 and 2 of Tennessee Erosion Prevention and Sediment Control (TNEPSC) Training Program for Construction Sites plus a Level 1 and Level 2 TNEPSC Recertification courses; Tennessee Hydrologic Determination Training and its corresponding Recertification course; and the Storm Water Control Measure Inspection and Maintenance Workshop and Recertification Course.

TNWRRC has offered a total of 30 course sessions and trained 2,000 professionals in these workshops. The courses were a combination of virtual, online and in person training.

TNEPSC offers three training workshops for developers, contractors, engineers, and other professionals, inspection personnel, and enforcement officials responsible for all aspects of preparation and implementation of Storm Water Pollution Prevention Plans for preventing erosion and controlling sediment at construction sites one acre or more in size.

Tennessee Hydrologic Determination Training is a course for conducting hydrologic determinations. Successful completion of the training course is one of the requirements for certification as a Qualified Hydrologic Professional.

Storm Water Control Measure Inspection and Maintenance Workshops are available to design engineers and architects as well as plan reviewers and other local municipal program personnel. They provide insights on avoidance and minimization approaches to site layout, design guidance on specific permanent stormwater control measures, and experience using tools developed to assist designers and plan reviewers with implementation of runoff reduction and pollutant removal requirements.

## STEMM Programs in Appalachia, National Institute of Health & National Science Foundation, Tim Ezzell

Dr. Ezzell assists with two established STEMM programs at UT - PIPES: Possibilities in Postsecondary Education and Science among Rural Appalachian Youth and ASPIRE: Appalachian Students Promoting the Integration of Research in Education. These programs are designed to help bring underrepresented population into STEM fields, at all levels. In particular, they work to help create opportunities for young people in rural Appalachian communities in East Tennessee.

PIPES: Possibilities in Postsecondary Education and Science among Rural Appalachian Youth, is funded by the National Institute of Health (NIH), provides opportunities for tenth- and eleventh-grade students in two Appalachian counties, Monroe and Campbell, to explore STEMM careers (science, technology, engineering, math, and medical science) and to promote college awareness.

ASPIRE: Appalachian Students Promoting the Integration of Research in Education, is funded by the National Science Foundation (NSF) and build on PIPES success by providing scholarships to academically talented Appalachian high school seniors majoring in STEM and STEMM fields. Aspire also creates a learning community for participating students and assists Appalachian students, and their families, in making the transition to college life.

## Worker Health and Safety Training at Department of Energy (DOE) Facilities, Sheila Webster

The training is funded by a grant from the National Institute of Environmental Health and Sciences (NIEHS) and administered by the Partnership for Environmental Technology Education (PETE). The use of HAZWHOPER ONLINE (developed by AWARDEES CCCHST and PETE) started transitioning to Roane State Community College (RSCC) in September 2020. Vol State incorporated HAZWOPER ONLINE with numerous OSHA and related Safety and Health courses that are offered on a regular basis.

ISSE's primary role was to obtain feedback and determine workplace impact of HAZWOPER ONLINE training. ISSE analyzed data for surveys for end of course and workplace follow up provided by Roane State Community College. ISSE also conducted follow up interviews to determine how training is applied in the workplace and how it is benefits the employee and the employer. ISSE observed classroom training and continues to with RSCC as they maintain the online training. Staff continued to attend virtual meetings including, training sessions offered by NIEHS, quarterly meetings hosted by PETE and the annual PETE Advisory Committee meeting.

# Outreach & Collaboration

### East TN Clean Fuels/Drive Electric TN, Jonathan Overly

East Tennessee Clean Fuels is the project lead on a 2020 DOE-funded project that works with 14 states to build their statewide 'Drive Electric' programs. The project's priority areas include developing branded websites, hosting outreach events, and creating social media campaigns; educating consumers and developing state chapters; planning electric vehicle (EV) charging infrastructure; reaching out to local and state government officials; engaging car dealers; and creating fleet partnerships for EV adoption.

In Year One, efforts began on all priority areas and the participating coalitions started assembling their branded programs. Coalitions began building partnerships around their state and developing a program logo as a part of their statewide plan development. Chapter development, building utility relationships, and dealer and fleet planning are other significant tasks underway in year one.

Before project completion, Drive Electric Tennessee (DET) will develop long-term funding approaches and expand the program to include additional states beyond the original 14. During summer 2021, the project added four states (Indiana, Kentucky, Connecticut, and New York) and discussions are currently underway with another dozen Clean Cities Coalitions. Additional states will be able to use all materials developed from the project to help establish their initiatives.

A cooperative partnership with Tennessee Technological University expanded to include a second, multi-state project that will bring a medium-duty electric truck ("eTruck") to fleets across Tennessee, where they will be able to borrow the truck for up to two months to vet its use in fleet



operations. Data from fleet use will not only help the fleets understand their potential applicability to electric truck use but also feed an information system to better understand various fleets' needs and desires with EVs.

DET efforts expanded to include further chapter development and to hold more Ride & Drive events in various areas across Tennessee. The "Appalachian Highlands Chapter" of DET, which covers the northeastern part of the state, ramped up in April 2021. Two events were held

including the first-ever Ride & Drive in Bristol, Tennessee that brought together about 25 local EV owners and reached nearly 100 citizens during the day with information about how EVs work and where you charge them. Attendees were able to drive EVs such as the Ford Mustang Mach-E, the Tesla Model 3, and the Nissan Leaf.

### Appalachian Teaching Project 2021-2022: Charge-Up Appalachia: Strategies to improve Electric Vehicles along Tennessee's ADHS Corridors, Tim Ezzell

This Year's UT ATP class examined Electric Vehicle (EV) infrastructure along Tennessee's Appalachian Development Highway System (ADHS) corridors and developed recommendations for improving EV access along these routes. The class created and distributed an EV driver's survey to help determine charging habits and preferences. They conducted an EV perception survey, distributed to stakeholders across East Tennessee, to help understand local EV perceptions and to identify potential barriers to adoption.

The class also conducted field research, with student teams traveling in EVs the length of three ADHS corridors in Tennessee. During the research, students identified potential charging sites, noted local barriers, and met with local stakeholders, including local officials (i.e., the mayors of Dunlap and Cumberland Gap), business owners, and other EV drivers. Using these findings, students developed recommendations for future charging sites and guidelines for future charger installations.

Students presented these findings at a forum at UT's Baker Center for Public Policy. The forum was attended by over fifty participants, including representatives from TVA and TDEC. The students gained a better understanding of the challenges and opportunities that exist in Rural Appalachian communities.

The class used surplus funds to purchase a level 2 smart EV charger for the town of Cumberland Gap. The town installed the charger this summer. The charger and the data it generates will be incorporated into UT's upcoming 2022-23 ATP project and it will continue to serve the community afterwards.

### TNWRRC Information Transfer Program, Tim Gangaware

The major emphasis of the information transfer program during FY 2021 was on technical publication support, conference planning and development, and improvement in the information transfer network. The purpose of the program was to support the objectives of the technical research performed under the FY 2021 Water Resources Research Institute Program. During the FY 2021 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, TNWRRC was involved in the planning and implementation of the 29th Tennessee Water Resources Symposium. 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 29th Symposium was very successful with 59 professional presentations and 32 student posters being presented online over the two-day period.

TNWRRC was a co-sponsor of the 2020 Tennessee Stormwater Association Annual Conference, held virtually on October 21-22, 2020. Over 150 attended on-line and hear 43 professional presentations that covered a variety of topics including Green Infrastructure, FEMA Permitting and Grant Funding., Urban Waters Report Card, TN GIS Data Resources and How to ACE your MS4 Audit.

# Publications, Presentations, Recognition & Awards

## Publications

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## Presentations

Jarrar, Z. A., Al-Raoush, R. I., Alshibli, K. A., and Jung, J-W (2020). "Dynamic 3D Imaging of Gas Hydrate Kinetics using Synchrotron Computed Tomography", 2nd International Conference on Energy Geotechnics (ICEGT-2020), Published online 18 November 2020, E3S Web of Conferences 205, 11004, https://doi.org/10.1051/e3sconf/202020511004

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Ash, K. T., Y. Li, D. C. Joyner, D. E. Williams, I. Alamilla, P. McKay, B. Green, C. Iler, F. Kara-Murdoch, C. Swift, F. Löffler, and T. C. Hazen. Contributed. Miles Away From Ordinary: Raw Wastewater Surveillance For The Novel SARS-CoV-2 Virus On The University of Tennessee - Knoxville Campus. World Microbe Forum, Online, June 20-24, 2021. American Society for Microbiology and Federation of European Microbiological Societies. World Microbe Forum

Brown, Jason R., (2021) Dissolved Organic Carbon and the Potential Role to Stream Acidity in the Great Smoky Mountains National Park. Master Thesis, Department of Civil Engineering, University of Tennessee. https://trace.tennessee.edu/utk_gradthes/6166.

C. K. Ku and M. Jin, Retailer Inventory Counting Policy, May 2021.

Campa, M. F., J. C. See, L. Unverdorben, O. Wright, K. A. Roth, J. M. Niles, D. Ressler, E. Macatugal, A. Putt, S. M. Techtmann, T. C. Hazen, and R. Lamendella. Contributed. Geochemistry, land coverage, and multiomics data differentiate streams in Pennsylvania based on unconventional oil and gas activity. World Microbe Forum, Online, June 20-24, 2021. American Society for Microbiology and Federation of European Microbiological Societies. World Microbe Forum

Chakraborty, R., X. Wu, D. C. Joyner, T. C. Hazen, R. G. Malana, A. P. Arkin and P. D. Adams. Invited. Applying Stable Isotopes for Source Fingerprinting of Dissolved Organic Nitrogen in Groundwater. February 23-26, 2020. Washington, DC. 2020 Genomic Sciences Program (GSP) Annual Principal Investigator (PI) Meeting. ORAU www.orau.gov › gsp2020.

Cianciolo, C.F. (2021) Impact of Urbanization Gradients and Stormwater Input on the Microbial Community Structure within Impaired Low-Order Streams. Master Thesis, Department of Civil Engineering, University of Tennessee, https://trace.tennessee.edu/utk_gradthes/6122.

D. M. Vance, C. Price, S. Nimbalkar, T. Wenning and M. Jin, Selecting a Smart Manufacturing Maturity Model, IISE Annual Conference, May 2021.

Dixon, E. R., K. F. Walker, D. Williams, and T. C. Hazen. Contributed. Modeling Dynamic Geochemical Processes: How Diurnal and Seasonal Water Table Fluctuations Influence Contaminated Groundwater Geochemistry. December 10, 2019, San Francisco, CA. AGU Fall Meeting.

Ellis, K. N. Variability in Knoxville's urban heat and residential exposure. Social Inequality in Energy, Environment, and Technology Workshop. University of Tennessee. 13 August 2021.

Fukai, I., and T. C. Hazen. 2021. Germ Anti-Warfare: Evaluating Microbial Biosensors for Nuclear Arms Nonproliferation. 9th Annual Oak Ridge Postdoctoral Association (ORPA) Research Symposium, Oak Ridge, TN, July 28–29, 2021.

Fukai, I., and T. C. Hazen. Contributed. Evaluation of Microbial Biosensors With Applications In Nuclear Arms Nonproliferation. World Microbe Forum, Online, June 20-24, 2021. American Society for Microbiology and Federation of European Microbiological Societies. World Microbe Forum .

Fuqai, Isis and T. C. Hazen. 2020. Biosensors for Detecting Nuclear Production Activity in the Environment. March 12, 2020. Ann Arbor, MI. MTV, University of Michigan.

Griffiths, Z., A. Putt, M. Campa, D. Joyner, J. Miller, O. Pelz, N. GaraJayeva, P. Gardinali, and T. C. Hazen. Contributed. Observing the Indigenous Microbial Community

Response to Crude Oil Amendment in Aerobic and Anerobic Conditions. World Microbe Forum, Online, June 20-24, 2021. American Society for Microbiology and Federation of European Microbiological Societies. World Microbe Forum

Gushgari-Dolye, S., A. P. Arkin, L. M. Lui, R. Chakraborty, T. C. Hazen and X. Wu. Contributed. Functional Diversity of Arthrobacter Strains Across the Dynamic Capillary Fringe and Adjacent Sediment Zones. December 16, 2020, San Francisco, CA. AGU Fall Meeting.

Gushgari-Doyle, S., M. O. Yee, J. V. Kuehl, H. J. Smith, M. P. Thorgersen, X. Ge, A. E. Otwell, T. L. Lie, K. A. Hunt, M. W. W. Adams, E. J. Alm, N. S. Baliga, J.-M. Chandonia, A. M. Deutschbauer, D. A. Elias, M. W. Fields, T. C. Hazen, T. R. Northen, A. Mukhopadhyay, G. E. Siuzdak, D. A. Stahl, P. J. Walian, J. Zhou, R. Chakraborty, A. P. Arkin, P. D. Adams. Invited. Targeted Isolation Using Field-Informed Approaches. February 22-24, 2021. Washington, DC. 2021 Genomic Sciences Program (GSP) Annual Principal Investigator (PI) Meeting. ORAU www.orau.gov › gsp2021.

H. Kose and M. Jin, Planning and Scheduling for a Single Additive Manufacturing Machine Using Multi-material Types, May 2021.

H. Sun, Y. Sun, R. E. Wagner, M. Jin, W. Tate, and J. Zhuang, Food losses and waste challenges for the food-water-energy nexus in the United States, AGU Annual Conference, December 2020

Harik, A.-M., T. C. Hazen, D. C. Joyner, and S. Rafie. Contributed. Imaging and Analysis of Methanotroph Induced Bioaggregation in Sand. World Microbe Forum, Online, June 20-24, 2021. American Society for Microbiology and Federation of European Microbiological Societies. World Microbe Forum

Hazen, T. C. Invited Webinar. Exxon Valdez vs. Deepwater Horizon and Considerations for Peru Repsol Spill. Online. Lima, Peru. January 27, 2022. Pontificia Universidad Católica del Perú.

Hazen, T. C. Invited Webinar. Repsol Oil Spill in Peru. Online. Lima, Peru. February 8, 2022. National Service of Protected Areas (SERNANP) from the Ministry of Environment (MINAM).

Hazen, T. C. Invited. After Chat June 21 3:45-4:30PM. "Environmental Systems Biology: The Whole is Greater than the Sum of its Parts – Team Science" ASM Environmental Microbiology Award. World Microbe Forum, Online, June 20-24, 2021. American Society for Microbiology and Federation of European Microbiological Societies. World Microbe Forum

Hazen, T. C. Invited. Biosensors for Detecting Nuclear Production Activity in the Environment (Consortium for Monitoring, Technology, and Verification (MTV)). September 8-10, 2021. Office of Defense Nuclear Nonproliferation Research and Development, University Program Review (UPR) 2021 Meeting.

Hazen, T. C. Invited. Careers in National Labs. U Mass Amherst online, 5/16/21.

Hazen, T. C. Invited. Environmental Systems Biology: The Whole is Greater than the Sum of it's Parts – Team Science. Online, August 6, 2021. Louisiana Tech Environmental Class.

Hazen, T. C. Invited. Environmental Systems Biology: The Whole is Greater than the Sum of it's Parts – Team Science. World Microbe Forum, Online, June 20-24, 2021. American Society for Microbiology and Federation of European Microbiological Societies. World Microbe Forum

Hazen, T. C. Invited. Lessons Learned from the Deepwater Horizon Oil Spill Response and Omics. Online, December 13, 2021. Louisiana Technical University CEE Departmental Seminar.

Hazen, T. C. Invited. Wastewater Based Epidemiology during the Covid-19 Pandemic at the University of Tennessee, Knoxville. September 16, 2021. Charlotte, NC. Global ENVIRO Summit https://www.envirosummit.com/

Hazen, T. C., E. R. Kelly*, A. Putt, K. Walker, D. C. Joyner, I. Fukai, K. Lowe, M. Rodriguez Jr, M. W. Fields, R. Chakraborty, X. Wu, D. Stahl, T. Lie, M. W. W. Adams, F. Poole, P. J. Walian, J. Zhou, J. V. Nostrand, T. R. Northen, J.-M. Chandonia, A. P. Arkin, and P. D. Adams. Invited. Cone Penetrometer 3-D Characterization of Y-12 Site to Determine the Hydrological, Geological and Biogeochemistry Best Sites for ENIGMA Subsurface Observatories. February 22-24, 2021. Washington, DC. 2021 Genomic Sciences Program (GSP) Annual Principal Investigator (PI) Meeting. ORAU  www.orau.gov › gsp2021.

Hazen, T. C., I. Fukai, A. P. Arkin, E. Alm, and H. Dulai. Invited. Environmental Surveillance for Biological Traces of Radionuclide Sources. MTV Monthly Seminar, online, 15 May 2021. University of Michigan.

Hunt, K. A., A. E. Otwell, S. Bowman, S. D. Wankel, K. F. Walker, E. R. Dixon, M. Rodriguez, K. A. Lowe, D. C. Joyner, A. Carr, L. Lui, T. Nielsen, N. S. Baliga, T. C. Hazen, D. A. Stahl, A. P. Arkin, P. D. Adams. Invited. Resolving Biotic and Abiotic Controls of Nitrous Oxide Flux in a Subsurface Site Contaminated with High Nitrate Concentrations. February 22-24, 2021. Washington, DC. 2021 Genomic Sciences Program (GSP) Annual Principal Investigator (PI) Meeting. ORAU www.orau.gov › gsp2021.

Hunt, K. A., A. V. Carr, K. F. Walker, E. R. Dixon, M. R. Jr, K. A. Lowe, D. C. Joyner, A. E. Otwell, S. D. Wankel, N. S. Baliga, T. C. Hazen, D. A. Stahl, A. P. Arkin and P. D. Adams. Invited. High nitrous oxide emissions from a nitrate contaminated subsurface indicate significant metabolic activity. February 23-26, 2020. Washington, DC. 2020 Genomic Sciences Program (GSP) Annual Principal Investigator (PI) Meeting. ORAU www.orau.gov › gsp 2020

Hunter, E., K. N. Ellis, J. First, and K. Kintziger: Beat the heat: Building adaptive capacity of vulnerable populations in Knox County to combined stressors from climate change and urban heat. Institute for a Secure and Sustainable Environment Research Conference. 15 September 2022. Poster.

J. Hale and M. Jin, Monitoring Additive Manufacturing Machine Health Using Partially Observed Markov Decision Process and a Witness Parts Framework, IISE Annual Conference, May 2021.

J. Overly, "ETCleanFuels – Actions & partnerships for Success", ISSE Advisory Board Meeting, December 2020, Knoxville, TN.

J. Overly, "Innovative, Diverse EV Applications for Your Fleet", Presented virtually in partnership with the Quebec Government Office in Atlanta, April 2021.

J. Overly, "Renewable Energy in Transportation – Actors & Opportunities for Fleets in Tennessee", Tennessee City Management Association Spring 2021 Conference, April 2021, Murfreesboro, TN.

J. Overly, "Statewide Action & Rural Alt Fuels Leadership – Examples of Success in Tennessee", TDOT RPO Virtual Conference, October 2020.

J. Wu, Socioeconomic inequalities and drinking water quality: Assessing arsenic concentrations in community water systems by novel field deployable biosensors, Social Inequality of Energy, Environment and Technology Workshop, University of Tennessee, August 6

Jarrar, Z. A., Al-Raoush, R. I., Alshibli, K. A., and Jung, J-W (2020). "Dynamic 3D Imaging of Gas Hydrate Kinetics using Synchrotron Computed Tomography", 2nd International Conference on Energy Geotechnics (ICEGT-2020), Published online 18 November 2020, E3S Web of Conferences 205, 11004, https://doi.org/10.1051/e3sconf/202020511004

Jarrar, Z. A., Al-Raoush, R. I., Alshibli, K. A., and Jung, J-W (2020). "Dynamic Imaging of Hydrate Specific Area Evolution during Xenon Hydrate Formation", International Conference on Civil Infrastructure and Construction (CIC2020), Feb. 2-5, 2020, Doha, Qatar, http://dx.doi.org/10.29117/cic.2020.0081

Jarrar, Z. A., Al-Raoush, R. I., Alshibli, K. A., Hannun, J. A., and Jung, J-W (2019). "Hydrate Surface Area Measurements During Dissociation using Dynamic 3D Synchrotron Computed Tomography". The 3rd European Association of Geoscientists and Engineers (EAGE) WIPIC workshop: Reservoir Management in Carbonates, 18-20 November 2019, Doha, Qatar.

Jarrar, Z. A., Alshibli, K. A., Al-Raoush, R. I., and Jung, J-W (2018). "3D Synchrotron Micro-computed Tomography Study of Gas-driven Fracture of Saturated Granular Materials", Abstract H33T-2349 presented at 2018 Fall Meeting, AGU, Washington, D.C., 10-14 Dec. 2018.

Jarrar, Z., Alshibli, K. A., Al-Raoush, R. I., and Jung, J.W. (2018) "Gas Driven Fracture during Gas Production using Hele-Shaw Cell", Annual Research Conference (ARC18), Qatar Foundation Research & Development, March 20-22, 2018.

Jin, Mingzhou, Automated Warehouse Design Considering 2D and 3D Automated Storage and Retrieval Systems, IISE Annual Conference, May 21-24, 2022, Seattle, WA.

Jin, Mingzhou, CO2 Conversion to Fuels Supply Chain Network Optimization, IISE Annual Conference, May 21-24, 2022, Seattle, WA.

Joyner, D. C., and T. C. Hazen. Contributed. Managing Your Graduate Career: Guidelines for Success. World Microbe Forum, Online, June 20-24, 2021. American Society for Microbiology and Federation of European Microbiological Societies. World Microbe Forum .

Kalina Scarbrough Real-Time Sensor-Based Prediction of Soil Moisture in Green Infrastructure: Case Study, Maintenance of Stormwater Control Measures, March 2022 (under review)

Kalina Scarbrough, Identifying a Minimal Set of Real-Time Sensors to Predict Soil Moisture in Green Infrastructure, 1794 Scholars Showcase, University of Tennessee, Spring 2020

Kalina Scarbrough, Identifying a Minimal Set of Real-Time Sensors to Predict Soil Moisture in Green Infrastructure, 2020 IISE Annual Conference, Virtual, May 30-June 2, 2020

Kalina Scarbrough, Identifying a Minimal Set of Real-Time Sensors to Predict Soil Moisture in Green Infrastructure, Poster presentation, EUReCA, University of Tennessee, Spring 2020

Kalina Scarbrough, Real-Time Sensor-Based Prediction of Soil Moisture in Green Infrastructure: Case Study, 2021 IISE Annual Conference, Virtual, May 22-25, 2021

Kalina Scarbrough, Real-Time Sensor-Based Prediction of Soil Moisture in Green Infrastructure: Case Study, 2021 IISE U.S. Mid-Atlantic Region Conference, Virtual, March 27, 2021

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

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

Li, Y., K. Ash, D. C. Joyner, D. E. Williams, C. Iler, I. Alamilla, P. McKay, B. Green, F. Kara-Murdoch, C. Swift, F. Löffler, and T. C. Hazen. Contributed. Decay of SARS-CoV-2 and Pepper Mild Mottle Virus (PMMoV) RNA in raw wastewater to inform application in wastewater-based epidemiology of the University of Tennessee student residential buildings. World Microbe Forum, Online, June 20-24, 2021. American Society for Microbiology and Federation of European Microbiological Societies. World Microbe Forum

Lui, L. M., H. J. Smith, F. V. Netzer, K. B. D. León, E. L.-W. Majumder, J. V. Kuehl, F. Song, A. Sczesnak, T. Nielsen, M. P. Thorgesen, X. Ge, F. L. Poole, B. P. Bowen, S. M. Kosina, C. J. Paradis, K. F. Walker, K. A. Lowe, D. C. Joyner, J. M. Rodriquez, B. A. Adams, D. Williams, J.-W. Moon, J. D. V. Nostrand, D. Ning, Y. Fu, W. Shi, Y. Li, D. J. Curtis, Y. Fan, L. Wu, R. Tian, G. M. Zane, A. B. Aaring, X. Wu, A. E. Kazakov, J.-M. Chandonia, P. S. Novichkov, P. J. Walian, R. Chakraborty, M. W. W. Adams, J. Zhou, T. R. Northen, J. D. Wall, D. A. Stahl, D. A. Elias, T. C. Hazen, M. W. Fields, A. P. Arkin and P. D. Adams. Invited. Core Values: Spatial Variation in Microbial Function, Activity, and Community Assembly in Groundwater and Sediment from a Contaminated Subsurface Aquifer. February 23-26, 2020. Washington, DC. 2020 Genomic Sciences Program (GSP) Annual Principal Investigator (PI) Meeting. ORAU  www.orau.gov › gsp2020.

Lui, L. M., T. Nielsen, H. J. Smith, F. V. Netzer, E. L.-W. Majumder, J. V. Kuehl, F. Song, A. Sczesnak, M. P. Thorgesen, X. Ge, F. L. Poole, C. J. Paradis, K. F. Walker, K. A. Lowe, D. C. Joyner, D. Ning, J. M. Rodriquez, A. B. Aaring, B. A. Adams, D. Williams, J. D. V. Nostrand, G. M. Zane, M. W. W. Adams, J. Zhou, R. Chakraborty, J. D. Wall, D. A. Stahl, T. C. Hazen, M. W. Fields, A. Arkin and P. Adams. Invited. A Method for Circularizing Microbial Genomes from Metagenomics Data. February 23-26, 2020. Washington, DC. 2020 Genomic Sciences Program (GSP) Annual Principal Investigator (PI) Meeting. ORAU  www.orau.gov › gsp2020.

Lui*, L. M., E. L.-W. Majumder*, H. J. Smith*, H. K. Carlson, F. V. Netzer, N. Nielsen, M. Peng, X. Tao, A. Zhou, M. Price, J. V. Kuehl, A. J. Hendrickson, V. Trotter, S. Gushgari-Doyle, J. Valenzuela, A. Otwell, K. Hunt, A. Carr, K. Walker, E. Dixon, F. Poole, M. Thorgersen, X. Ge, M. W. W. Adams, E. J. Alm, N. S. Baliga, J.-M. Chandonia, A. M. Deutschbauer, D. A. Elias, M. W. Fields, T. C. Hazen, T. R. Northen, A. Mukhopadhyay, G. E. Siuzdak, D. A. Stahl, P. J. Walian, J. Zhou,

R. Chakraborty, A. P. Arkin, and P. D. Adams. Invited. Mechanism across scales: integrating laboratory and field studies for microbial ecology as illustrated by the ENIGMA SF. February 22-24, 2021. Washington, DC. 2021 Genomic Sciences Program (GSP) Annual Principal Investigator (PI) Meeting. ORAU www.orau.gov › gsp2021.

M. Galbreth, and M. Jin, Should OEMs Authorize Third-Party Remanufacturers? INFORMS Annual Conference, November, 2020.

M. Jin, Remanufacturing and Supply Chain Managements: Dynamics between Dynamics between Original Equipment Manufacturers and Third Part Remanufacturers, PRES'20, August, 2020.

Miller, J. I., S. M. Techtmann, J. Fortney, N. Mahmoudi, D. C. Joyner, J. Liu, S. Olesen, E. Alm, A, Fernandez, P. Gardinali, N. GaraJayeva, F. S. Askerov and T. C. Hazen. Contributed. Potential for rapid microbial biodegradation of petroleum hydrocarbons in hypoxic marine environments. San Antonio, TX. October 7-9, 2019. International Petroleum Environmental Conference Annual Meeting.

Miller, J. I., Z. Griffiths, S. Techtmann, J. Fortney, N. Mahmoudi, D. Joyner, J. Liu, S. Olesen, E. Alm, A. Fernandez, P. Gardinali, N. GaraJayeva, F. S. Askerov, O. G. Brakstad, O. Pelz, M. Kuijper and T. C. Hazen. Contributed. Microbial Community Structure and Oil Biodegradation in a Hypoxic Marine Environment. May 6, 2020. Dublin, Ireland (online). SETAC SciCon SETAC Europe 30th Annual Meeting.

Needham, D. M., A. Zhang, J.-M. Chandonia, D. Chivian, L. M. Lui, W. Zheng, S. Zhao, Y. Yin, D. A. Weitz, T. C. Hazen, P. S. Novichkov, J. Zhou, E. J. Alm, A. P. Arkin and P. D. Adams. Invited. Integrating data and algorithms from the ENIGMA project into KBase. February 23-26, 2020. Washington, DC. 2020 Genomic Sciences Program (GSP) Annual Principal Investigator (PI) Meeting. ORAU www.orau.gov › gsp2020.

Ning, D., Y. F., L. M. Lui, J. P. Michael, Y. Fu, J. D. Van Nostrand, R. Tian, Y. Wang, K. F. Walker, E. R. Dixon, A. D. Putt, D. E. Williams, D. C. Joyner, K. A. Lowe, F. L. Poole, X. Ge, M. P. Thorgersen, M. W. W. Adams, R. Chakraborty, X. Wu, D. A. Elias R. L. Wilpiszeski, J. Zhou, M. W. Fields, T. C. Hazen, A. P. Arkin, and P. D. Adams. Invited. Physical size matters in groundwater bacterial community assembly. February 22-24, 2021. Washington, DC. 2021 Genomic Sciences Program (GSP) Annual Principal Investigator (PI) Meeting. ORAU www.orau.gov › gsp2021.

Overly, J. and Danniel Siksay, East Tennessee Clean Fuels redesignation webinar, September 19, 2022.

Palino GM, Thompson J, Schwartz J, Hathaway J. 2021. Presentation. Urban floodplain reconnection through regenerative stormwater conveyances. Tennessee Water Resources Symposium. Web. April 15.

Palino GM, Thompson J, Schwartz J, Hathaway J. 2021. Urban floodplain reconnection through regenerative stormwater conveyances. Tennessee Water Resources Symposium. Web. April 15.

Palino GM, Thompson J, Schwartz J, Hathaway J. 2022. Presentation. Hydraulic modeling of regenerative stormwater conveyances. UCOWR/NIWR Annual Water Resources Conference. Greenville, SC.

Parker, C. and Kintziger, K. Identifying medically vulnerable areas in Tennessee. Summer Undergraduate Research Internship Program, Discovery Day. University of Tennessee. 31 August 2021.

Persaud, P.P. (2021) The Performance Impacts of Real-Time Control on Bioretention. PhD Dissertation, Department of Civil Engineering, University of Tennessee.

Pineda, P., I. Alamilla, A. Salim, A. Putt, and T. C. Hazen. Contributed. Comparison of Bacterial DNA Extraction from Stream Water. World Microbe Forum, Online, June 20-24, 2021. American Society for Microbiology and Federation of European Microbiological Societies. World Microbe Forum

Putt, A., P. Pineda, I. Alamilla, A. Salim, A. P. Arkin, P. D. Adams, and T. C. Hazen. Contributed. Response of Filterable Microbes to a Beta-Cyclodextrin Injection. World Microbe Forum, Online, June 20-24, 2021. American Society for Microbiology and Federation of European Microbiological Societies. World Microbe Forum

R. Li and M. Jin, Defect Detection on Additive Manufacturing Parts with Machine Learning Informed by Discrete Mean Curvature Measures, IISE Annual Conference, May 2021.

R. Zhou, Z. Li, and M. Jin, Techno-economic Analysis of $CO_2$ Conversion to Jet via Ethanol, IISE Annual Conference, May 2021.

Rafie, S. A. A., K. P. Hoyt, M. R. Schubert, M. T. Kerr, L. R. Blentlinger, A. M. Faiia, A. Szynkiewicz, J. F. Franklin, S. P. Horn, and T. C. Hazen. Contributed. Soil bacterial response to prescribed fires in a southern Appalachian clear cut with fuel manipulation. World Microbe Forum, Online, June 20-24, 2021. American Society for Microbiology and Federation of European Microbiological Societies. World Microbe Forum

Rexhausen, V., Hathaway, J.M., and Anna Szynkiewicz, (2020), Investigating sewage influence on nitrate 15N and 18O values in Baker Creek in Knoxville, TN., 5th Symposium on Urbanization and Stream Ecology. Austin, Texas.

Rexhausen, V., Hathaway, J.M., and Anna Szynkiewicz, (July 2021), "Urban runoff source partitioning using isotopic analysis of nitrate and sulfate" Goldschmit 2021 Virtual Conference. (Virtual Oral Presentation).

Rexhausen, V., Hathaway, J.M., and Anna Szynkiewicz, (October 2021), "Urban runoff source partitioning using isotopic analysis of nitrate and sulfate" International Conference on Urban Drainage. (Virtual Oral Presentation).

Rexhausen, V., Hathaway, J.M., and Anna Szynkiewicz, (October 2021), "Urban runoff source partitioning using isotopic analysis of nitrate and sulfate" Tennessee Stormwater Association Annual Conference. (Oral Presentation)

Rexhausen, V., Hathaway, J.M., and Anna Szynkiewicz. (January 2022) "Using isotopic source partitioning of urban runoff to verify effective impervious area model in a partially forested, partially developed urban watershed" Urban Drainage Modeling Annual Meeting. (Virtual Oral Presentation.

Robertson, Savannah, Tennessee Smart Mobility Conference, Nashville, TN, August 4–5, 2022.

Rui Zhou, Yaopoing Wang, and Mingzhou Jin, Global Coffee Supply Chain under Climate Change, 24th Conference on Process Integration for Energy Saving and Pollution Reduction - PRES'21, October 31-November 3, 2021, Brno, Czech Republic.

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

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

Salim, A. A., A. Putt, and T. C. Hazen. Invited. Learning and growing as a Scholar : My Experience as an Undergraduate Researcher. April 14, 2020. Knoxville, TN. 1794 UTK Annual Scholars Showcase one of 20 finalists.

Salim, A. A., P. Pineda, I. Alamilla, A. Putt, and T. C. Hazen. Invited. A Novel approach for Characterizing the Ultra-Micro Size-Fraction Community. April 13, 2020. Knoxville, TN. EURēCA Undergraduate UTK Annual Research Meeting.

Scarbrough, Kalina. Identifying a Minimal Set of Real-Time Sensors to Predict Soil Moisture in Green Infrastructure, 1794 Scholars Showcase, University of Tennessee, Spring 2020

Scarbrough, Kalina. Identifying a Minimal Set of Real-Time Sensors to Predict Soil Moisture in Green Infrastructure, 2020 IISE Annual Conference, Virtual, May 30-June 2, 2020

Scarbrough, Kalina. Identifying a Minimal Set of Real-Time Sensors to Predict Soil Moisture in Green Infrastructure, Poster presentation, EUReCA, University of Tennessee, Spring 2020

Scarbrough, Kalina. Real-Time Sensor-Based Prediction of Soil Moisture in Green Infrastructure: Case Study, 2021 IISE Annual Conference, Virtual, May 22-25, 2021

Scarbrough, Kalina. Real-Time Sensor-Based Prediction of Soil Moisture in Green Infrastructure: Case Study, 2021 IISE U.S. Mid-Atlantic Region Conference, Virtual, March 27, 2021

Scarbrough, Kalina. Real-Time Sensor-Based Prediction of Soil Moisture in Green Infrastructure: Case Study, Maintenance of Stormwater Control Measures, March 2022 (under review)

Serrano Matos, Y., A. Gonzalez, A. Rivera, D. Williams, T. C. Hazen, and G. A. Toranzos. Contributed. Prophage and CRISPR Sequences Detected in Enterococci Isolates From Soils and Waters with Low Anthropogenic Disturbances. November 20-24, 2019, Anaheim, CA. Annual Biomedical Research Conference for Minority Students (ABRCMS) 2019.

Social Inequality of Energy, Environment and Technology Workshop, Aug.6, UT. "Socioeconomic inequalities and drinking water quality: Assessing arsenic concentrations in community water systems by novel field deployable biosensors," team presentation

T. Cokyasar, W. Dong, M. Jin and O. Webas, Optimization Methods for Innovative UAV Applications, INFORMS Annual Conference, November, 2020.

V.Rexhausen, J.M Hathaway, A. Szynkiewicz. (January 2022) "Using isotopic source partitioning of urban runoff to verify effective impervious area model in a partially forested, partially developed urban watershed" Urban Drainage Modeling Annual Meeting. (Virtual Oral Presentation)

V.Rexhausen, J.M Hathaway, A. Szynkiewicz. (July 2021) "Urban runoff source partitioning using isotopic analysis of nitrate and sulfate" Goldschmit 2021 Virtual Conference. (Virtual Oral Presentation)

V.Rexhausen, J.M Hathaway, A. Szynkiewicz. (October 2021) "Urban runoff source partitioning using isotopic analysis of nitrate and sulfate" International Conference on Urban Drainage. (Virtual Oral Presentation)

V.Rexhausen, J.M Hathaway, A. Szynkiewicz. (October 2021) "Urban runoff source partitioning using isotopic analysis of nitrate and sulfate" Tennessee Stormwater Association Annual Meeting. (Oral Presentation)

W. Dong and M. Jin, Travel Time Models for Tier-to-tier SBS/RS with Different Storage Assignment Policies and Shuttle Dispatching Rules, IISE Annual Conference, May 2021.

Walker, K. F., E. R. Dixon, D. C. Joyner, K. A. Lowe, F. L. Poole, X. Ge, M. P. Thorgersen, D. Ning, Y. Fan, J. P. Michael, Y. Fu, R. Tian, Y. Wang, J. D. V. Nostrand, L. M. Lui, X. Wu, K. J. Davis, M. W. W. Adams, R. Chakraborty, D. A. Elias, R. L. Wilpiszeski, J. Zhou, M. W. Fields, T. C. Hazen, A. P. Arkin and P. D. Adams. Invited. Spatiotemporal Dynamics of Groundwater and Sediment: Geochemistry, Microbial Communities and Activities in a Contaminated Aquifer. February 23-26, 2020. Washington, DC. 2020 Genomic Sciences Program (GSP) Annual Principal Investigator (PI) Meeting. ORAU www.orau.gov › gsp2020.

Walker, K. F., E. R. Dixon, D. C. Joyner, K. A. Lowe, F. L. Poole, X. Ge, M. P. Thorgersen, D. Ning, Y. Fan, J. P. Michael, Y. Fu, R. Tian, Y. Wang, J. D. V. Nostrand, L. M. Lui, X. Wu, M. W. W. Adams, R. Chakraborty, D. A. Elias, R. L. Wilpiszeski, J. Zhou, M. W. Fields, A. P. Arkin, P. D. Adams, and T. C. Hazen. Contributed. Diurnal and Seasonal Fluctuations with the Subsurface: A 17-Week Survey of Groundwater and Sediment in 27 Contaminated Wells. World Microbe Forum, Online, June 20-24, 2021. American Society for Microbiology and Federation of European Microbiological Societies. World Microbe Forum

Wang, Y. (Presenter), J. Mao, M. Jin, F. Hoffman. 2020. Developing a Gridded Upscaled Soil Moisture Dataset Using Sparse in situ Observations. AGU Fall Meeting. Online virtual meeting, United States.

Wu, X., D. C. Joyner, T. C Hazen, R. G. Malana, and R. Chakraborty. Invited. Applying Stable Isotopes for Source Fingerprinting of Dissolved Organic Nitrogen in Groundwater. Goldschmidt2020.

Wu, X., L. Lui, Y. Liu, N. Justice, T. Simmons, T. Nielsen, S. Jagadamma, N. J. Hess, T. C. Hazen, A. P. Arkin, and R. Chakraborty. Contributed. Insights into the Depth-resolved Geochemical Constraints on Microbial Community Structure and Metabolic Potential for Carbon Cycling in Shallow Subsurface Sediment. December 10, 2019, San Francisco, CA. AGU Fall Meeting.

Xu Zheng and Mingzhou Jin, Modeling and Analysis of Sustainable Soybean Supply between China and the U.S., IISE Annual Conference, May 21-24, 2022, Seattle, WA.

Xu Zheng, Mingzhou Jin, Yaoping Wang, Modeling and Analysis for Global Soybean
　　　　Supply Chain, University of Tennessee, Knoxville, TN, United States, 2021
　　　　Annual INFORMS Conference, October 24-27, 2021, Anaheim, California.

Zhang, A., D. M. Needham, A. E. Kazakov, W. Zheng, S. Zhao, Y. Yin, D. A. Weitz, T.
　　　　C. Hazen, E. J. Alm, N. S. Baliga, A. M. Deutschbauer, J.-M. Chandonia, M.
　　　　W. Fields, T. R. Northen, J. D. Wall, M. W. W. Adams, M. Auer, K. Bender, G.
　　　　Butland, R. Chakraborty, D. A. Elias, P. S. Novichkov, A. Mukhopadhyay, G. E.
　　　　Siuzdak, D. A. Stahl, P. J. Walian, J. Zhou, A. P. Arkin, and P. D. Adams. Invited.
　　　　Strain dynamics and functional diversity of 22 high-quality single cell genomes
　　　　from ENIGMA ground water. February 22-24, 2021. Washington, DC. 2021
　　　　Genomic Sciences Program (GSP) Annual Principal Investigator (PI) Meeting.
　　　　ORAU  www.orau.gov › gsp2021.

**Theses**

Brown, Jason R., "Dissolved Organic Carbon and the Potential Role to Stream Acidity in
　　　　the Great Smoky Mountains National Park. " Master's Thesis, University of Ten-
　　　　nessee, 2021. https://trace.tennessee.edu/utk_gradthes/6166

Persaud, P.P. (2021). The Performance Impacts of Real-Time Control on Bioretention
　　　　[PhD Dissertation]. The University of Tennessee

Cianciolo, C. F. Impact of Urbanization Gradients and Stormwater Input on the Microbial
　　　　Community Structure within Impaired Low-Order Streams. Master's Thesis, Uni-
　　　　versity of Tennessee, 2021. https://trace.tennessee.edu/utk_gradthes/6122

## Recogniton

Dr. **Jon Hathaway**, Associate Professor (CEE), is a senior member of an award-winning research team led by colleagues in the Department of Industrial Systems Engineering, including Dr. Anahita Khojandi and Dr. Xueping Li. The team was honored with the Best Paper Award by Omega journal for their paper "Optimizing green infrastructure placement under precipitation uncertainty." Their research addresses the impacts of increased urbanization, infrastructure degradation, and climate change on stormwater systems across the nation. The team developed modeling to determine optimal placement of green infrastructure practices across a set of locations in a watershed and minimize the total expected runoff under medium-term precipitations uncertainties.

Dr. **Qiang He**, Professor and Dr. **Shuai Li,** Assistant Professor, Department of Civil and Environmental Engineering, University of Tennessee, Knoxville, were recognized at the Chancellor's Honors Banquet, 2021. Dr. He and Dr. Li were awarded with the Success in Multidisciplinary Research Award. This award is given to a team of faculty members in more than one academic college who have succeeded in gaining major external resources and recognition for multidisciplinary research. Their research is support in part through 2020TN130B.

**Timothy Gangaware**, Associate Director, Tennessee Water Resources Research Center, received the Dr. Bruce Tschantz Lifetime Achievement Award (2021) at the Tennessee Stormwater Association's Annual Conference. Dr. Bruce Tschantz Lifetime Achievement Award is TNSA's highest honor for outstanding, longtime stormwater professionals with a minimum of 20 years of service. These individuals' long-term contributions have made a noticeable impact on stormwater management efforts in the State of Tennessee.

**Jonathan Overly**, ISSE Outstanding Staff Award 2022. This is the first time this award was given; it will be awarded annually.

## Other Recognition

**East TN Clean Fuels and Madelyn Collins**, ETCF Project Coordinator, were chosen by the U.S. Department of Energy to participate in an Energy and Environmental Justice (EEJ) educational program. This is the second part of a three-part program focused on EEJ work for Clean Cities Coalitions. Collins has been able to travel to Chicago, Illinois twice to participate in in-person workshops as well as several other virtual workshops focused on teaching Coalitions how to engage with EEJ communities and incorporate EEJ into all future programs and projects.

**East TN Clean Fuels** was chosen by the TN Department of Environment and Conservation and the TN Department of Transportation to host this year's TN Sustainable Transportation Forum & Expo (STFE) in Knoxville, TN in November 2022. The Drive Electric Tennessee initiative will also host a one-day conference before STFE in November 2022 called the DriveElectricTN Momentum Summit.

## Media Coverage
**Chris Clark**
- https://foundationfar.org/grants-funding/grants/university-of-tennessee-receives-ffar-grant-to-help-address-food-waste-challenges/
- https://utianews.tennessee.edu/utia-receives-308171-grant-to-keep-food-waste-out-of-landfills/

**Kelsey Ellis**
- https://www.wvlt.tv/video/2022/06/08/heat-your-health-an-upcoming-study-needs-your-help-see-how-much-hotter-knoxville-can-get/
- https://www.wbir.com/article/tech/science/ut-researchers-looking-into-heat-inequities-in-knoxville-and-in-the-us/51-60a5bfa4-96cb-45c5-8551-782fab850cd4
- https://news.utk.edu/2022/04/29/researchers-map-heat-inequities-in-knoxville/

**Qiang He**
- WBIR 10NEWS Interview (10/10/2021): Sevierville traffic could be hurting your lungs; https://www.wbir.com/article/news/local/sevierville-worst-in-tennessee-for-ozone-days/51-5ec98bb5-478b-458b-96e1-0b50eb0e84cf
- WBIR 10NEWS (08/12/2022): Blount County Schools reports elevated lead levels in some of its schools; https://www.wbir.com/article/news/local/blount-county-schools-lead-levels-in-some-of-its-schools/51-ede7bae8-30e8-4afb-a70d-00fcd3404eb7

## Student Awards
- Gillian Palino, Second Place, Student Oral Presentation Award, 2022 UCOWR/NIWR Annual Water Resources Conference in Greenville, SC
- Kalina Scarbrough, Third place, Global Undergraduate Student Technical Paper Competition, IISE, 2021
- Kalina Scarbrough, First place, Mid-Atlantic Region, Regional Undergraduate Student Technical Paper Competition, IISE, 2021

# Director's Goals for 2022—23

ISSE continues to implement its five-year strategic plan to increase its research, educational, and outreach activities at the University of Tennessee. ISSE will promote the development of policies, technologies, and educational programs that will address and help remedy critical environmental issues around the world. We will strengthen our emphasis on cross-disciplinary collaborations that will help bring about global sustainability and environmental equity and justice.

ISSE will help the Office of Research, Innovation & Economic Development launch and grow the Global Energy Ecosystems (GE2) initiative. The goal of GE2 is to develop and deploy sustainable and equitable energy technologies for industry, agriculture, and communities. The vision is to build a self-sustaining GE2 research center with national and international influence that will be impact-oriented, bold and audacious, with systems that are integrated, linked, and convergent. It will address eight of the United Nation's Sustainable Development Goals: zero hunger; clean water and sanitation; decent work and economic growth; industry, innovation, and infrastructure; reducing inequality; creating sustainable cities and communities; taking climate action; and delivering affordable and clean energy.

This past year, ISSE added a new initiative to our research areas. With a sizeable gift and support from Schneider Electric, we will grow our building environment initiative to create a live lab and conduct research on smart buildings for energy saving and human health through data collection and integration, analytics, adaptive controls, and personal engagement.

Building on the DOE-funded work of Baoshan Huang and Nick Zhou, ISSE is considering adding another initiative to its research areas: net-zero and decarbonization. This would provide a promising pathway to rethink the use of the US domestic coal resources by utilizing the low-cost, electrically conductive, and mechanically strong coal-derived solid carbon materials to produce infrastructural components. It does not require any change to existing paving equipment and process and makes it possible to produce multifunctional smart pavements at costs comparable to those of regular pavements.

In addition to these larger goals, ISSE plans to develop a track-1 NSF Sustainable Regional Systems proposal; further grow outreach and research at ETCF and lead the adoption of EV and other alternative fuel vehicles in Tennessee and the US; increase TNWRRC research, training, and outreach activities; take leadership in environmental and energy justice and outreach; and add more affiliated faculty members and more collaboration with other disciplines and other institutions.

## East Tennessee Clean Fuels

ETCF plans to accomplish many goals between now and next year. Our Coalition continues to grow with the addition of multiple Project Coordinators and new interns in the last year. We hope to continue to see growth in our ability to hire new staff to take on one of our many projects and also hope to see professional growth in all of our current staff members. We plan to continue to seek out and apply for new grant opportunities, develop creative ways to solve problems we see in the sustainable transportation field, and finish out several current ongoing projects by the end of 2023. Finally, the largest shift our Coalition has seen in the last year has been a shift in the overall focus on the work we do. Moving forward, all of the projects we participate in and work we do will incorporate some kind of energy and environmental justice focus. It is vital that the work we do benefits all communities, and we plan to take action to ensure that everything we do considers how we are helping or harming already underserved communities.

## Reimagining Urban Watershed Management: A Systems Approach to Stormwater Control and Ecological Rehabilitation

During this project year, our goal is to perform field monitoring of Conner Creek to establish current conditions and to better understand what flow regime might best fit the ecology in the system. Modeling will be conducted to ensure the system can be accurately represented, a critical component to ensure the solutions we generate are transferable. Finally, the team will begin to perform machine learning with the model outputs in preparation for the system optimization that will occur in later years.

## REU Site: Green Infrastructure for Sustainable Urban Environments

During this project year, we will recruit another exception cohort of students to take part in the summer 2023 program. Based on the program evaluation conducted for summer 2022, we will modify our approach as needed to ensure knowledge transfer and an enriching experience for the REUs. Further, the top two students from 2022 will be invited to present their work at a national conference in 2023. Finally, we anticipate the work of the REU students will contribute to peer reviewed publications in the future.

## Urban floodplain reconnection through regenerative stormwater conveyances

Data collection is underway at the site. These efforts will be critical to understanding the benefits of RSC installation at the site by first establishing the current hydrologic regime. We anticipate positive environmental outcomes from the RSC installation, i.e., reduced erosion and increased infiltration to the groundwater system, but this monitoring

will allow quantification of these outcomes. During this project year, we will construct the regenerative stormwater conveyance. Post-construction monitoring will begin to allow a better understanding of the impact of this storm-water control on local hydrology. Lastly, a publication will be prepared based on the work performed to date whereby advanced computer modeling was used to aid in the system design.

### Paving the Way for a Sustainable Future

The project will move on to full scale demonstration and testing using UTK's Accelerated Pavement Tester (APT) facility. The experiments will help to understand the performance of this novel pavement system under simulated service conditions. This project will provide a promising pathway to rethink the use of the US domestic coal resources by utilizing the low-cost, electrically conductive, and mechanically strong coal-derived solid carbon materials to produce infrastructural components. It does not require any change to existing paving equipment and process and makes it possible to produce multifunctional smart pavements at costs comparable to those of regular pavements.

### Beat the heat: Building adaptive capacity of vulnerable populations in Knox County to combined stressors from climate change and urban heat

We plan to submit a proposal to the National Institutes of Health under their Notice of Special Interest: Climate Change and Health (NOT-ES-22-006). We will submit either through the parent R21 (PA-20-195) or the R03 (PA-20-200) mechanism, with a target submission deadline of February 5, 2023.

# Schedule 7

## CENTERS OF EXCELLENCE ACTUAL, PROPOSED, AND REQUESTED BUDGET

**Institution:** University of Tennessee, Knoxville    **Center:** Institute for a Secure & Sustainable Environment

| | FY 2021-22 Actual | | | FY 2022-23 Proposed | | | FY 2023-24 Requested | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Matching** | **Appropr.** | **Total** | **Matching** | **Appropr.** | **Total** | **Matching** | **Appropr.** | **Total** |
| **Expenditures** | | | | | | | | | |
| **Salaries** | | | | | | | | | |
| Faculty | $166,901 | $185,909 | $352,810 | $171,908 | $190,900 | $362,808 | $177,065 | $130,141 | $307,206 |
| Other Professional | $368,463 | $179,581 | $548,044 | $375,832 | $148,203 | $524,035 | $387,107 | $151,000 | $538,107 |
| Clerical/ Supporting | $165,010 | $59,366 | $224,376 | $168,310 | $60,230 | $228,540 | $173,359 | $61,434 | $234,794 |
| Assistantships | $170,531 | $191,687 | $362,218 | $173,942 | $192,487 | $366,429 | $179,160 | $196,337 | $375,497 |
| **Total Salaries** | **$870,905** | **$616,543** | **$1,487,448** | **$889,992** | **$591,819** | **$1,481,811** | **$916,692** | **$538,912** | **$1,455,604** |
| Longevity (Excluded from Salaries) | $6,902 | $5,084 | $11,987 | $7,040 | $5,186 | $12,226 | $7,181 | $5,290 | $12,471 |
| Fringe Benefits | $221,606 | $167,700 | $389,305 | $226,038 | $128,766 | $354,804 | $230,559 | $132,198 | $362,757 |
| **Total Personnel** | **$1,099,413** | **$789,327** | **$1,888,740** | **$1,123,070** | **$725,771** | **$1,848,841** | **$1,154,432** | **$676,400** | **$1,830,832** |
| **Non-Personnel** | | | | | | | | | |
| Travel | $63,596 | $3,870 | $67,466 | $64,868 | $10,500 | $75,368 | $66,165 | $2,000 | $68,165 |
| Software | $5,828 | $4,693 | $10,521 | $5,944 | $2,000 | $7,944 | $6,063 | $2,040 | $8,103 |
| Books & Journals | $795 | | $795 | $811 | $7,000 | $7,811 | $827 | $2,000 | $2,827 |
| Other Supplies | $100,452 | $19,571 | $120,022 | $102,461 | $41,320 | $143,781 | $104,510 | $15,000 | $119,510 |
| Equipment | $2,739 | $1,782 | $4,521 | $2,794 | $5,000 | $7,794 | $2,850 | $3,000 | $5,850 |
| Maintenance | $2,749 | | $2,749 | $2,804 | $2,500 | $5,304 | $2,860 | $2,500 | $5,360 |
| Scholarships | $18,452 | $2,500 | $20,952 | $18,821 | $5,000 | $23,821 | $19,197 | $5,000 | $24,197 |
| Consultants | $46,000 | | $46,000 | $46,920 | | $46,920 | $47,858 | | $47,858 |
| Other (Specify): | | | | | | | | | |
| Printing, Duplicating, Binding | $7,272 | $4,056 | $11,328 | $7,418 | $4,000 | $11,418 | $7,566 | $4,000 | $11,566 |
| Postage, Freight, & Telephone | $5,136 | $5,790 | $10,927 | $5,239 | $6,000 | $11,239 | $5,344 | $6,120 | $11,464 |
| Professional Serv & Memberships | $43,316 | $5,000 | $48,316 | $44,182 | $3,000 | $47,182 | $45,066 | $3,000 | $48,066 |
| Computer Services | $1,740 | $5,568 | $7,308 | $1,775 | $5,600 | $7,375 | $1,810 | $5,712 | $7,522 |
| Rentals | $51 | | $51 | $52 | | $52 | $53 | | $53 |
| Grants & Subsidies | $67,327 | $68,483 | $135,810 | $68,674 | $106,073 | $174,747 | $70,047 | $108,194 | $178,242 |
| Contractual & Special Services | $148,655 | $4,788 | $153,443 | $151,628 | $4,000 | $155,628 | $154,660 | $3,000 | $157,660 |
| Other Expenditures | $55 | | $55 | $56 | $2,000 | $2,056 | $57 | $2,000 | $2,057 |
| Entertainment, Food & Housing | $99,071 | | $99,071 | $101,053 | | $101,053 | $103,074 | | $103,074 |
| Facilities & Admin | $248,586 | | $248,586 | $253,558 | | $253,558 | $258,629 | | $258,629 |
| Direct Cost Sharing | $28,414 | $44,210 | $72,623 | $28,982 | | $28,982 | $29,562 | | $29,562 |
| **Total Non-Personnel** | **$890,234** | **$170,310** | **$1,060,544** | **$908,038** | **$203,993** | **$1,112,031** | **$926,199** | **$163,566** | **$1,089,766** |
| **GRAND TOTAL** | **$1,989,647** | **$959,636** | **$2,949,283** | **$2,031,109** | **$929,764** | **$2,960,873** | **$2,080,631** | **$839,966** | **$2,920,597** |
| **Revenue** | | | | | | | | | |
| New State Appropriation | | $773,966 | $773,966 | | $799,968 | $799,968 | | $839,966 | $839,966 |
| Carryover State Appropriation | | $315,466 | $315,466 | | $129,796 | $129,796 | | | $0 |
| New Matching Funds | $1,989,647 | | $1,989,647 | $2,031,109 | | $2,031,109 | $2,080,631 | | $2,080,631 |
| Carryover from Previous Matching Funds | | | $0 | | | $0 | | | $0 |
| **Total Revenue** | **$1,989,647** | **$1,089,432** | **$3,079,079** | **$2,031,109** | **$929,764** | **$2,960,873** | **$2,080,631** | **$839,966** | **$2,920,597** |